American Journal of Food Science and Technology, 2022, Vol. 10, No. 1, 42-48
Available online at http://pubs.sciepub.com/ajfst/10/1/6
Published by Science and Education Publishing
DOI:10.12691/ajfst-10-1-6

Changes in Sensory Attributes of Avocado Fruits and Quality of Their Oils during Storage at Ambient Temperature

Nahed M M Atta, Mohamed F AL-Okaby*, Christina S F Shenouda

Oils & Fats Research Department, Food Technology Research Institute, Agriculture Research Center, Giza, Egypt
*Corresponding author: mfawzynrc@gmail.com

Received February 10, 2022; Revised March 13, 2022; Accepted March 20, 2022

Abstract Fuerte, Ettinger and Bacon avocados varieties were stored at ambient temperature (24-28°C) for seven days to determine the changes in physio – chemical properties, fatty acid composition, atherogenic index (AI), COX and PI factors oxidative as predicting oxidative stability, total poly phenols, total tocopherols, chlorophyll and carotenoid contents of extracted oil from their pulps and also to evaluation of sensory attributes for them and compared with those of fresh avocado fruits at harvest time (as a control samples). The obtained results indicated that; values of FFA, PV, K230 and K270 nm and IV were increased, but values of color and % UNS decreased in extracted oils from the pulp of stored avocado fruits at ambient temperature compared with those in oil from fresh ones. There was no remarkable difference between oils from fresh and stored avocados in fatty acid composition, AI, COX and PI factors. Total polyphenols, total tocopherols, chlorophyll and carotenoid contents recorded a higher decrease in oil from avocados stored at atmospheric temperature compared with that of oils from fresh avocados. Stored avocado fruits had higher values from hardness in mouth, creamy, nutty and eating quality attributes compared with fresh avocados and vice versa for the grassy attribute.

Keywords: *avocados, storage, physicochemical properties, antioxidant, fatty acid composition, sensory attributes*

Cite This Article: Nahed M M Atta, Mohamed F AL-Okaby, and Christina S F Shenouda, "Changes in Sensory Attributes of Avocado Fruits and Quality of Their Oils during Storage at Ambient Temperature." *American Journal of Food Science and Technology*, vol. 10, no. 1 (2022): 42-48. doi: 10.12691/ajfst-10-1-6.

1. Introduction

Avocado (*Persea americana* Mill.) belongs to the laurel family and is one in every of the few commercially vital members of the Persea. The fruit is termed 'Ahuacatl' by the Aztecs and from there derived the term 'avocado' 'aguacate' (in Spanish), 'avocat' (in French) and 'abacate' (in Portuguese) [1]. Avocados ripen only after harvest unlike other climacteric fruits and ripens takes place in ambient conditions for 5 to 6 days after harvesting and most customers don't have the patience to wait out this process and may be turned off from buying the fruit [2]. Avocado (*Persea americana* Mill.) production area units around the world are typical remote from their overseas markets. Therefore there's usually a major delay between gathering and therefore the arrival of the fruit to the purpose of consumption, throughout times of over production. Thus, there's a necessity to develop associate degree acceptable storage technology to delay ripening and supply quality turn out native and export markets [3]. Analyses of avocado fruits oil indicate that the linolenic acid content of the 'Hass' avocado oil averages just over 21%, but the content of the monounsaturated fatty acid was higher [4]. Avocados are a good source of lipid content (10% - 30%) of its fresh pulp weight depending on the variety and seasonality in most commercial avocado cultivars, such as Hass and Fuerte vars. the avocados not only is an excellent source of monounsaturated oleic acid, but contains important lipid-soluble antioxidants and phytochemicals with high levels such as carotenoids, chlorophylls, polyphenols, tocopherols, and phytosterols [5]. Fresh avocado oil (~11%–19%) is comprised of monounsaturated fatty acids (MUFA ~71%), saturated fatty acids (SFA ~16%) and poly unsaturated fatty acids (PUFA~13%) [6]. An important characteristic of this fruit is the high content of unsaponifiable matters it was found to be from 1.0 to 22.1% in different avocado fruits oil when compared with that of common edible oils [7]. Avocado oils are very close to olive oil. Avocado is nutritionally rich in many health attributes compounds and a valuable energy source to their high quality fat content. Avocado oil contains fatty acids almost like virgin olive oil [8]. Developing postharvest management techniques victimization environmentally friendly and non-chemical approaches is essential to extending the period of avocados in a safer and health acutely aware manner. Most of the literature on postharvest decay and disorders moving avocado fruit quality and its physical attributes green skin and black or purple skin avocados include commercial fruit weight and

size, shape (oval or pyriform), degree of uniform skin coloration, skin texture (smooth or rough), absence of defects (e.g., sunburn) and internal fruit attributes flavor, seed size, flesh texture and pulp color. Throughout storage and selling is devoted to the Hass avocado [9].

