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The Effect of Storage Time on the Quality of Olive Oil Produced by Cooperatives for Olive Growers in the North of Morocco

I. Ibarhim Hassan Abdalla[1] , M. Khaddor[1], A. Boussab[1], D. El Garrouj[2], M. Ayadi[3], T. Hassan Mohammed Bakheet[4]

[1]Laboratory of physical chemistery of material , natural substance and environment, faculty of Science and Tecnology.University of Abdelmalik Essaadi Tanger Tetouan

Email Address: isamib2000 {at} yahoo.com

[2]Regional Directorate of Agriculture Tanger - Tetouan (Department of local product)

[3]National Institute of Agronomic Research, - Regional Centre Tangier

[4]Faculty of science and technology- University of Abdelmalik Essaadi Tanger Tetouan

ABSTRACT— ***Olive oil is much appreciated for its nutritional value which is strongly related to the quality and olive oil shelf life is affected by storage time. The effect of storage time was studied for olive oil produced by cooperatives for olive growers in the north of Morocco, to evaluate the quality and mark improvement in quality parameters of olive oils produced in this region stored at room temperatures in dark and monitored for 12 months. The samples which were studied collected from the North of Morocco are specific to the region of Ouazzane in Loukkos area were examined for physical and chemical properties (free fatty acid (% oleic acid), peroxide values (meq O_2 /kg), saponification number (mg KOH/g), iodine value (g /100 g), specific absorbance values (k232, k270), refractive index, pH) and total phenol content. This work reports changes in the major quality parameters of olive oils samples stored at room temperature in dark and monitored every three months for one year and all olive oil samples compared with International Olive Oil Council (IOOC), were not exceed the limits and exhibited remarkable physicochemical properties and could be useful as edible oils and industrial applications after one year.***

Keywords— Olive oil, physicochemical, total phenol, shelf life

1. INTRODUCTION

Olive oil, an important component in the diet of Mediterranean people, is obtained by mechanical extraction from the fruit of the Olea europaea L. tree, which belongs to the Olive family, comprises some 400 species, and thrives in temperate and tropical climates [1]. In Morocco especially in Ouazzane region (northern Morocco), the Picholine cultivar is a population variety which dominates the olive zone (90% of the cultivated olive patrimony). Nonetheless, there are other olive varieties which are not widely spread and which are distinguished by their own biometric characteristics, especially, autochthon varieties are protected by the population. Ouzzani et al. [2], have demonstrated that these varieties present genotypic and phenotypic variations. Many factors which influence the quality of the oil include the cultural and harvesting practices, the health of the drupe, and the interval between harvest and processing [3]. As in other foods, the quality of olive oil decreases during storage, and is attributable to lipid oxidation mechanisms which lead to rancidity [4]. Therefore, it would be a good practice to consume olive oil produced during one crop season before the following crop season [5]. It is a matter of great concern for the olive oil industry to preserve the positive attributes of oil during the time elapsing from production to bottling, and up to purchasing [6, 7]. Accordingly, variation of storage conditions during olive oil storage and transportation, affecting its quality, is common and may be attributed to natural climatic changes as well as bad storage techniques [8, 9]. During the shelf-life of bottled extra virgin olive oil, the packaging must adequately protective against autoxidation processes that cause rancidity [10].

The objective of this study was to evaluate physical and chemical characteristics for 12 months of local olive oils in the north of Morocco from cooperatives for olive growers, and samples were subjected to comparison to the International Olive Oil Council which have designated the quality of olive oil, based on physicochemical analysis especially the quantity of free fatty acids (FFA) is an important factor for classifying olive oil into commercial grades and this certification increases the oil value [11], and the assurance of the stability and quality of food products is a matter of great concern for producers and sellers. In the case of fats and oils, oxidation (one of the most fundamental reactions in lipid chemistry) is the main cause of quality deterioration and its reaction rate determines the shelf life of this type of food product.

2. MATERIALS AND METHODS

2.1 Olive oils samples

Ten (10) olive oils samples were collected from Loukkos areas from cooperatives for olive growers in North of Morocco are specific to the region of Ouazzane such as Azohour Harara (ZH), Bulouaan Asjenne (BS), Beni Hamed algarbiah (BH), Aljauhara (JA), Alraihan Beni Kalaa (RB), Alwifaag Beni Darkol (BD), Alamaal Mounasara (AM), Masmouda (MS), Alnajaah Brikcha (NB) and Cefchaouen (CF). Samples were collected during the period when olives are usually harvested for oil production (November 2010). The olive oils samples were placed into sterilized bottles and monitored every three months for one year.

