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EFFECT OF STORAGE CONDITION ON SOME QUALITY CHARACTERISTICS AND VOLATILE COMPONENTS OF CASIMIROA (WHITE SAPOTE)

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ABSTRACT

This work was carried out during the two successive seasons of 2007, 2008 on white sapote *casimiroa edulis, Llave&Lex.* The Fruits were obtained from El –kanater horticulture Research station, to determine the optimum maturity stage of fruits alongside assessment of fruit quality under various circumstances of storage. The obtained data revealed that fruit reached maturity stage after 117-121days from full bloom, rind color changed from dark green to light green and pulp color became white cream and TSS reached to 13.3-13.8 in both seasons of study .There was obvious relation between storage temperatures and ripening process .The fruits held at room temperatures 35°C and 65%RH ripened after 5 days, however fruits held at 10°C &5°c and 90%RH, this period reached 15 and 25 days respectively. Fruits held at 0°C did not ripen till 30days at cold storage and could be transfer to room temperature 35°C to reach ripening stage. The headspace volatiles of fresh white sapote *Casimiroa edulis* and of those exhibited the best quality after storage at different temperature were isolated and subjected to gas chromatography – mass analysis. A total of 23 component were identified in casimiroa aroma including esters (8), alcohols (7), aldehydes (3), terpenes (4), and (1) ketone. Esters and alcohols comprised more than 85% of the total volatiles in casimiroa fruits at mature and in all stored samples .The major esters were ethyl butyrate, ethyl acetate and hexyl acetate while the major alcohols were ethanol and 3-methyl butanol. The results revealed no remarkable changes between volatiles of mature and stored samples. However, sample 3 that stored at 10°C for 15 days comprised the highest yield of ethyl butanoate (43.4%) which possessed sweet and furity aroma and considered as index of good quality. In general storage of casimiroa fruits at different temperatures 5&10 and 35 °C caused their ripening which lead to high concentrations of ethyl butyrate and ethanol. These compounds are responsible for the consumer acceptability of casimiroa fruits.

Keywords: Casimiroa Fruits, Storage, Temperature, Postharvest Properties, Volatile Components.

INTRODUCTION

Casimiroa *casimiroa edulis Llave&* belongs to family Rutaceae is a tropical fruit tree native to the highlands of Mexico and Central America. It is commercially grown in these regions (George, *et al.,* 1986). In Egypt

it can be considered as exotic fruit usually harvest in July (Osman, *et al* 1990), however its cultivation has been gradually increased during the last two decades. Fruits are usually consumed fresh, but attempts have been made in Central America to use these fruits in preparation sweet preserve juice on a commercial scale. Casimiroa fruits has a high nutrient value, its chemical analysis is as followes 72.64 %water, 20.64 total sugars (inverted sugar 8.44 and Sucrose 12.20), sarceh 3.92, protein 0.64, fat 0.46 and crude fiber 1.26 (Bastawros, *et al.,* 2003).

Sapodilla fruits were harvested manually in Culiacan, Mexico, in June, and then stored under marketing conditions (20°C, 85% RH) for 6 days. At

harvest, the fruits had 13.2°Brix, 0.24% titratable acidity and a firmness of 64.6 N. Fruit weight loss after 6 days at 20°C reached 5.1%, while firmness dropped to 1.9 N; on the other hand, soluble solids content increased to 25.8°Brix. Titratable acidity didn't show any significant changes during marketing. Pulp colour ranged from white-cream at harvest to light orange after 6 days at 20°C. (Baez, *et al.,* 1997).

At 5°C, softening occurred only on the fruit surface, and the surface became water-soaked. All the fruits stored at 1°C. for 10, 20, 46 and 63 days could be ripened after they were transferred to an environment at 25° C. Since chilling injury occurred in the fruits stored for 63 days, it is suggested that the storage period could be extended to 46 days by storage at 1° C (Yonemoto, *et al.,* 2002)

The effect of storage temperature (2.5°C, 10°C and 20°C) on the sapote fruits was studied. There was a highly significant linear relationship between storage temperature and increase in weight loss during storage. At 2.5°C, fruits showed abnormal ripening with partial browning of the flesh near to the skin, indicating chilling injury. Flesh firmness was higher in fruits at 2.5°C and 10°C than at 20°C (Perez *et al.,* 1999).

Little work has been done on flavour of Casimiroa (Everett, 1947; Mizrahi *et al.,* 1991). Furthermore there was no available literature on the volatile components of casimiroa till that investigated and published by Abd El Mageed (2007).

The aim of this study was to determine optimum maturity stage of Casimiroa fruits and assessment of fruits quality under various circumstances of storage at different temperatures and their effect on post-harvest of fruits properties and volatile components.

MATERIALS AND METHODS

The experimental study was carried out through two successive seasons of 2007 and 2008 on Casimiroa *casimiroa edulis Llave* fruits the selected trees (K3) according to *Bastawros et al. 2003* were grown at El–kanater horticulture Research station, Kaliobia Governorate, at their age about 25-30 years old. This investigation concerned with the following topics:

1. Determine stage of Casimiroa (white sapote) fruits.
2. Assesment of fruits quality under various circumstances of storage.