Sensory attributes play an important role in consumer satisfaction [10] with avocado, as with many other fruits, parameters related to appearance and texture (based on touch in hand) are important in consumer acceptance and purchase decision and eating quality determined consumer satisfaction and repeat purchases [11]. Fruit flavor (taste plus aroma) and texture are the main components of eating quality [12]. Fresh avocado fruits (Fuerte, Ettinger, Bacon, Hass and Pinkerton vars.) didn't show any significant differences in all sensory attributes (external and internal fruit attributes) parameters except for fruit size, shapes and flesh defect attributes [13]. This study demonstrates the changes in sensory attributes of stored avocados at ambient temperature 24-28°C and in physico-chemical properties, fatty acid composition, some bioactive compounds as natural antioxidants, AI, COX and PI factors of their oils.

2. Materials and Methods

2.1. Materials

Avocado (*Persea americana* CVs) fruits varieties; Fuerte, Ettinger, Bacon vars were obtained from a horticulture research station in Al-Qanater Charitable, Horticultural Research Institute, Agricultural Research Center, Giza, Egypt.

2.2. Chemicals

All chemicals (hexane, cyclohexane, chloroform, acetic acid, ethanol, methanol, toluene, potassium hydroxide and sodium sulphate anhydrous used in this study analytical grades were obtained from Sigma Aldrich, Darmstadt, Germany.

Reagents and standards: Folin–Ciocalteu reagent and 2,2-diphenyl-1-picrylhydrazyl were obtained from Gerbsaure Chemical Co. Ltd. Germany, caffeic acid and tocopherol standards were purchased from Sigma Chemical Co. (St. Louis, Mo).

3. Methods

3.1. Avocados Storage at Ambient Temperature

The selected avocados for each variety was washed, dried and divided into two groups as follows:

The first group was control samples (fresh fruits at harvest time).The second group was stored at room temperature (24-28°C) for seven days.

All fresh and stored avocados were removed manually pell and seeds from fruits. Avocado fruits pulp for each variety was prepared for analysis and extracted their oils.

3.2. Moisture and Fat Contents of Avocado Fruits Pulp (AFP)

The moisture and fat contents of avocado fruits pulp during storage were determined as described by AOAC [14].

3.3. Oil Extraction from Avocado Fruits Pulp

All samples of avocado fruits pulp were cut into very small pieces and were dried at 40°C overnight in the oven [15]. The dried samples were ground using grinder model (MFIO micro-fine grinder), then soaked in pure n-hexane for 48 h, this process was repeated three times using fresh solvent each time. The miscella for each variety was collected and filtered. The solvent was evaporator at 40°C, the moisture in oil was removed by over anhydrous sodium sulfate, filtered (Whatman NO.1) and stored in brown bottles and then kept at 5°C until analysis [16].

3.4. Physical and Chemical Properties of Avocado Fruits Pulp Oil (AFPO)

The refractive index of AFPO was measured according to AOAC [14] using Abbe refractometer at 25°C.

The color measurement: The method described by Lee et al [17] was applied for measuring color of AFPO. The absorbance of 5% (w/v) solutions of oil in chloroform was measured at 420 nm using a “Spectronic 20” Spectrophotometer (Bauch& Lamb).

Acidity, peroxide value and % unsaponifiable matters of AFPO were determined according to the methods of [14].

UV absorbance at 230 and 270 nm. Diene and Triene (K230 and K 270 nm.) of oil were determined according to the [18] of the olive oil.

Fatty acids composition: The fatty acid methyl ester of oils was prepared using trans-esterification with a cold methanolic solution of potassium hydroxide. The fatty acid methyl esters of AFPO were identified by GC- capillary column according to the method of [19].

Iodine and saponification values of AFPO were calculated from fatty acids percentage by equation according to [20].

3.5. Natural Antioxidants of AFPO

The total polyphenols (ppm) of AFPO of all samples was determined according to the method of [21].

Total tocopherols as α-Tocopherols (ppm) of AFPO of all samples was determined according to the method described by [22].

Chlorophyll and carotenoid contents (ppm) of AFPO were estimated according to [23] method.