2.2. Chemical and physical analysis

Chemical analysis (free oil acidity, peroxide value and iodine value) were performed according to AOAC [12]. Saponification number was determined using the method described by Lecoq [13]; the pH measurement of olive oils were obtained with a pH meter (Consort) was calibrated with standard solutions buffered. Refractive index was determined by Jasco spectrometer FT / IR 410 according to AOAC [12]. Absorbance at 232 and 270 nm was determined in a spectrophotometer (Shimadzu UV-2450, Japan), using the pure cyclohexane as the blank. The Wijs method was used for the determination of the iodine value (IV).

For the free oil acidity, a known weight of olive oil was dissolved in a mixture of diethyl ether/ethanol (1:1 v/v). The mixture was titrated with potassium hydroxide in methanol (0.05M) in the presence of phenolphthalein as indicator. For peroxide value, about 5g of olive oil was dissolved in a mixture of acetic acid/ chloroform (3:2 v/v), and saturated solution of KI (1ml) was then added. The liberation iodine was titrated with sodium thiosulphate solution (0.05M) in the presence of starch as indicator. For saponification number, a known weight of olive oil (1g) was dissolved in alcoholic potassium hydroxide (25 ml) then evaporated for 30mn. The sample was titrated with chlorydric acid (0.5N) in the presence of phenolphthalein as indicator.

2.3. Determination of total phenol content

The total phenol content was determined according to the methods described by Ollivier [14]. Total phenol was isolated from a solution of oil in hexane by triple-extraction with water – methanol (40: 60 v/v). The total phenols in the oil extracts were measured by the Folin-Ciocalteu assay. The measurement was carried out at 765nm via UV-spectrophotometer. Results were expressed as mg of gallic acid equivalent in one kg oil.

2.5 Statistical analysis

Analyses were performed in triplicate and statistical analysis of the data was done by analysis of variance (ANOVA) using a SPSS (the 10th version) was used. Duncan's Multiple Range Test was used to compare mean variance. Significance was accepted at 5% level probability following Steel procedures [15].

Data were expressed as mean values ± standard deviation derived from triplicate determination of your text, balance the columns using the option from the same menu. Insert a switch to one column before any page-wide tables.

3. RESULTS AND DISCUSSION

3.1.1 Free fatty acid

Analysis of free fatty acid (oleic acid %) for 12 months of olive oils sample were shown in Table 1, there were significant differences found among olive oils samples when analyzed for acidity percentage after 0 month, 3 month, 6 month, 9 month and 12 month they were in the range (0.25 – 0.57 %), (0.21 – 0.60 %), (0.44 – 0.84 %), (0.51 – 0.91 %) and (0.62 – 0.99 %) respectively. According to the International olive oils council (I.O.O.C, 2007), olive oils should have acidity (%) ≤ 3.3% [11] and the acidity contents of all samples were not higher than limited, there were shown in figure1.

Table.1 Effect of storage time on free fatty acid (% oleic acid) of 10 olive oils samples