Determination of maturity:

Fruit sample were picked at 7 days interval after (103) days from full bloom on March 20th in the first season and (107) days from full bloom on March 25th in the second season to determine fruit maturity, before anticipated commercial maturity. Six fruits were transferred directly to laboratory and each sample divided to 2 parts .The first part was used for determine physical (fruit weight, shape index, peel and pulp color (a/ratio) and firmness) and chemical characters(TSS and acidity) at harvest .The second part samples were packed in carton boxes and held at room temperature to study weight loss, shrinkage degree (moderate – light – non) firmness and appearance (unripe-ripe) to determinate, if maturity is attained at that specified proper date ,fruit that remains not shrink were considered mature and their characters were recorded .

Assessment of fruit quality during storage:

The fruits were picked after reached maturity, washed with water and left to dry, then divided into four groups and packed in a one layer in carton boxes/5kg, and stored at 0°C, 5°C, 10° C, under 90% RH, and room temperature 35°C under 65% RH, samples were taken every five days to determine fruit quality.

Percentage of weight loss:-

Fruits were periodically weighed and the Percentage of weight loss was calculated by the difference between the initial weight and that recorded at the date of sampling.

Fruit firmness:-

Was determined in 6 fruits after removing a thin layer from the skin (2 mm) and measured by using shatilon's instrument for measuring firmness for pome fruits. Fruit firmness was represented as (Ib/ in ^{2}).

Peel and pulp color:-

Peel color changes were estimated by a Hunter colorimeter type (DP-9000) for the estimation of "L", "a" and "b" values and color was represented as a/b ratio as described by McGuire (1992)

Fruit Chemical analysis:-

Total soluble solids (TSS %): This property was determined by Carl-Zeiss hand refractometer

Total acidity%:

This property was determined according to A. O. A. C method (1990); acidity was determined as malice acid (mg/100cm of juice).

Isolation of headspace volatiles

The volatiles in the headspace of each sample under investigation were isolated by using a dynamic headspace system. The samples were purged for 1 h with nitrogen gas (grade of N2 > 99.99%) at a flow rate 100 ml/min. The headspace volatiles were swept into cold traps containing diethyl ether and pentane (1:1, v/v) and held at -10 °C. The solvents containing the volatiles were dried over anhydrous sodium sulfate for 1 h. The volatiles were obtained by evaporation of the solvents under reduced pressure (Fadel *et al.,* 2006).

Gas chromatographic (GC) analysis

GC analysis was performed by using Hewlett-Packard model 5890 equipped with a flame ionization detector (FID). A fused silica capillary column DBS (60m x 0.32 mm id) was used. The oven temperature was maintained initially at 50°C for 5 min, and then programmed from 50 to 250°C at a rate of 4°C/min. Helium was used as the carrier gas, at flow rate 1.1 ml/min. The injector and detector temperatures were 220 and 250°C, respectively. The retention indices (Kovats index) of the separated volatile components were calculated using hydrocarbon (C8-C22, Aldrich CO.) as references.

Gas chromatographic-mass spectrometric (GC-MS) analysis

The analysis was carried out by using a coupled gas chromatography Hewlett-Packard (5890)/mass spectrometry Hewlett-Packard-MS (5970). The ionization voltage was 70 eV, mass range m/z 39-400amu. The GC condition was carried out as mentioned above. The isolated peaks were identified by

matching with data from the library of mass spectra (N1ST) and compared with those of authentic compounds and published data (Adams, 2001). The quantitative determination was carried out based on peak area integration.

Statistical analysis: Complete randomized design was used in this study. Each treatment was replicated three times, data were tabulated and parameters except some chemical analysis were subjected to statistical analysis according to Snedecor and Cochran (1990). Means were compared by LSD test at 5% level of probability.

RESULTS AND DISCUSSION

1-Maturity studies

It is evident from Table(1) that fruit weight increased slightly gradually till the age of (117) days from full bloom on March 20th to reach maturity in July 19th in the first season and (121) days from full bloom on March 25th to reach maturity in July 16th in the second season. No difference was observed regarding fruit shape index during maturation. Peel color as measured by a/b ratio revealed that during maturity, it was changed from dark green (after (103-117 days) from full bloom to light green (after107&121days). Concerning pulp color, there was slight increased in a/b ratio values and the pulp became white cream. Total soluble solids % increased gradually during maturity and reached from (12.6-13.3) to13.3-13.8%. Acidity of juice decreased gradually with advanced time and reached from (0.469 to 0.335) in the first season, similar results were obtained in the second seasons.

As mentioned before Casimiroa (white sapote) fruits were packed and kept at room temperature and examined daily. Table (1) shows the major changes that occurred during that period in fruit quality. Fruits that ripened normally without shrinkage and low rate of weight loss were considered mature fruits. However, fruits properties, shrieked, did not loose firmness, and lost high percentage of their weight loss this may be due to that immature fruits. The same trend was observed for all parameters in the second season. These findings are in accordance with those obtained by Baez *et al*., (1997) who noted that Sapodilla fruits were harvested manually in Culiacan, Mexico, in June. The fruits reached maturity 13.2°Brix, 0.24% titratable acidity and a firmness of 64.6 N. Also, Bastawros *et al.,* 2003 found that harvest of Casimiroa (white sapote) started from the end of May and extended to the end of July. Concerning peel color it ranged from dark green to greenish yellow and the pulp color is creamy. The fruits had 14.67°Brix, 0.218% titratable acidity.