3.6. Determination AI, COX and PI Factors of AFPO

Atherogenicity index (AI), calculation of oxidative stability (COX) and peroxidability index (PI) were calculated from fatty acid composition as described according to [24,25,26], respectively. The COX and PI

factors are indicators as predictors of oxidative stability of AFPO during fruits storage at ambient temperature (24-28°C) for 7 days.

$$AI = \left[C12 + 4(C14) + C16\right] : (sum\ of\ \ unsaturated\ FA)$$

$$\text{COX} = \frac{1*X1 + 10.3*X2 + 21.6*X3}{100}$$

Whereas:
x1, x2, and x3 are the percentages of C18:1, C18:2, and C18:3 acids in total fatty acids of an oil sample, respectively.
PI=(% monoenoic FA×0.025)+(% dienoic FA×1)+(% trienoic FA×2)+(% tetraenoic FA×4)+(% pentaenoic FA×6)+(% hexaenoic FA×8).

3.7. Sensory Attributes

The sensory attributes for all avocados samples; fruits size, color, shape, firmness in finger and skin defect (external fruit attributes) and flesh defects, hardness in mouth, creamy, grassy, nutty flavor and eating quality (internal fruit attributes) were evaluated. Whereas a five point hedonic scales was used for each attribute where (1) is the worst value and (5) is the best value as shown in Table 1 as described by [10].

Table 1. Organoleptic attributes scored by sensory evaluation panel in 'Hass' avocado

Quality attributes	Scale 1-5	
	Value = 1	value = 5
External attributes:		
Size	Small	Large
Skin color	Green	Black
Shape	Not pyriform	Pyriform
Skin defect	Very much	Non
Firmness(in finger)	Hard	Soft
Global performance	Bad	Excellent
Internal attributes:		
Flesh defects	Very much	None
Texture:		
Hardness (in mouth)	Hard	Soft
Creamy	None	Very much
Flavor:		
Grassy	Very much	None
Nutty	None	Very much
Eating quality	Bad	Excellent
Global performance	Bad	Excellent

[10] (Canet et al., 2015).

3.8. Statistical Analysis

A) The obtained data were statistically analyzed by the least significant (L.S.D) at the 5% level of probability procedure according to [27] using a version of costat 6.451. B) The data of sensory evaluation were analyzed by the analysis of variances and differences between the mean or median values using the General Linear Model (GLM) procedure within a package program of statistical analysis system (Copyright 1987). Specific differences between samples were determined by the LSD test for each attribute. The results were tested of the degree of the significant level at $p \leq 0.05$.

4. Results and Discussion

4.1. Changes in Moisture and Oil Contents of Avocado Fruits Pulp during Fruits Storage

The results in Table 2 showed the moisture and oil contents in the pulp of fresh and stored avocado fruits at ambient temperature (24-28°C) for seven days for Fuerte, Ettinger and Bacon varieties.

The results indicated that stored avocados fruit at 24-28°C contained higher amounts of oil content (16.37, 11.12 and 11.37%) than fresh fruits (11.68, 10.43 and 10.14%) for Fuerte, Ettinger and Bacon vars. respectively. On the contrary moisture content decreased from 76.75, 79.74 and 80.74% in fresh fruits to 71.10, 77.92 and 75.67 % in stored fruits for the same previous varieties, respectively.

The decrease in moisture content of stored avocados related to respiration of fruits during storage, that decreased in moisture content, but an increase in oil content of avocados by storage may be related to accumulated of oil drops when fruits ripening during storage period, this caused an increment in oil content.

4.2. Changes in the Physical and Chemical Characteristics of Avocados Pulp Oil during Fruits Storage

Changes in the physical and chemical properties (Color , RI, FFA, PV, K_{232} and 270 nm., IV, SV and % UNS) of avocados pulp oil during fruits (Fuerte, Ettinger and Bacon vars.) storage at ambient temperature (24-28°C) for 7 days are presented in Table 3. Results revealed that FFA, PV and UNS% values in oil extracted from fresh fruits were ranged from 0.63 to 1.48 (% as oleic acid), from 1.5 to 5.1 (meq O_2 / kg oil) and from 5.53 to 5.80 %, respectively. These results were very similar to that obtained by Nahed *et al.* [13] and Christina [28]. The results indicated that, there were an increased in values of acidity (FFA), PV, K 230 and 270 nm, and IV, and a decrease in values of color, SV and %UNS in produced oils from the pulp of all avocado fruits stored at ambient temperature compared them with oils from fresh fruits. The increase in FFA in extracted oils from the pulp of avocado fruits stored at ambient temperature may be due to microorganisms in the pulp tissue of avocado fruits that indicated hydrolytic activity by lipase which leads to the release of fatty acids from triacylglycerol molecules of the oil as explained by Clodoveo *et al.* [29] who mentioned that acidity of olive oil increased as a results of olive fruit storage at atmospheric condition caused an increase in the rates of respiration, that increase in activity of lipase enzyme, which caused an increase of acidity.