Sample code	FFA after 0 month (Mean ± SD)	FFA after 3 month (Mean ± SD)	FFA after 6 month (Mean ± SD)	FFA after 9 month (Mean ± SD)	FFA after 12 month (Mean ± SD)
ZH	0.25^{a} ± 0.003	0.30^{bc} ± 0.006	0.44^{a} ± 0.004	0.51^{a} ± 0.008	0.62^{a} ± 0.005
BS	0.27^{a} ± 0.006	0.29^{a} ± 0.001	0.45^{ab} ± 0.003	0.52^{a} ± 0.007	0.62^{a} ± 0.002
BH	0.57^{d} ± 0.00.3	0.60^{g} ± 0.00.1	0.84^{e} ± 0.00.3	0.91^{f} ± 0.00.7	0.99^{f} ± 0.001
JA	0.25^{a} ± 0.004	0.21^{a} ± 0.007	0.44^{a} ± 0.006	0.58^{c} ± 0.007	0.68^{d} ± 0.005
RB	0.29^{b} ± 0.006	0.29^{a} ± 0.005	0.47^{b} ± 0.004	0.57^{c} ± 0.002	0.69^{d} ± 0.006
BD	0.30^{b} ± 0.004	0.37^{e} ± 0.005	0.50^{c} ± 0.002	0.62^{d} ± 0.002	0.66^{c} ± 0.001
AM	0.33^{c} ± 0.008	0.39^{f} ± 0.005	0.55^{d} ± 0.001	0.65^{e} ± 0.008	0.70^{e} ± 0.002
MS	0.29^{b} ± 0.005	0.31^{b} ± 0.004	0.46^{ab} ± 0.003	0.55^{b} ± 0.004	0.66^{bc} ± 0.005
NB	0.29^{b} ± 0.003	0.32^{cd} ± 0.003	0.46^{ab} ± 0.002	0.57^{c} ± 0.004	0.65^{b} ± 0.003
CF	0.30^{b} ±. 0.004	0.32^{d} ±. 0.004	0.54^{d} ±. 0.003	0.62^{d} ±. 0.003	0.68^{d} ±. 0.007

Different letters within a column indicate significant differences ($p < 0.05$)

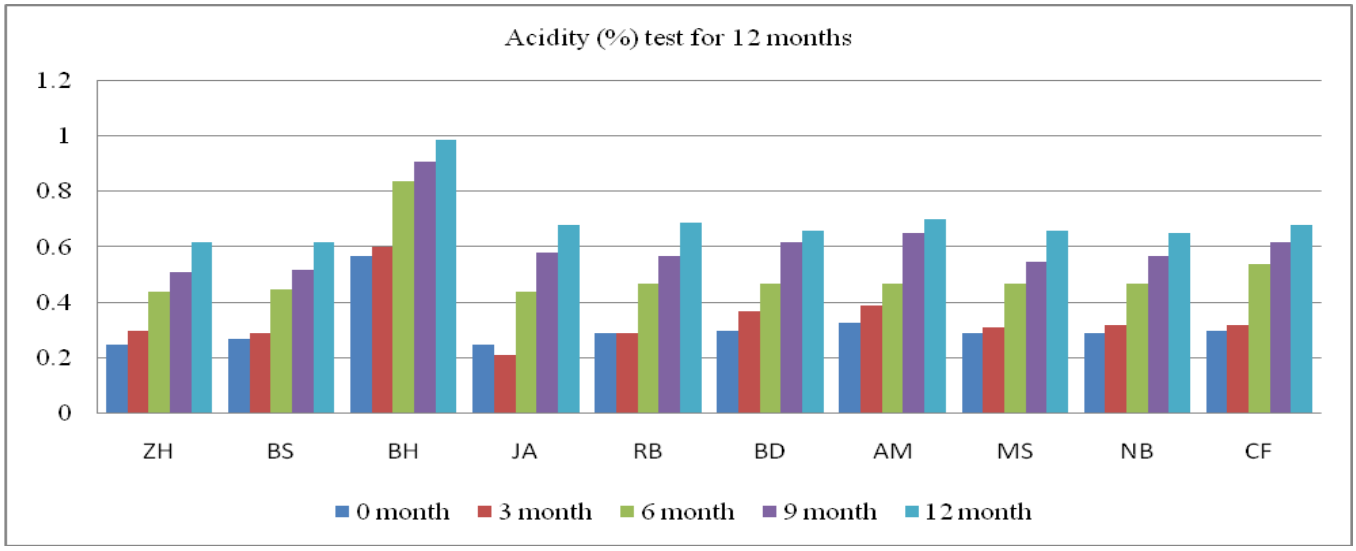

Fig.1 Effect of storage time on free fatty acid (% oleic acid) of 10 olive oils samples

3.1.2 Peroxide value

In table 2, the results obtained, indicate that peroxide values after 0 month, 3 month, 6 month, 9 month and 12 month they were ranged (6.58 - 10.14), (7.61 – 10.73), (9.07 – 12.56), (10.91 – 13.95) and (13.91 – 15.03 meq O_2/kg) respectively. It is clear that peroxide values of all olive oils samples were under the value of 20 meq O_2/kg of olive oil, which is the maximum established by the council for international olive oil. Figure 2 shows peroxide values, where high peroxide value was found in samples coded BH, JA and CF.