2- Cold storage studies:

2.1. Weight loss: The loss in weight increased almost linearly with advancing storage time. It is clear from table (2), that there was a highly significant linear relationship between storage temperature and increase in weight loss, the highest percentage of weight loss was recorded at room temperature followed by 10°C. However, the lowest percentage was recorded at 0°C followed by 5°C in both seasons. Fruits held at room temperature (35°C) for 5 days had weight loss nearly equal the weight loss of fruits held at (0°C and 5°C) for 35 days and at 10°C for 15 days.

Table (1): Maturity indices and effect of fruit age of white sapota (Casimiroa) on fruit quality after marketing at room temperature (30-35°C) in 2007&2008 seasons.

Seasons	Days from full bloom	Fruit weight	Shape index	Peel color (a/b)	pulp color (a/b)	Fruit Firmness lb/inch2	Tss%	Acidity %	Marketing period (days	Weight loss%	Shrinkage degree	Appearance
2007	103	112	0.89	-0.73	-0.33	28	12.6	0.469	6	6.90	2	Unriped
	110	126	0.91	-0.66	-0.27	28	12.9	0.402	5	6.09	1	Riped
	117	131	0.94	-0.58	-0.25	28	13.3	0.335	5	5.86	N	Riped
2008	107	120	0.90	-0.71	-0.34	28	12.8	0.502	6	6.95	2	Unriped
	114	125	0.91	-0.64	-0.32	28	13.3	0.442	5	5.80	1	Riped
	121	130	0.93	-0.60	-0.30	28	13.8	0.385	5	5.45	N	Riped

Shrinkage degree **2: Moderate**
L: Light **N: Non**

This could be due low temperature, which delay ripening process through reducing respiration rate and other undesirable metabolic changes. These findings are in accordance with those obtained by Perez *et al*., (1999) who noted that there was a close significant correlation between storage temperature and increase in their weight loss during storage.

2.2. Flesh firmness:

As the length of storage period increased and as storage temperature raised, the firmness levels of fruits decreased. Data in Table (2) Disclosed that room condition resulted in fruit ripening during five days. Results obtained here nearly agreed with those obtained by Perez *et al.* (1999) who stated that flesh firmness was higher in fruits at 2.5 or 10° than at 20°C and Baez *et al.* (1997) who noted that firmness dropped from 64.6 N. to 1.9 N; after 6 days at 20°C.

2.3. Peel and pulp color:

Data of peel color as measured by a/b ratio indicated a gradual increase with advancing the storage period, Table (2). Generally, low temperature (0° C and 5° C) delayed the development of peel color during storage in comparison with high storage temperatures (10°C and 35° C) in both seasons. Also, a/b ratio of pulp decreased as temperature increased, pulp color increased during storage period and a/b ratio was highest at 35°C ,10°C in comparison with low temperatures 0 °C and 5°C . Data revealed changes from white cream to light yellow. These results are in agreement with those of (Baez, *et al.,* 1997). Who suggested that Pulp colour ranged from white-cream at harvest to light orange after 6 days at 20°C.

2.4. Total soluble solids %:

It was observed that total soluble solids contents increased gradually till the end of storage period in both seasons. Regarding the effect of temperature,

it was detected that the T.S.S. % was significantly higher in fruits stored at room temperature followed by 10°C compared with those stored at 0°C & 5°C. These results are further in line with. Baez *et al.* (1997).

Who noted that soluble solids content increased from 13.2 at maturity to 25.8°Brix. after 6 days at 20°C.

Table (2): Physical changes determined in Casimiroa (white sapota) fruits as affected by storage temperatures (2007&2008)