The increase in peroxide value of oil from all stored avocado fruits, may be indicated that, the rate of oxygen was increased by increasing the respiration rate in fruits tissue during ripening avocados throughout the storage period at room temperature, which caused an increase of peroxidase activity which related to the increase in peroxide values of its oils [30].

Table 2. Changes in oil and moisture contents of avocados pulp during fruits storage at ambient temperature at (24-28°C) for 7 days

Parameters	Avocado fruits vars.					
	Fuerte		**Ettinger**		**Bacon**	
	Fresh	**Stored**	**Fresh**	**Stored**	**Fresh**	**Stored**
Oil content (%)	11.68[b]	16.37[a]	10.43[a]	11.12[a]	10.14[a]	11.73[a]
Moisture content (%)	76.75[b]	71.10[a]	79.74[a]	77.92[a]	80.75[a]	75.67[a]

Means in a raw not sharing the same letter for each variety are significantly different at p≤0.05.
* Results of (zero time) fresh avocado fruits according to Nahed *et al*. [13] and Christina [28].

Table 3. Changes in the physical and chemical characteristics of avocados pulp oil during fruits stored at (24-28°C) for 7 days

Physico - chemical properties of avocado fruits oil (AFPO)	**Avocado fruits vars.**					
	Fuerte		**Ettinger**		**Bacon**	
	Fresh	**stored**	**Fresh**	**stored**	**Fresh**	**stored**
Color at 420 nm.	1.89 [a]	1.69 [a]	1.41 [a]	1.31 [a]	2.01 [a]	1.91 [a]
RI (at 25°C)	1.4678 [a]	1.4672 [a]	1.4682 [a]	1.4683 [a]	1.4686 [a]	1.4685 [a]
FFA (% as oleic acid)	0.63 [a]	1.87 [b]	0.95 [a]	17.03 [b]	1.48 [a]	4.14 [b]
Peroxide value (meq O_2 / kg oil)	3.1 [a]	8.84 [b]	1.5 [a]	13.72 [b]	5.1 [a]	17.85 [b]
Diene at 230 nm.	1.76 [a]	7.43[b]	4.48 [a]	23.58 [b]	6.36[a]	12.96 [b]
Triene at 270 nm.	0.95[a]	1.91[b]	2.38[a]	6.44[b]	3.18[a]	4.01[b]
Iodine value (I_2/ 100 g oil)	90.93 [a]	97.73 [b]	84.87 [a]	90.97 [b]	91.17 [a]	91.33 [a]
Saponification value (mg KOH/g oil)	204.69[a]	204.62 [a]	203.62[a]	203.45 [a]	205.85 [a]	205.60 [a]
UNS(%)	5.6 [a]	3.9 [b]	5.53 [a]	3.45 [b]	5.80 [a]	2.40 [b]

Means in a raw not sharing the same letter for each variety are significantly different at p≤0.05.

The increase in K_{232} and K_{270} nm. (conjugated diene and conjugated triene) in pulp oils from all stored avocado fruits at room temperature may be due to an increase in peroxide values of these oils under investigation.

The increase in IV of pulp oils from all stored avocado fruits at atmospheric condition may be related to an increase in total unsaturated and the decrease in total saturated fatty acids in these oils compared to oil from all fresh avocados as observed in Table 3.

The decrease in values of color of pulp oils from stored avocado fruits at ambient temperature may be due to degradation in pigments contents (chlorophyll and carotenoid contents) under investigation.

The decrease in % UNS of all stored avocados pulp oils may be related to a decrease in total tocopherols of these oils compared to those in oil from fresh avocados as shown in Table 6.

4.3. Changes in the Fatty Acid Composition of Avocado Fruits Pulp Oil during Fruits Storage

The results in Table 4 showed that changes in fatty acids composition of avocado pulp oil from different avocado fruits (Fuerte, Ettinger and Bacon vars.) during storage them at room temperature (24-28°C) for seven days and compared them with oil from fresh fruits at harvest time. From the data in the above mentioned table, from the results there is no remarkable difference between the oils from fresh and stored avocado fruits in the percentages of fatty acid composition of oils from stored fruits recorded a slight increase in palmitic (C16:0), palmitoleic (C16:1) and linoleic (C18:2) acids compared to oils from fresh fruits. On the other hand, oils from stored fruits recorded a slight decreased in stearic (C18:0), oleic (C18:1) and linolenic (C18:3) acids compared with those in oils from fresh fruit for all varieties. Also no clear change in TSFA/ TUFA ratio of avocados oil as a result of stored fruits at ambient temperature compared with that in oil from fresh avocados.