Table.2 Effect of storage time on peroxide value (meq O_2 / kg) of 10 olive oils samples

Sample code	Peroxide value after 0 month (Mean ± SD)	Peroxide value after 3 month (Mean ± SD)	Peroxide value after 6 month (Mean ± SD)	Peroxide value after 9 month (Mean ± SD)	Peroxide value after 12 month (Mean ± SD)
ZH	$8.51^{d} \pm 0.4$	$8.91^{c} \pm 0.07$	$9.44^{b} \pm 0.02$	$11.48^{b} \pm 0.02$	$14.53^{b} \pm 0.05$
BS	$8.51^{d} \pm 0.07$	$8.89^{c} \pm 0.04$	$10.46^{c} \pm 0.02$	$13.89^{d} \pm 0.04$	$15.00^{de} \pm 0.05$
BH	$10.14^{e} \pm 0.04$	$10.73^{e} \pm 0.07$	$12.10^{d} \pm 0.04$	$13.91^{d} \pm 0.04$	$15.01^{de} \pm 0.05$
JA	$10.10^{e} \pm 0.08$	$10.73^{e} \pm 0.04$	$12.13^{d} \pm 0.08$	$13.91^{d} \pm 0.06$	$14.94^{d} \pm 0.04$
RB	$7.50^{b} \pm 0.02$	$8.37^{b} \pm 0.07$	$9.45^{b} \pm 0.05$	$11.54^{b} \pm 0.05$	$14.53^{b} \pm 0.04$
BD	$7.47^{b} \pm 0.07$	$8.37^{b} \pm 0.03$	$9.51^{b} \pm 0.08$	$11.52^{b} \pm 0.03$	$13.92^{a} \pm 0.03$
AM	$6.58^{a} \pm 0.03$	$7.61^{a} \pm 0.07$	$9.07^{a} \pm 0.02$	$10.91^{a} \pm 0.02$	$13.91^{a} \pm 0.04$
MS	$8.38^{c} \pm 0.02$	$10.30^{d} \pm 0.05$	$12.56^{e} \pm 0.03$	$13.95^{d} \pm 0.03$	$14.93^{d} \pm 0.01$
NB	$8.39^{c} \pm 0.03$	$10.27^{d} \pm 0.07$	$12.52^{e} \pm 0.03$	$13.53^{c} \pm 0.03$	$15.03^{e} \pm 0.06$
CF	$10.09^{e} \pm 0.07$	$10.72^{e} \pm 0.02$	$12.12^{d} \pm 0.07$	$13.91^{d} \pm 0.04$	$14.61^{c} \pm 0.04$

Different letters within a column indicate significant differences ($p < 0.05$)

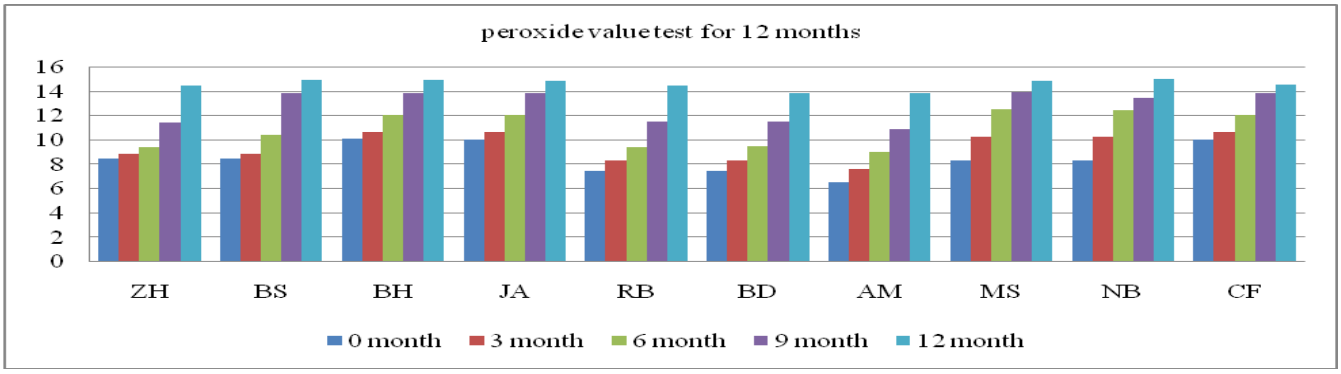

Fig 2. Shows peroxide value of 10 olive oils samples (2010)