Storage Period (days)	Storage Temp.	Weight loss%		Peel Color a/b ratio		Pulp Color a/b ratio		Fruit Firmness lb/inch2	
		1st	2nd	1st	2st	1st	2nd	1st	2nd
Five days	Initial	0.00	0.00	-0.60	-0.60	-027	-030	Over	Over
	0°C	1.10d	1.13c	-0.62c	-0.59c	-027b	-028b	26a	26a
	5°C	1.28c	1.20c	-0.58b	-0.55b	-025b	-026b	24b	24b
	10°C	1.40b	1.67b	-0.50b	-0.50b	-022b	-022b	18c	18c
	Room temp.	5.18a	5.85a	-0.38a	-0.36a	-0.13a	-.0.11a	6d	5d
	LSD	S	S	S	S	S	S	S	S
Ten days	0°C	1.74b	1.66b	-0.61b	-0.55	-0.25	-0.26	25a	24a
	5°C	1.72b	1.65b	0.55a	0.55	-0.25	0.25	22b	22b
	10°C	2.69a	2.63a	-0.48	-0.48	-0.19	-0.22	15c	14c
	LSD	S	S	S	Ns	Ns	Ns	S	S
Fifteen days	0°C	2.56c	2.48c	-0.48b	-0.48	-0.25b	-0.25	24a	24a
	5°C	2.77b	2.70b	0.45b	0.43	0.23a	0.25	20b	19b
	10°C	3.50a	3.88a	-0.34a	-0.40	-0.15a	-0.18	8c	10c
	LSD	S	S	S	Ns	S	Ns	S	S
Twenty days	0°C	3.58b	3.88b	-0.46	-0.48	-0.25	-0.25	23a	24a
	5°C	4.16a	4.03a	0.42	0.40	0.22	0.22	15b	15b
	LSD	S	S	Ns	Ns	Ns	Ns	S	S
Twenty five days	0°C	3.82b	3.99b	-0.46b	-0.47	-0.23	-0.24	22a	22a
	5°C	4.33a	4.78a	0.36a	0.38	0.18	0.18	10b	10b
	LSD	S	S	S	Ns	Ns	Ns	S	S
Thirty days	0°C	5.32b	5.20b	-0.45b	-0.45b	-0.22b	-.0.21b	20a	21a
	5°C	5.88a	6.00a	-0.23a	-0.27a	-0.09a	-.0.11a	6b	6b
	LSD	S	S	S	S	S	S	S	S

Values followed by the same letters within the column are not significantly different at <0.05

2.5. Total Titratable acidity%:

Data presented in Table (3) indicated that total titratable acidity significantly decreased towards the end of storage period. Data also showed a great variability among temperatures' effects on the decrease of total acidity. Fruits stored at high temperatures had high decreases of total acidity. Decrease of total acidity might, be due to the degradation of malic acid which could be attributed to increased activity of malic acid glyoxylase during ripening. These findings are not accordance with those obtained by Baez *et al.* (1997) who noted that titratable acidity didn't show any significant changes during marketing after 6 days at 20°C.

2.6. Storage life:

The main considered period of storage for Casimiroa (white sapote) was five days at room temperature in both season and fifteen days at 10° C. However, at 5°C, ripening may be occurred after twenty five days. All the fruits stored at 0°C for 30 days could be ripened after they were transferred to an environment at 35° C. These findings are in accordance with those obtained by Yonemoto *et al.,* (2002) who noted that all the fruits stored at 1°C. for 10, 20, 46 and 63 days could ripen after transferring them to an environment at 25°C. It is suggested that the storage period could be extended to 46 days by storage at 1°C.

Table (3): Chemical changes determined in Casimiroa (white sapota) fruits as affected by storage temperatures (2007&2008)

Storage Period (days)	Storage Temp.	TSS%		Acidity%		TSS/Acid ratio	
		1st	2nd	1st	2st	1st	2nd
Five days	Initial	13.3	13.8	0.335	0.385	39.7	35.84
	0°C	13.5c	13.8c	0.335a	0.385a	39.7c	35.84c
	5°C	13.5c	13.8c	0.335a	0.385a	39.7c	35.84c
	10°C	14.2b	15.4b	0.268b	0.335b	52.98b	45.97b
	Room temp.	16.6a	16.7a	o.201c	0.268c	82.59a	62.31a
	LSD	S	S	S	S	S	S
Ten days	0°C	13.5b	13.9b	0.335a	0.385a	40.29b	36.10b
	5°C	13.5b	13.8b	0.335a	0.385a	40.29b	35.84b
	10°C	14.5a	15.5a	0.201b	0.268b	72.14a	57.84a
	LSD	S	S	S	S	S	S
Fifteen days	0°C	13.6b	14.0b	0.335a	0.385a	40.60b	36.36b
	5°C	13.9b	13.9b	0.335a	0.385a	41.49b	36.10b
	10°C	16.6a	17.3a	0.201b	0.201b	82.58a	86.07a
	LSD	S	S	S	S	S	S
Twenty days	0°C	13.8b	14.0a	0.335a	0.385a	41.19b	36.36b
	5°C	14.7a	14.6a	0.268b	0.268b	54.85a	54.48a
	LSD	S	NS	S	S	S	S
Twenty five days	0°C	13.8b	14,0b	0.335a	0.385a	41.19b	36.36b
	5°C	16.6a	16.7a	0.201b	0.201b	82.59a	83.08a
	LSD	S	S	S	S	S	S
Thirty days	0°C	13.8b	13.8b	0.335a	0.385a	41.19b	35.84b
	5°C	16.8a	17.0a	0.201b	0.201b	83.58a	84.58a
	LSD	S	S	S	S	S	S

Values followed by the same letters within the column are not significantly different at <0.05

3. Volatile compounds in headspace of fruits (at maturity) and stored samples of white Sapote (*Casimiroa edulis*) at different temperatures.

The samples exhibited the best quality characteristics during storage at different temperatures (5 days at room temperatures ,15 days at 10 °C. and 30 days at 0°C. were selected and their headspace volatiles were investigated in comparison with the mature sample .