4.4. Changes in the PI, COX, AI Factors of Avocados Pulp Oil during Fruits Storage

The data in Table 5 illustrated that changes in the peroxidability index (PI) , calculation of oxidative stability (COX) and atherogenic index (AI) factors of avocado fruits pulp oil as a result of fruits storage (Fuerte , Ettinger and Bacon) at ambient temperature (24-28°C) for seven days and compared with those in oils from fresh fruits. From the results in previous mentioned Table 5, it could be found that, no change clear in PI, COX and AI factors of oils from stored avocado fruits compared with oils of fresh fruits for all varieties. This may be due to the fatty acid composition of these oils recording slight changes in its percentages which are used for calculating these factors as shown in Table 4.

4.5. Changes in some Bioactive Compounds of Avocados Pulp Oil during Fruits Storage

The data in Table 6 revealed that there were changes in some bioactive compounds as natural antioxidants (polyphenols, tocopherols, carotenoids and chlorophyll contents) of avocado pulp oil from Fuerte, Ettinger and Bacon vars. as a result of fruit storage at ambient temperature (24-28°C) for seven days and compared them with fresh fruits at harvest time.

Table 4. Changes in fatty acid composition of avocados pulp oil during fruits storage at (24-28°C) for 7 days

Fatty acids composition of AFO (%)	Avocado fruits vars.					
	Fuerte		Ettinger		Bacon	
	Fresh*	Stored	Fresh*	Stored	Fresh*	Stored
C 14:0	0.09	0.06	0.06	ND	0.11	ND
C 16:0	20.50	20.60	16.43	16.52	23.93	23.99
C 16:1	7.97	7.98	6.60	7.05	9.21	9.53
C 17:0	0.08	0.06	0.08	0.08	0.16	0.17
C 17:1	0.13	0.99	0.1	0.12	0.08	0.07
C 18:0	1.01	0.60	0.85	0.75	0.81	0.74
C 18:1 (omega 9)	51.36	50.57	54.60	54.09	38.13	38.07
C 18:2 (omega 6)	17.57	18.02	19.70	19.93	24.80	25.17
C18:3 (omega 3)	1.00	0.90	1.34	1.27	2.53	2.09
C 20:0	0.12	0.10	0.09	0.09	0.09	0.10
C 20:1	0.13	0.09	0.12	0.09	0.11	0.09
C 22:0	0.04	0.03	0.03	0.03	0.04	0.04
TSFA	21.84	21.45	17.54	17.45	25.14	25.04
TUSFA	78.16	78.55	82.46	82.55	74.86	75.02
TSFA/TUSFA	0.27	0.27	0.21	0.21	0.33	0.33

ND= Not detected,
* Results of (zero time) fresh avocado fruits according to Nahed *et al*. [13] and Christina [28].

Table 5. Changes in the PI, COX and AI factors of avocados pulp oil during fruits storage at (24-28°C) for 7 days

Factors	Avocado fruits vars.					
	Fuerte		Ettinger		Bacon	
	Fresh*	Stored	Fresh*	Stored	Fresh*	Stored
PI	20.85 [a]	21.08 [a]	23.75 [a]	23.80 [a]	30.81 [a]	30.30 [a]
COX	2.54 [a]	2.55 [a]	2.86 [a]	2.86 [a]	3.48 [a]	3.42 [a]
AI	0.24 [a]	0.26 [a]	0.20 [a]	0.20 [a]	0.33 [a]	0.32 [a]

Means in a raw not sharing the same letter for each variety are significantly different at p≤0.05.
* Results of (zero time) fresh avocado fruits according to Christina [28].

Table 6. Changes in some bioactive compounds of avocados pulp oil during fruits storage at (24-28°C) for 7 days

Natural antioxidant of AFPO (ppm)	Avocado fruits vars.					
	Fuerte		Ettinger		Bacon	
Total polyphenols	Fresh *	stored	Fresh *	Stored	Fresh *	stored
	1276.14 [a]	507.51 [b]	1324.49 [a]	872.46 [b]	1217.95 [a]	765.61 [b]
Tocopherols (as α- tocopherol)	54.35 [a]	10.76 [b]	71.81 [a]	53.25 [b]	54.46 [a]	40.99 [b]
Pigments:						
Cartooned	5.21 [a]	2.12 [b]	1.56 [a]	1.38 [a]	6.70 [a]	5.95 [a]
Chlorophyll	9.29 [a]	1.21 [b]	2.64 [a]	1.96 [b]	34.40 [a]	26.01 [b]

Means in a raw not sharing the same letter for each variety are significantly different at p≤0.05.
* Results of (zero time) fresh avocado fruits according to Nahed *et al*. [13] and Christina [28].

