RELATION OF TIME OF HARVEST ON RESPIRATION, CHEMICAL CONSTITUENTS AND STORAGE LIFE OF MANGOS

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Abstract. **Mango fruits (cvs 'Haden', 'Irwin' and 'Kent') were harvested at two periods, first on reaching physiological maturity and again when the fruits were physiologically over mature and started to soften on the tree. The former showed a normal respiratory climacteric followed by ripening in 9-10 days when stored at 25 ± 2°C (73-80°F) and RH 65-75%. They also showed a better acid-sugar ratio and good eating quality accompanied by better texture and color besides lasting longer. The tree-ripe fruits, on the other hand, did not show a respiratory climacteric, showed uneven ripening with low acid-sugar ratio, tissue break down and reduced storage life. The study shows the importance of harvesting mango fruits before ripening on the tree in order to have better quality fruits.**

Mango is one of the important tropical fruits produced in Mexico and occupies the fifth place in the world among the fruits with an annual production of 380,000 tons, valued at 612,183,107 pesos, distributed over an area of 28955 hectares (2). This is likely to increase considerably in the next ten years as the new mango plantations come to production. The mangos grown in Mexico belong to three classes 1. 'Manila,' a polyembryonic type comprising 35 per cent, 2. unclassified seedling mangos of local importance amounting to 40 per cent and the rest accounted by Floridan cultivars like 'Haden', 'Irwin', 'Tommy Atkins', 'Sensation', 'Kent', 'Keitt' and Zill.' Mango cultivation on a systematic basis is fairly new to Mexico and as such its aspects of production are not fully understood. Large quantities are lost during pre and post harvest handling, transport and storage due to diseases and pests and faulty techniques of harvesting. Unless modern techniques of harvesting, handling and storage are strictly applied, conservation of fresh fruit becomes a serious problem in the years to come. Until recently mango fruits were harvested when the fruits began to soften on the tree i.e., beyond the stage of physiological maturity. This obviously resulted in heavy post-harvest losses due to susceptibility of the partially ripe fruits to spoilage organisms with reduced storage life, nonuniformity in ripening and spongy tissue. Studies conducted on 'Alphonso' mangos (5) indicated that fruits harvested at physiological maturity and slightly earlier passed through normal respiratory climacteric after harvest and possessed better color and texture and longer storage life. Tree ripe fruits presented ripening disorders and spongy tissue and did not present a post harvest respiratory climacteric. Maturity in different mango varieties is known to influence the chemical composition and respiratory patterns during ripening limiting storage life and consumer acceptability (5, 10, 13).

The object of this study was to establish a relationship of time of harvest to respiration, chemical constituents and storage life in order to fix standards of maturity for harvesting to obtain better quality mangos. The results reported here are a summary of work carried out during 1972-75. The study was conducted with three Floridan mango cultivars namely 'Haden,' 'Irwin' and 'Kent' each representing early, middle and late varieties.

Materials and methods

Mango fruits 'Haden,' 'Irwin' and 'Kent' were harvested at two stages, first on reaching physiological maturity or at preclimacteric stage (green hard, outgrown shoulders, pit around the stalk end, showing an apparent break of yellow colour in the pulp) and again when the fruits were physiologically over mature becoming soft and ripe on the tree (partially or fully colored, medium soft-soft with apparent aroma). Several harvests were made in each season at stages described above and subjected to respiration, chemical analysis and storage studies. At every stage more than 50 fruits were harvested and brought to the laboratory within 24 hr and stored in plastic boxes in a ripening room at 25°C and 65-75% relative humidity. Daily respiration rate was studied (at 25°C) by a modified continuous current method using individual, whole fruit. The chemical analyses of the pulp were made twice, once immediately after harvest and subsequently when ripe. Acidity, apparent ascorbic acid and total

soluble solids (°B) were determined by AOAC methods (1), sugars by the method of Ting (18) and carotenoids by the method described by the Association of vitamin chemists (9). Color and consistency of the pulp was noted only by visual observation. All values were expressed on fresh weight basis.

Results

Respiration. Fig. 1-3 show a graphic representation of the respiratory drifts in mango 'Haden', 'Irwin' and 'Kent' respectively. Curve no. 1 (Fig. 1) of 'Haden' mango corresponds to a fruit harvested at physiological maturity following the classical climacteric pattern showing preclimacteric minimum, maximum and post climacteric decline. Curves No. 2-6 represent respiration pattern of fruits harvested at different stages of softness on the tree. In none of the instances was there an apparent climacteric pattern indicating that respiration climacteric maximum passed off while still being on the tree; in other words, respiration curves 2-6 represented only the post climacteric decline in CO_2 production. The readings for CO_2 represented in curves 2-6 were taken until the 7th day after harvest by which time the fruits had become over ripe and consequently over soft. Similar trends were noticed with respect to 'Irwin' and 'Kent' mangos also (Fig. 2 and 3).