In order to explain the changes in volatiles aroma in the headspace of each sample was subjected fruits at maturity and stored samples to the high resolution gas chromatographic (HRGC) and GC-MS analysis.

Twenty three volatile compounds were identified and listed with their area percentages in Table (4). All these compounds were identified by kovats index values and MS spectra (Adams 2001). They included; 8 esters, 7 alcohols / 3 aldehydes / 4 terpenes and 1 ketone.

The typical gas chromatograms of the volatiles of fruits at maturity and stored samples of Casimiroa fruit at different conditions are shown in Fig. (1-2). the total area percentages of the main chemical classes of the volatile components in the headspace of fruits at maturity and stored Casimiroa fruit at different conditions are shown in Fig. (3).

Although many studies had been investigated concerning postharvest behavior (Nerd *et al.,* 1994), fruit ripening as affected by storage, temperature (Yonemoto *et al.,* 2002), there was very little work have been done on flavour of Casimiroa (Everett, 1947, Mizrahi *et al.,* 1991), there were no available literature contains accurate information about the volatile components of Casimiroa till investigated and published by Abd El Mageed (2007).

It is well documented that esters are important for the sensory impression because of their type of smell and their low odor thresholds (Kakiuchi *et al.,* 1986; Brockhoff *et al.,* 1993). Esters were the predominant class of constituents in headspace volatiles of casimiroa in all samples under investigation , at maturity, and in other three stored samples which considered as three stages of ripening, their total yield were 56.44%, 65.55%, 66.40%, and 50.93%, respectively Fig. (3). The major esters were ethyl butyrate (31.80% 24.40%, 43.41% and 13.05% respectively), ethyl acetate (6.64%, 15.27%, 12.52% and 18.51% respectively) and hexyl acetate (11.22%, 17.25%, 7.77% and 10.04% respectively) Table (4). These results are in agreement with Abd El Mageed (2007) and confirm those previously reported by Abd El Mageed and Ragheb (2005) who reported that esters were the predominant class values, in fresh orange and cantaloupe juices and increased in concentration as storage time increased reaching 55-89% and 50.31%, respectively in pasteurized blend juice stored for 3 months at 25ºC and for 6 months at 4ºC. The same trend was appeared in pasteurized blend juice of apple and kiwi fruits ((Abd El-Mageed and Ragheb2006). The authors attributed the increase or decrease in total esters contents of stored samples to the change in ethyl butyrate percentage. Ethyl butyrate was dominated headspace extract in fresh as well as all stored coated orange sample with concentration ranged between 11.49% to 66.92% including control one (Abd El-Moneim and Abd El Mageed 2006). It was the only ester judged to contribute to Kiwi fruit falvour (Matich *et al.,* 2003).

General decrease in ethyl butyrate as well as in total esters was observed with decreasing quality of the fruit quality (Nisperos – Carrido and Shaw 1990; Abd El Mageed and Ragheb 2005, 2006). Increasing in the esters contents during ripening give the fruits a more fruity aroma (Takeoka *et al*., 1988; Abd El Mageed 2007).