From the tabulated data in Table 6, it could be noted that polyphenols recorded the highest values in oils from fresh and stored avocado fruits compared to the other natural antioxidants. Concerning the results in the same Table 6 polyphenols decreased from 1276.14, 1324.49 and 1217.95 ppm in oils from the pulp of fresh fruits to 507.51, 872.46 and 765.61 ppm in oils from the pulp of stored fruits at atmospheric condition (24-28°C) for seven days for Fuerte, Ettinger and Bacon avocado varieties respectively. This decrease in polyphenols during fruits storage at ambient temperature may be provide an optimum medium from growth of fungi and bacteria which can metabolize a wide variety of aromatic compounds , such as phenols and its derivatives [31] Who mentioned that the total polyphenols of olive oil was decreased by fruit storage at atmospheric condition. Also from the results in this table tocopherol, carotenoid and chlorophyll contents decreased during fruits kept at room temperature, they decreased from (54.35 , 5.21 and 9.23), (71.81, 1.56 and 2.64) and (54.64 , 6.70 and 34.40) ppm. in oils from pulp of fresh fruits to (10.76 , 2.12 and 1.21), (53.25, 1.38 and 1.96) and (40.99, 5.95 and 26.01) ppm in extracted oils from stored avocado fruits at ambient temperature for 7 days for Fuerte, Ettinger and Bacon avocado vars. respectively. This decrease in chlorophyll contents of extracted oils from avocados stored at ambient temperature compared with that of oils from fresh avocados may be due to degradation of chlorophyll and an increase in the synthesis of cyanidin S-O-glocoside and anthocyanin during avocado ripening [32].

4.6. Changes in Sensory Attributes of Avocado Fruits during Fruits Storage

The sensory attributes (external and internal fruit attributes) for fresh and stored avocado fruits at ambient temperature (24-28°C) for 7 days for Fuerte, Ettinger and Bacon varieties are shown in Table 7. The results in this Table revealed that there were differences in scores of external fruit attributes (fruit size, color, shape, firmness in finger and skin defect) and internal fruit attributes (hardness in mouth, creamy, grassy, flesh defect and eating quality) as a result avocado fruits storage at room temperature compared with those in fresh avocado fruits for all the previous varieties. With regarding the results in the same previous Table 7 it could be observed that the value of skin color attribute, was found to be (1) (green color) for all the fresh varieties and increased to (4), (5) and (4) (black color) in Fuerte, Ettinger and Bacon vars. during fruits storage at atmospheric condition respectively, this may be due to degradation in chlorophyll pigments by ripening fruits during fruits storage, and also this may be due to the color change of peel during avocado ripening is determined by chlorophyll degradation and an increase in the synthesis of cyanidin 3-O-glucoside, and anthocyanin [33]. The values of creamy and nutty attributes increased from (1) and (1) in fresh fruits to (5) and (4) in stored fruits at room temperature for all avocados varieties, respectively, The increase in values of a creamy attribute of stored avocados may be related to increasing the oil percentage in stored avocado fruits compared with that in fresh avocados under study. On the other hand grassy attribute was determined to be (5) in fresh fruits and decreased to (1) in all stored fruits for three avocado varieties this may be due to the volatile oil having a grass-like aroma in whole green and ripe avocado fruits (Fuerte var.) reduced with ripening [30]. The results of sensory attributes of fresh avocado fruits were agreed with Nahed *et al*. [13] and Christina [28]. Also from the data in Table 7, stored fruits for all avocado varieties had higher values from eating quality compared with those in fresh fruit.

Table 7. Changes in sensory attributes of avocados pulp during fruits storage at (24-28°C) for 7 days