3.1.3. Specific extinctions at (232 nm)

Table 3 shows specific extinction at 232 nm after 0 month, 3 month, 6 month, 9 month and 12 month they were ranged (2.86 – 3.45), (3.24 – 3.48), (3.26 – 3.55), (3.39 – 3.68) and (3.55 – 3.76) respectively were not exceeding permitted limits according to IOOC [11] except after 12 month there were slight increase exceeding 3.50, where shown in figure 3.

Table.3 Effect of storage time on specific extinctions at (232 nm) of 10 olive oils sample

Sample No.	Sample code	E232 after 0 month (Mean ± SD)	E232 after 3 month (Mean ± SD)	E232 after 6 month (Mean ± SD)	E232 after 9 month (Mean ± SD)	E232 after 12 month (Mean ± SD)
1	ZH	$3.18^{b} \pm 0.03$	$3.24^{a} \pm 0.08$	$3.37^{ab} \pm 0.11$	$3.44^{ab} \pm 0.05$	$3.55^{a} \pm 0.04$
2	BS	$3.17^{b} \pm 0.01$	$3.32^{ab} \pm 0.08$	$3.39^{ab} \pm 0.16$	$3.49^{bc} \pm 0.05$	$3.62^{b} \pm 0.04$
3	BH	$3.45^{d} \pm 0.04$	$3.48^{b} \pm 0.02$	$3.50^{b} \pm 0.11$	$3.57^{cd} \pm 0.08$	$3.66^{bc} \pm 0.06$
4	JA	$3.22^{bc} \pm 0.05$	$3.43^{ab} \pm 0.12$	$3.52^{b} \pm 0.07$	$3.65^{de} \pm 0.03$	$3.72^{cd} \pm 0.02$
5	RB	$3.16^{b} \pm 0.02$	$3.32^{ab} \pm 0.14$	$3.40^{ab} \pm 0.15$	$3.57^{cd} \pm 0.04$	$3.70^{cd} \pm 0.03$
6	BD	$3.22^{bc} \pm 0.06$	$3.46^{b} \pm 0.09$	$3.55^{b} \pm 0.04$	$3.68^{e} \pm 0.01$	$3.75^{d} \pm 0.01$
7	AM	$3.16^{b} \pm 0.03$	$3.24^{a} \pm 0.14$	$3.26^{a} \pm 0.12$	$3.39^{a} \pm 0.04$	$3.59^{ab} \pm 0.03$
8	MS	$3.25^{c} \pm 0.02$	$3.36^{ab} \pm 0.12$	$3.45^{ab} \pm 0.09$	$3.63^{de} \pm 0.03$	$3.74^{d} \pm 0.05$
9	NB	$2.86^{a} \pm 0.02$	$3.30^{ab} \pm 0.12$	$3.36^{ab} \pm 0.09$	$3.53^{c} \pm 0.04$	$3.62^{b} \pm 0.03$
10	CF	$3.45^{d} \pm 0.03$	$3.47^{b} \pm 0.02$	$3.53^{b} \pm 0.05$	$3.67^{e} \pm 0.05$	$3.76^{d} \pm 0.03$

Different letters within a column indicate significant differences ($p < 0.05$).