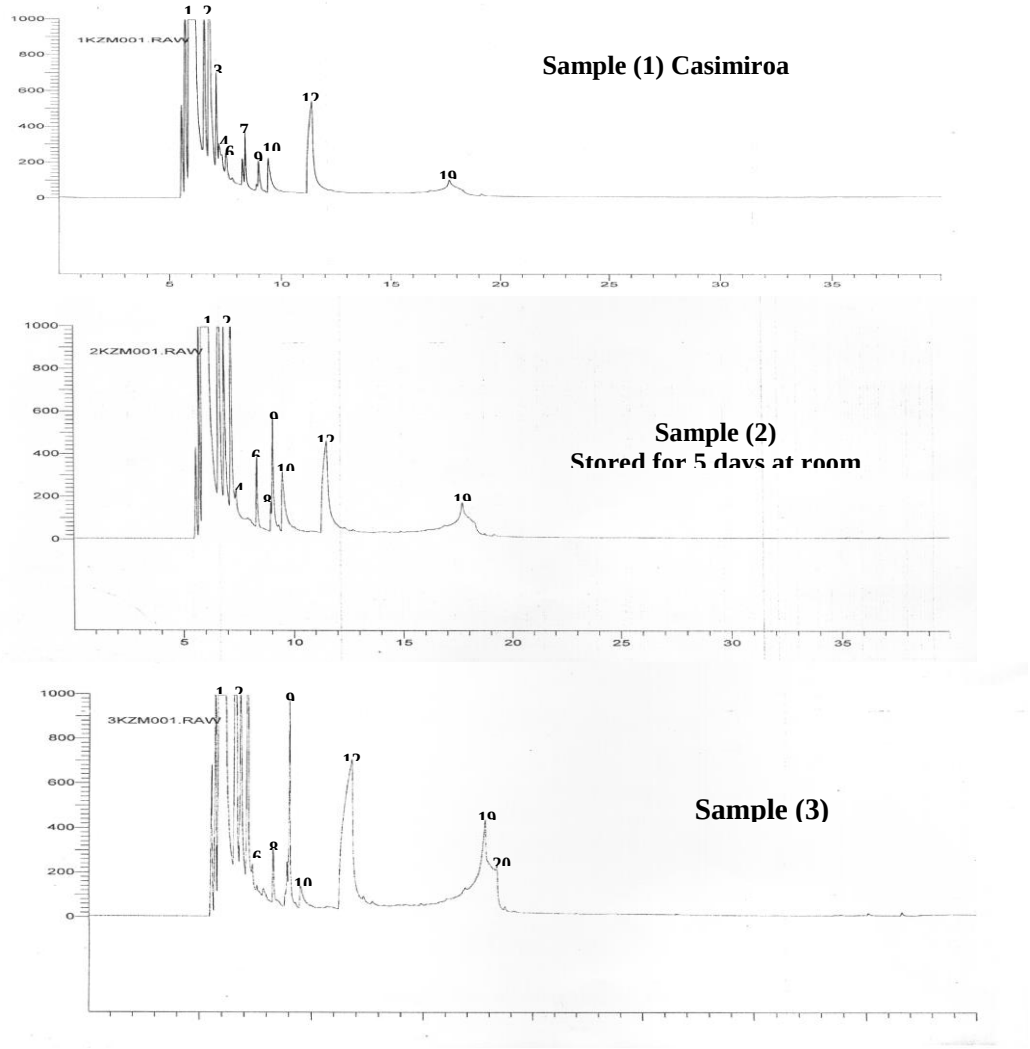

Fig (1): Gas chromatogram of volatiles in headspace of fruits (at maturity) sample, stored sample (2) 5 days at room temperature and sample (3) stored for 15 days at 10ºC.

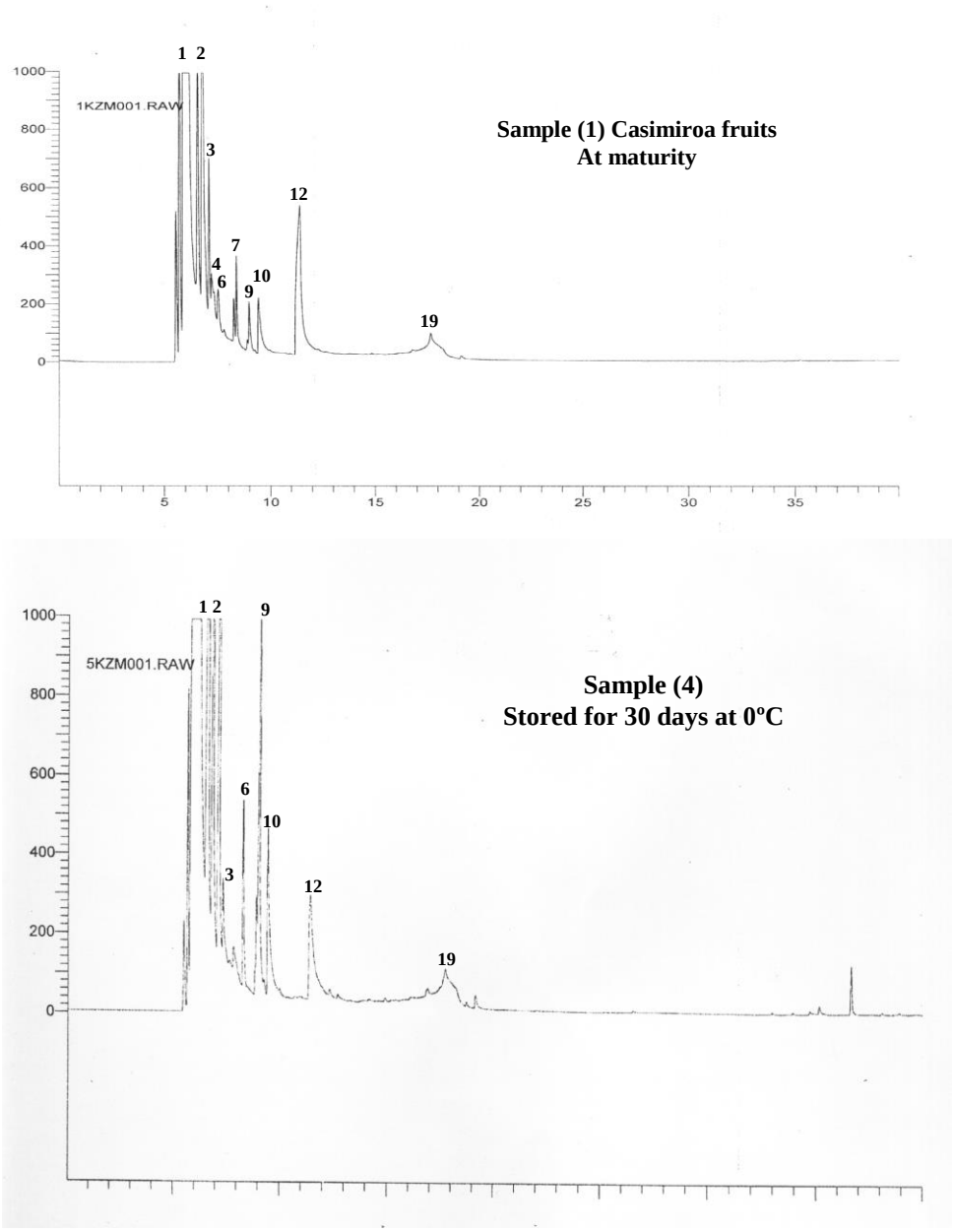

Fig (2): Gas chromatogram of volatiles in headspace of fruits (at maturity) sample, stored sample (4) stored for 30 days at 0ºC.