Chemical constituents, storage life and quality of mangoes.

Tables 1-3 show a relationship between time of harvest to chemical constitutents, storage life and quality of mangos. In the case of 'Haden' mango

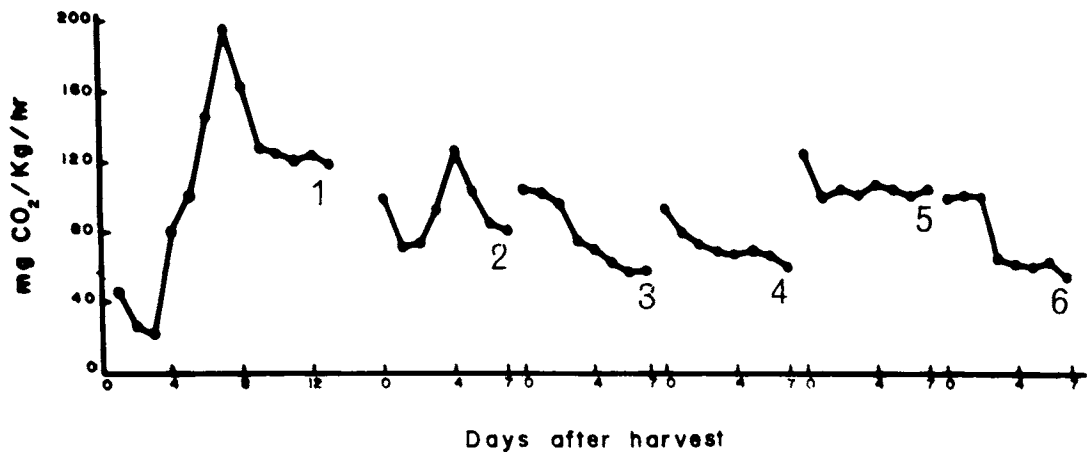

Fig. 1. Respiration patterns of 'Haden' mango. 1. Respiration pattern of a physiologically mature mango. 2-6. Respiration patterns of mangos harvested at various stages after physiological maturity.

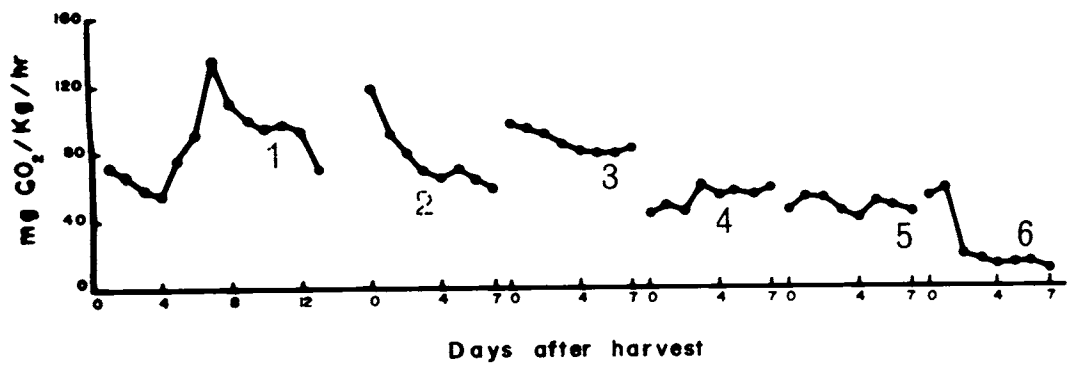

Fig. 2. Respiration patterns of 'Irwin' mango. 1. Respiration pattern of a physiologically mature mango. 2-6. Respiration patterns of mango harvested at various stages after physiological maturity.