Quality attributes sample		Avocado fruits vars.					
		Fuerte		Ettinger		Bacon	
		Fresh	Stored	Fresh	Stored	Fresh	Stored
Size:							
Small	**1**	**4** ^{a}	**4** ^{a}	**4** ^{a}	**4** ^{a}	**2** ^{a}	**2** ^{a}
Large	**5**						
Skin color:							
Green	**1**	**1** ^{a}	**4** ^{b}	**1** ^{a}	**5** ^{b}	**1** ^{a}	**4** ^{ba}
Black	**5**						
Shape:							
Not pyriform	**1**	**3** ^{a}	**4** ^{a}	**2** ^{b}	**4** ^{a}	**2** ^{b}	**4** ^{a}
Pyriform	**5**						
Skin defects:							
Very much	**1**	**1** ^{b}	**3** ^{a}	**1** ^{b}	**4** ^{a}	**1** ^{b}	**3** ^{a}
None	**5**						
Firmness(in fingers):							
Hard	**1**	**2** ^{b}	**4** ^{a}	**1** ^{b}	**5** ^{a}	**1** ^{b}	**5** ^{a}
Soft	**5**						
Flesh defects:							
Very much	**5**	**4** ^{a}	**3** ^{a}	**5** ^{a}	**4** ^{a}	**5** ^{a}	**3** ^{b}
None	**1**						
Hardness(in mouth):							
Hard	**1**	**1** ^{b}	**4** ^{a}	**1** ^{b}	**5** ^{a}	**1** ^{b}	**4** ^{a}
Soft	**5**						
Creamy:							
None	**1**	**1** ^{b}	**5** ^{a}	**1** ^{b}	**5** ^{a}	**1** ^{b}	**5** ^{a}
Very much	**5**						
Grassy:							
Very much	**5**	**5** ^{b}	**1** ^{a}	**5** ^{b}	**1** ^{a}	**5** ^{b}	**1** ^{a}
None	**1**						
Nutty:							
None	**1**	**1** ^{b}	**4** ^{a}	**1** ^{b}	**4** ^{a}	**1** ^{b}	**4** ^{a}
Very much	**5**						
Eating quality:							
Bad	**1**	**1** ^{b}	**4** ^{a}	**1** ^{b}	**5** ^{a}	**1** ^{b}	**3** ^{a}
Excellent	**5**						

Means in a raw not sharing the same letter for each variety are significantly different at $p \leq 0.05$.

5. Recommendations

It's a must to future studies on the avocado fruits and methods to store them after the harvest to make them available in the market for as long as possible without the negative effect on the fruit eating quality, and also the nutritional and healthy oil quality whereas the oil represents third of the fruit.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Yahia, E. M., & Woolf, A. B. (2011). Avocado (*Persea americana* Mill.). In Postharvest biology and technology of tropical and subtropical fruits. pp. 125-186e.

[2] Hernández, I.; Fuentealba, C.; Antonio, J.; Poblete-echeverría, C. (2017). Effects of heat shock and nitrogen shockpre-treatments on ripening heterogeneity of Hass avocados stored in controlled atmosphere. Sci. Hortic., 225: 408-415.

[3] Florissen, P.; Ekman, J.S.; Blumenthal, C.; McGlasson, W.B.; Conroy, J.; Holford, P.L (1996). The effects of short heat treatments on the induction of chilling injury avocado fruit (*Persea americana* Mill.). Postharvest Biology and Technology, 8, 129-134.

[4] Gupta, S. K., Singhal, P., Singh, A., Chauhan, R., and Kumar, B. (2018). Nutritional and pharmaceutical benefits of avocado plant .*Journal of Advanced Scientific Research*, *9*(2): 04-11.

[5] Qin, X and Zhong, J. (2016). A review of extraction techniques for avocado oil. J. Oleo Sci. 65, (11) 881-888.

[6] Dreher, M. L. and Davenport, A. J. (2013). Hass avocado composition and potential health effects. Critical Reviews in Food Science and Nutrition, 53(7): 738-750.

[7] Kameni, A. and Tchamo, P. (2003). Water extraction of avocado oil in the High Lands of Cameroon. Tropical Science, 43(1): 10-12.

[8] Elsorady, M., Khalil, I., and Abd Elkarim, H. (2016). Use of avocado oil fruits as fat replacer in some food products. Journal of Productivity and Development, 21(2): 187-201.

[9] Karen, M , Semakaleng, M and Dharini, S. (2020). Extension of Avocado Fruit Postharvest Quality Using Non-Chemical Treatments. Agronomy, 10, 212.

[10] Cañete, M. L., Hueso, J. J., Pinillos, V., and Cuevas, J. (2015). Ripening degree at harvest affects bruising susceptibility and fruit sensorial traits of loquat (*Eriobotrya japonica Lindl*.). *Scientia Horticulturae*, *187*: 102-107.

[11] Kader, A.A. (2002). Fruits in the global market. In fruits quality and its biological basis, M. knee, ed. (uk: Sheffield Academic Press), 1-16.

[12] Tan, S. C. (2000). Determinants of eating quality in fruit and vegetables. In Proceedings-Nutrition Society of Australia (24): 183-190. Nutrition Society of Australia; 1998. Twenty-fourth Annual Scientific Meeting, Freemantle, Australia, 3-6 December, 2000.

[13] Nahed, M.M. Atta, EL-Tanahy, H.H, EL-Mansy, H.A and Christina, S.F. Shenouda. (2021). Study on some avocado fruits varieties and its extracted oil. Annals of Agric.Sci., Moshtohor. Vol. 59(3), 773-784.