Alcohols were the second major compounds identified in headspace volatiles of casimiroa. Their total yield at maturity sample and in sample stored for 30 days at 0ºC were (35.18% and 34.73%). The same behavior was found in sample (2) and (3) (Fig 3)which stored for 5 days at room temperature and 15 days at 10ºC (22.98% and 22.95% respectively). The major alcohols were ethanol (26.05%, 12.99%, 10-62% and 15.31%) and 3-methylbutanol (3.21%, 6.53%, 8.33% and 13.75%) respectively in mature fruit and other three stored samples Table 4.

Table (4): Volatile compounds identified in headspace of fresh (at maturity) and storage samples of white sapote (*Casimiroa edulis*) at different temperatures (*values expressed as relative area percentages to total identified compounds)

Peak No	KI[a]	Components	Stored samples Period of storage (days) Fresh – zero time sample (1) (mature)	(2) 5 days at room temp.	(3) 15 days at 10ºC	(4) 30 days at 0ºC	Methods of identification[b]
1	614	Ethanol	*26.05	12.99	10.62	15.31	MS, KI, St
2	646	Ethyl acetate	6.64	15.27	12.52	18.51	MS, KI, St
3	658	2-Methyl propanol	1.31	1.69	0.93	2.92	MS, KI
4	660	Methyl propanoate	2.42	0.25	0.21	0.19	MS, KI
5	695	1-Butanol	0.29	0.44	0.62	0.72	MS, KI
6	699	Propylacetate	2.33	3.90	1.96	5.90	MS, KI, St
7	730	1-Penten -3-ol	3.00	0.41	0.26	1.01	MS, KI
8	740	3-Penten-2-one	0.57	1.26	2.11	3.40	MS, KI
9	753	3-Methylbutanol	3.21	6.53	8.33	13.75	MS, KI
10	798	Hexanal	6.61	8.41	2.40	9.37	MS, KI, St
11	833	2-furfural	0.04	0.07	0.09	0.10	MS, KI
12	847	Ethyl butyrate	31.80	24.40	43.41	13.05	MS, KI
13	862	1-Hexanol	1.23	0.65	2.03	0.71	MS, KI
14	981	B-Pinene	0.16	0.55	0.56	0.46	MS, KI, St
15	993	Myrecene	0.08	0.20	0.10	0.08	MS, KI, St
16	998	Butyl butanoate	0.10	0.45	0.11	0.16	MS, KI
17	1002	α-Phellandrene	0.18	0.15	0.13	0.10	MS, KI, St
18	1011	Ethyl hexanoate	1.89	3.84	0.25	1.38	MS, KI
19	1017	Hexyl acetate	11.22	17.25	7.77	10.04	MS, KI
20	1031	D-Limonene	0.45	0.65	3.22	0.19	MS, KI, St
21	1045	(E)-2-Octenal	0.30	0.19	2.05	0.69	MS, KI
22	1073	Octanol	0.09	0.27	0.16	0.31	MS, KI
23	1085	Ethyl octanoate	0.04	0.19	0.17	1.65	MS, KI

Compounds listed according to their elution on DB5 column.

[a] Kovats index

[b] compound identified by GC-MS (MS) and / or by kovats index on DB5 (KI) and / or by comparison of MS and KI of standard compound (St) run under similar GC-MS conditions.

From the previous results we can concluded that esters and alcohols are responsible for the flavor of casimiroa fruit since recorded a high concentration (91.62%, 88.53%, 89.18% and 85.66%) respectively, in sample at maturity and other three stored samples. These results are in agreement with Abd El Mageed (2007) also indicated the good odour quality of the stored fruits compared with the mature sample. Hexanal, 2-furfural and (E)-2-octenal are the three aldehydes identified in headspace volatiles of mature

and other three stored samples (Table 4) The total aldehydes content comprised 6.95 %, 8.67%, 4.54% and 10.16% of the total volatiles in four samples under investigation Fig. (3). The increase or decrease in total aldehydes content was attributed to hexanal content which is the major aldehyde in all samples (Table 4) ,hexanal has tallowy / leaf – like, apple like / leafy / green / fatty / unripe – fruit (concentration dependent) notes respectively *(*Rychlik*, et al., 1998*). This compound is a product of lipoxygenase breakdown of long-chain fatty acids such as lenolenic acid (Matheis, 1995).