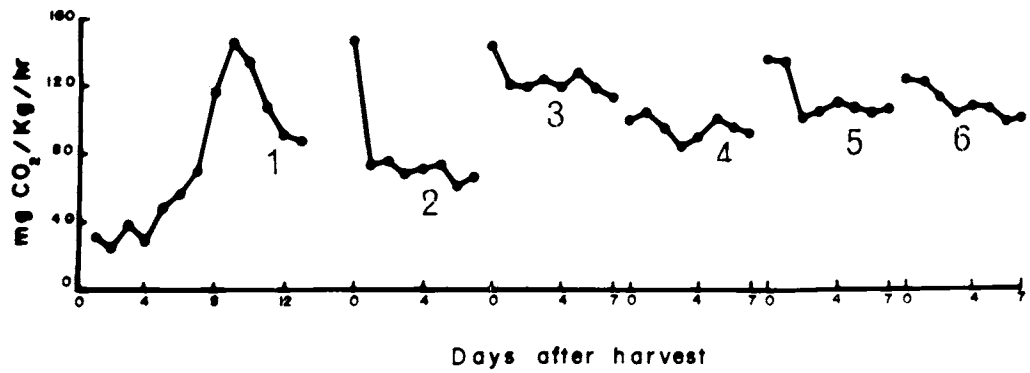

Fig. 3. Respiration patterns of 'Kent' mango. 1. Respiration pattern of a physiologically mature mango. 2-6. Respiration patterns of mangos harvested at various stages after physiological maturity.

(Table 1) when the fruit was harvested at physiologically mature (preclimacteric) stage and ripened at 25°C the increase in total soluble solids, total sugars and carotenoids was quite marked and high besides developing very attractive color, flavor and texture having a storage life of 12-14 days. Contrary to this, fruits harvested at physiologically over-mature stage showed a reduction in total soluble solids, slight increases in sugars and carotenoids which were less than those shown by fruits harvested at physiologically mature stage and subsequently ripened at 25°C. Physiologically over mature fruits at harvest were medium soft to feel and internally there was apparent spongy areas in pulp (Fig. 4-5) which in the course of the short storage life of 3-5 days showed tissue disintegration, in certain cases even becoming mushy in texture. Similar behaviour of the fruits with regard to chemical constituents, color, texture and storage life was noticed in the case of *'Irwin'* as well as 'Kent' mango.

Discussion

Several studies have been conducted in the last decade to fix maturity standards in mango for harvesting and shipping taking into consideration the effect of size of fruit and dates of sampling on physical and chemical constituents (12) like starch, sugars, soluble solids and phenolic compounds (11, 13, 15). A correlation was established between maturity and chemical constituents such as starch, sucrose, soluble solids, etc. But unfortunately none of these factors were found use-

TABLE 1. CHEMICAL CONSTITUENTS* OF HADEN MANGO

		Titratable acidity (%)	Apparent asc. acid (mg/100g)	Brix (°B)	Total sugars (%)	Total carotenoids (μ/100g)	beta carotene (μ/100g)	Storage life (days, 25°C-RH 65%)	Color of the pulp	Consistency of the pulp
Initial analysis at harvest	Physiologically mature	0.97	28.0	9.8	4.43	910	322	-	turning yellow	uniform consistency
	Physiologically over mature	0.31	22.7	17.0	13.10	6642	2705	-	bright yellow	apparently soft and spongy tissue
Final analysis when ripe	Physiologically mature	0.22	32.1	18.9	16.22	9212	4617	12-14	golden yellow	uniformly consistent texture
	Physiologically over mature	0.11	24.3	16.0	14.62	8805	3584	3-5	golden yellow	apparently spongy and tissue break down

* Average of four estimations expressed on fresh weight basis.

TABLE 2. CHEMICAL CONSTITUENTS* OF IRWIN MANGO

		Titratable acidity (%)	Apparent asc. acid (mg/100g)	Brix (°B)	Total sugars (%)	Total carote noids (μ/100g)	beta carotene (μ/100g)	Storage life (days 25°C-RH 65%)	Color of the pulp	Consistency of the pulp
Initial analysis at harvest	Physiologically mature	0.41	59.3	9.7	5.17	1874	727	-	light yellow	uniform consistency
	Physiologically over mature	0.22	41.6	16.6	13.97	4520	1587	-	orange yellow	spongy areas near stalk and apex
Final analysis when ripe	Physiologically mature	0.12	45.7	16.7	13.71	5002	2292	14-16	golden yellow	uniform consistent texture
	Physiologically over mature	0.14	44.6	16.6	13.96	5775	2258	3-5	golden yellow	visible spongy tissue

* Average of four estimations expressed on fresh weight basis.