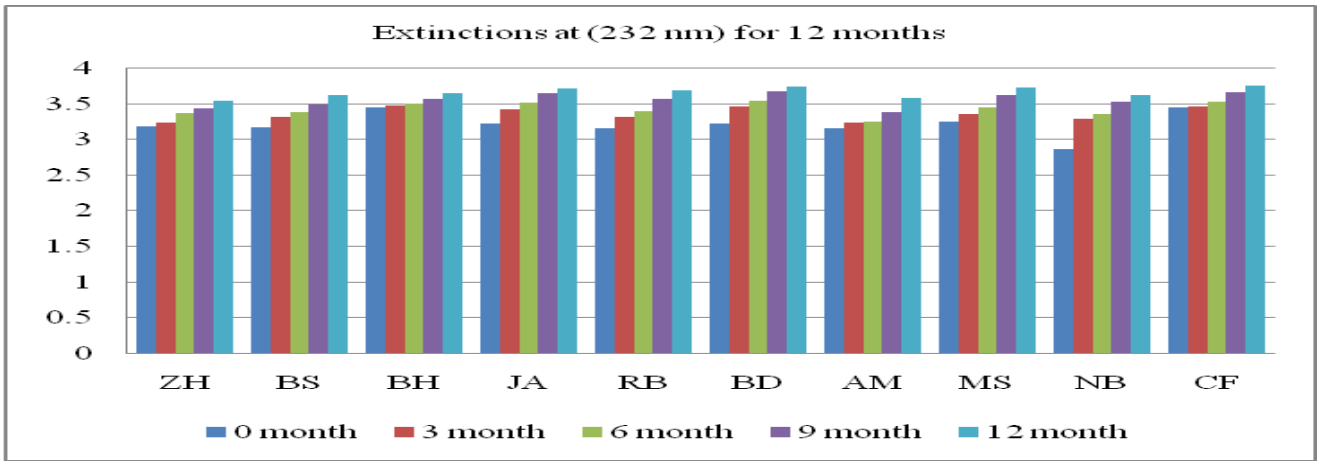

Fig. 3 Effect of storage time on specific extinctions at (232 nm) of 10 olive oils samples

3.1.4 Specific extinctions at (270 nm)

Table 4 shows specific extinction at 270 nm after 0 month, 3 month, 6 month, 9 month and 12 month they were ranged (0.32 – 0.62), (0.45 – 0.70), (0.55 – 0.86), (0.57 – 0.89) and (0.65 – 0.91) respectively were not exceeding permitted limits as virgin olive oil according to IOOC [11] except after 12 month there were slight increase exceeding 0.90, where shown in figure 4 in sample coded AM.

Table.4 Effect of storage time on specific extinctions at (270 nm) of 10 olive oils samples

Sample code	E270 after 0 month (Mean ± SD)	E270 after 3 month (Mean ± SD)	E270 after 6 month (Mean ± SD)	E270 after 9 month (Mean ± SD)	E270 after 12 month (Mean ± SD)
ZH	$0.35^{a} \pm 0.05$	$0.47^{a} \pm 0.07$	$0.66^{abc} \pm 0.10$	$0.72^{bc} \pm 0.06$	$0.76^{cd} \pm 0.03$
BS	$0.37^{a} \pm 0.08$	$0.46^{a} \pm 0.08$	$0.68^{abc} \pm 0.11$	$0.69^{abc} \pm 0.11$	$0.73^{abc} \pm 0.08$
BH	$0.47^{ab} \pm 0.07$	$0.62^{bc} \pm 0.06$	$0.82^{cd} \pm 0.06$	$0.85^{d} \pm 0.05$	$0.89^{e} \pm 0.03$
JA	$0.55^{bc} \pm 0.06$	$0.66^{bc} \pm 0.10$	$0.77^{bcd} \pm 0.11$	$0.80^{cd} \pm 0.09$	$0.83^{de} \pm 0.06$
RB	0.34a ± 0.11	$0.51^{ab} \pm 0.07$	$0.55^{a} \pm 0.12$	$0.57^{a} \pm 0.01$	$0.65^{a} \pm 0.03$
BD	$0.38^{a} \pm 0.11$	$0.58^{abc} \pm 0.09$	$0.68^{abc} \pm 0.11$	$0.71^{bc} \pm 0.08$	$0.75^{bc} \pm 0.06$
AM	$0.62^{c} \pm 0.08$	$0.70^{c} \pm 0.07$	$0.86^{d} \pm 0.06$	$0.89^{d} \pm 0.04$	$0.91^{e} \pm 0.02$
MS	$0.46^{ab} \pm 0.13$	$0.55^{ab} \pm 0.06$	$0.64^{ab} \pm 0.07$	$0.67^{ab} \pm 0.04$	$0.70^{abc} \pm 0.03$
NB	$0.32^{a} \pm 0.06$	$0.45^{a} \pm 0.08$	$0.55^{a} \pm 0.09$	$0.60^{ab} \pm 0.04$	$0.67^{ab} \pm 0.02$
CF	$0.34^{a} \pm 0.08$	$0.57^{abc} \pm 0.09$	$0.76^{bcd} \pm 0.05$	$0.79^{cd} \pm 0.02$	$0.87^{e} \pm 0.03$

Different letters within a column indicate significant differences ($p < 0.05$).