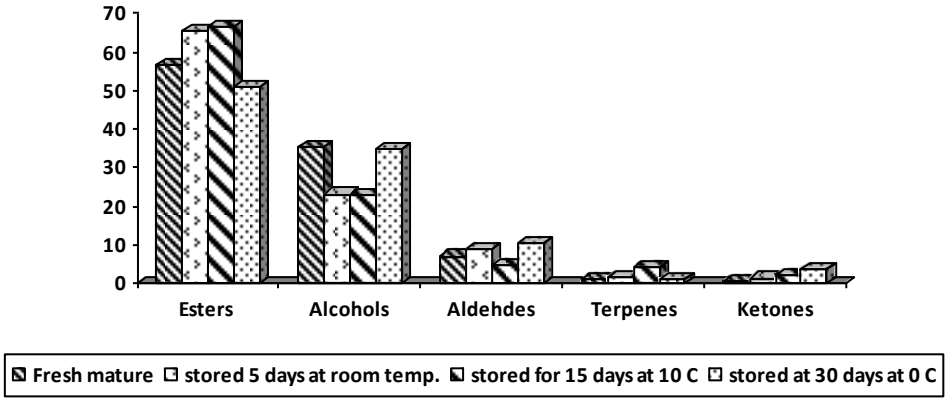

Fig. 3. The total area percentages of the main chemical classes of volatile components in the headspace of mature and stored samples of Casimiroa at different temperatures.

Conclusion

From the above mentioned results it can be concluded that the presence of ethylbutyrate and ethanol as predominant volatile compounds may be responsible for consumer acceptability of casimirioa fruit flavor attribute. In general Storage of casimirioa fruit at three selected conditions lead to good ripening fruits especially for sample 3 that stored for 15 days at 10ºC which possessed high content of ethyl butyrate that responsible for sweet and fruity aroma and considered as quality index of the fruits.

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تأثير ظروف التخزين على بعض صفات الجودة ومكونات النكهة لثمار الكازمرو (السابوتا البيضاء)

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أجرى هذا البحث خلال موسمى النمو ٢٠٠٧-٢٠٠٨ على ثمار الكازمرو (السابوتا البيضاء) أحضرت الثمار من مزرعة محطة بحوث البساتين بالقناطر لتحديد مرحلة اكتمال النمو وكذلك تقييم جودة الثمار تحت مختلف ظروف التخزين، ولقد أوضحت النتائج أن الثمار وصلت إلى مرحلة اكتمال النمو بعد (١١٧-١٢١) يوم من اكتمال التزهير خلال موسمى النمو على التوالى حيث تتحول قشرة الثمار من اللون الأخضر الداكن إلى الأخضر الفاتح ويصبح لون اللب أبيض كريمى وتكون نسبة المواد الصلبة الذائبة الكلية ١٣,٣ - ١٣,٨% خلال موسمى الدراسة توجد علاقة واضحة بين درجات حرارة التخزين وعملية النضج. حيث أن الثمار المخزنة على درجة حرارة الغرفة ٣٥°م ورطوبة نسبة ٦٥% قد نضجت بعد ٥ أيام بينما الثمار المخزنة على درجة ١٠°م، و٥°م ورطوبة نسبة ٩٠% نضجت بعد ١٥، ٢٥ يوم على التوالى. لم تنضج الثمار المخزنة على درجة صفر حتى ٣٠ يوم من التخزين المبرد ويمكنها الانضاج عند نقلها إلى درجة حرارة الغرفة ٣٥°م. وقد تم تجميع المركبات الطيارة للعينة المكتملة النمو والعينات المخزنة على درجات حرارة مختلفة ثم تحليلها على جهاز التحليل الغازى الكروماتوجرافى - طيف الكتلة. ولقد تم تعريف ٢٣ مركب لنكهة ثمار الكازمرو وقد اشتملت على ٨ مركبات استرات و٧ مركبات كحولية وثلاثة الدهيدات وأربعة مركبات تربينية ومركب كيتونى. ووجد أن الاسترات والكحولات تكون أكثر من ٨٥% من المحتوى الكلى للمركبات الطياة فى ثمار الكازمرو فى العينة المكتملة النمو والعينات المخزنة. وكانت الاسترات السائدة بالنسبة لتركيزها هى الايثيل بيوتيرات، والايثيل استيات، والهكسيل استيات، بينما كانت الكحولات السائدة هى الايثانول و٣ مثيل بيوتانول. وقد وجد أنه لا توجد فروق واضحة فى محتوى المركبات الطياة فى العينات المخزنة بالنسبة للعينة المكتملة النمو أى أن العينات المخزنة كانت على درجة عالية من الجودة حتى نهاية فترة التخزين. وخاصة العينة رقم ٣ المخزنة على درجة ١٠°م لمدة ١٥ يوم وذلك لاحتوائها على أعلى نسبة من الايثيل بيوتيرات المسئولة عن رائحة الفاكهة المستحبة والتى تحدد جودة الثمار.

عموماً التخزين على درجات حرارة مختلفة ٥&١٠ و٣٥°م أدى إلى نضج الثمار وذلك لارتفاع نسبة الايثيل بيوتيرات والايثانول فى الثمار المخزنة نيتجة النضج حيث انهما المسئولين عن قابلية المستهلك لاستساغة ثمار الكازمرو.