[14] AOAC (2012). Official Methods of Analysis of AOAC International 19th Ed. Association of Official Analytical Chemists, Gaithorsburg Maryland.

[15] Satriana, S., Supardan, M. D., Arpi, N., and Wan Mustapha, W. A. (2019). Development of methods used in the extraction of avocado oil. European Journal of Lipid Science and Technology, 121(1): 1800210.

[16] AOCS. (1998). American Oil Chemists Society. Official and Tentative methods of American Oil Chemists' Society. 5th ed., 35 East waker drive, Chieago, illinos, USA.

[17] Lee, Y. C., Oh, S. W., Chang, J. and Kim, I. H. (2004). Chemical composition and oxidative stability of safflower oil prepared from safflower seed roasted with different temperatures. Food Chemistry, 84(1): 1-6.

[18] EEC, E. R. (1991). 2568/91 on the characteristics of olive and olive pomace oils and their analytical methods. Off. J. Eur. Communities L, 248, 1À82.

[19] IOOC (2001). Method of Analysis of the International Olive Oil Council preparation of the fatty acid methyl esters from olive oil and olive pomace oil. Co, T. 20: 24.

[20] Nelson, S. (2009) Chapter 14. Fat Characterization. In: O'Keefe, S.F. and Pike, O.A., Eds., Food Analysis, Fourth edition, Springer, New York, 239-260.

[21] Gutfinger, T. (1981). Polyphenols in olive oils. Journal of the American Oil Chemists' Society, 58(11), 966-968.

[22] Wong, M.L., Timms, R.E., and Goh, E.M. (1988). Colorimetric determination of total tocopherols in palm oil, olein and stearin. Journal of the American Oil Chemist Society, 65(2): 258.

[23] Isabel Minguez-Mosquera, M., Rejano-Navarro, L., Gandul-Rojas, B., SanchezGomez, A. H., and Garrido-Fernandez, J. (1991). Color-pigment correlation in virgin olive oil. Journal of the American Oil Chemists' Society, 68(5): 332-336.

[24] Idamokoro, E. M., Muchenje, V., Afolayan, A. J., & Hugo, A. (2019). Comparative fatty-acid profile and atherogenicity index of milk from free grazing Nguni, Boer and non-descript goats in South Africa. Pastoralism, 9(1): 1-8.

[25] Cao, J., Li, H., Xia, X., Zou, X. G., Li, J., Zhu, X. M. and Deng, Z. Y. (2015). Effect of fatty acid and tocopherol on oxidative stability of vegetable oils with limited air. International Journal of Food Properties, 18 (4): 808-820.

[26] Yun, J. M. and Surh, J. (2012). Fatty acid composition as a predictor for the oxidation stability of Korean vegetable oils with or without induced oxidative stress. Preventive Nutrition and Food Science, 17(2), 158.-associated autoantibodies. JAMA; 290: 1721-1728.

[27] Snedecor, G. W., and Cochran, W. G. (1980). Statistical Methods Iowa State University Press, Ames. Statistical Methods, 7th ed.The Iowa State University Press, Ames.

[28] Christina, S.F.Shenouda (2021). Effect of cold storage on the physo-chemical properties and bioactive compounds of avocado fruits and avocado pulp oil. M.Sc. Thesis, Food Technology Department, Faculty of Agriculture, Moshtohor, Benha University, Egypt.

[29] Clodoveo, M.L., D.Delcuratolo, T.gomes and collelli (2007). Effect of different temperature and storage atmospheres coratioa olive oil quality j.Food Chem., 102: 571-576.

[30] David, O., S. collin, J.sievertm F. Negm, M.L. Arpaia (2012). Influence of maturity and ripening on aroma volatiles and flavor in "HASS" avocado. Postharvest Biology and Technology 71: 91-50.

[31] Servili, M., R. Selvoggini, S. Esposto, A. Tatichi, Cs. Montedoro and CS. Morossi (2004). Health and sensory properties of virgin olive hydrophilic phenols. agronomic and technological aspects of production that affect their occurremce in the oil. Journal of Chromatography A.1054:113-117.

[32] Wong, Marie. Cecilia, Requejo-Jackman, and Woolf Allan. (2010). What is unrefined, extra virgin cold-pressed avocado oil? Inform April 2010, Vol. 21 (4) 259. 198-202.

[33] Sivankalyani, V., Feygenberg, O., Diskin, S., Wright, B. and Alkan, N. (2016). Increased anthocyanin and flavonoids in mango fruit peel are associated with cold and pathogen resistance. Postharvest Biology and Technology, 111: 132-139.