ful as a commercial measure of maturity. It has been earlier demonstrated that 'Alphonso' mangos harvested at any stage of maturity underwent the usual respiration drifts and changes in chemical constituents and ripening (6) similar to those in bananas (3). However, fruits harvested late in the season showed ripening disorders such as the occurrence of spongy tissue which has been reported as a physiological ripening disorder (16). This, perhaps, may be an instance of fruit harvested late in the season after passing the stage of physiological maturity. Similar instances were noticed in mangos grown in Israel but were later confirmed as related to time of harvest (19). 'Haden,' 'Irwin' and 'Kent' mangos harvested late in the season, which were beginning to soften on the tree also presented this problem as all these fruits were at the post climacteric maximum stage of respiration at harvest. On the other hand, fruits harvested at the stage of physiological maturity (preclimacteric stage) and then ripened showed better colour, flavour and texture. A correlation of respiration pattern on time of harvest in 'Irwin' and 'Kent' mangos (Fig. 4-5) clearly demonstrates this view.

It is generally felt by the producers and shippers that mangos harvested in the green hard stage (physiological maturity) fail to ripen proper-

TABLE 3. CHEMICAL CONSTITUENTS* OF KENT MANGO

		Titratable acidity (%)	Apparent asc. acid (mg/100g)	Brix (°B)	Total sugars (%)	Total carote-noids (μ/100g)	beta carotene (μ/100g)	Storage life (days, 25°C-RH 65%)	Color of the pulp	Consistency of the pulp
Initial analysis at harvest	Physiologically mature	0.51	10.5	8.7	10.95	572	178	-	turning yellow	uniform consistency
	Physiologically over mature	0.49	20.8	13.4	15.50	4539	1808	-	bright yellow	extensive spongy tissue
Final analysis when ripe	Physiologically mature	0.12	23.5	21.0	20.90	5729	2613	14-16	golden yellow	uniform consistent texture
	Physiologically over mature	0.50	21.5	17.2	14.84	3519	1524	4-6	golden yellow	visible tissue break down

* Average of four estimations expressed on fresh weight basis.

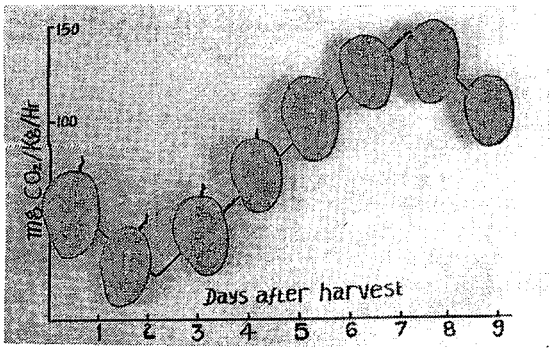

Fig. 4. Respiration and maturity in relation to ripening, color and texture of the pulp in 'Irwin' mango.

ly, but given proper conditions of ripening develop excellent edible quality (14). Most mango varieties on reaching physiological maturity show changes in the pulp colour breaking to yellow which can easily be determined by slicing the pulp of a few fruits before harvest which may incidentally serve as a guiding factor for harvest. As the fruits reach the respiration climacteric maximum on the tree and harvested during the post climacteric maximum or decline the sugars, colour, flavour and texture of mangos show adverse changes which seriously impair the quality of the fruit while reducing the storage life also.

Fruits harvested medium ripe or ripe (corresponding to post climacteric decline of respiration) and stored for a short period and then analyzed showed in general, lesser quantity of sugars and carotenoids in all the three varieties tested here than those harvested at the pre-

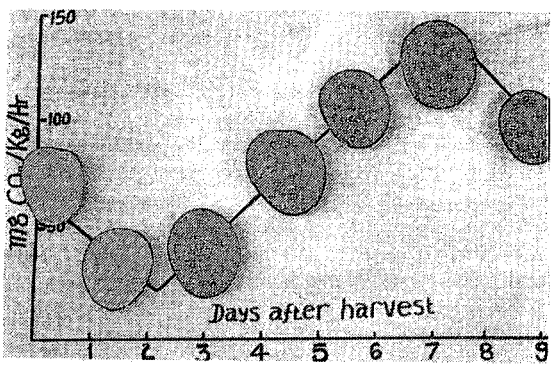

Fig. 5. Respiration and maturity in relation to ripening, color and texture of the pulp in 'Kent' mango.

climacteric stage and ripened at 25°C. It is explained that field temperatures ranging from 35-40°C prevailing at harvest and the fruits being exposed too long for these conditions after reaching physiological maturity might be responsible for reducing the sugar and carotene contents. It has been recently reported that the best conditions for aroma, flavour and carotenoid development in 'Alphonso' mango is 25°C (17). Our results with regard to Mexican grown Floridan cvs. of mango are in conformity with the above findings.

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