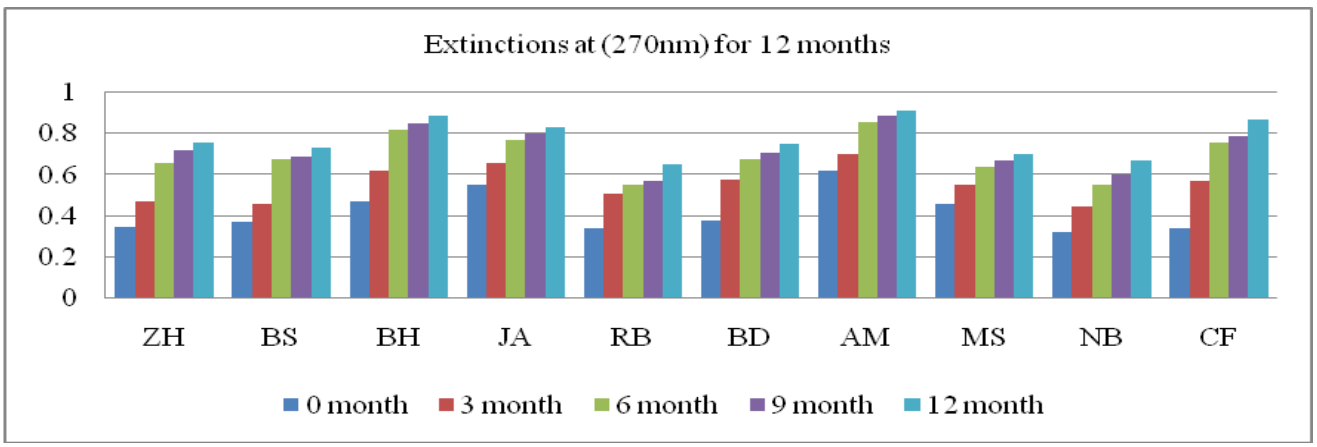

Fig 4. Effect of storage time on specific extinctions at (270 nm) of 10 olive oils samples

3.1.5 Effect of storage time on pH

Table 5 shows specific effect of storage time on pH of 10 olive oils samples after 0 month, 3 month, 6 month, 9 month and 12 month they were ranged (5.08 – 4.61), (4.96 – 4.52), (4.84 – 4.10), (4.52 – 3.87) and (4.43 – 3.77) respectively were approved acidity values and it found that acidity increase as pH decreased. Figure 5 was shown sample coded BH have lower pH in all storage periods which approved that had a high percentage of acidity.

Table.5 Effect of storage time on pH of 10 olive oils samples

Sample No.	Sample code	pH after 0 month (Mean ± SD)	pH after 3 month (Mean ± SD)	pH after 6 month (Mean ± SD)	pH after 9 month (Mean ± SD)	pH after 12 month (Mean ± SD)
1	ZH	$5.05^{d} \pm 0.04$	$4.79^{cd} \pm 0.03$	$4.57^{e} \pm 0.07$	$4.52^{d} \pm 0.07$	$4.40^{f} \pm 0.01$
2	BS	$4.95^{c} \pm 0.005$	$4.87^{e} \pm 0.02$	$4.55^{e} \pm 0.04$	$4.49^{d} \pm 0.06$	$4.43^{f} \pm 0.05$
3	BH	$4.61^{a} \pm 0.01$	$4.52^{a} \pm 0.01$	$4.10^{a} \pm 0.05$	$3.87^{a} \pm 0.01$	$3.77^{a} \pm 0.01$
4	JA	$5.08^{d} \pm 0.01$	$4.96^{f} \pm 0.04$	$4.57^{e} \pm 0.11$	$4.39^{c} \pm 0.005$	$4.32^{e} \pm 0.02$
5	RB	$4.96^{c} \pm 0.01$	$4.83^{cde} \pm 0.02$	$4.46^{cd} \pm 0.03$	$4.36^{c} \pm 0.03$	$4.32^{de} \pm 0.02$
6	BD	$4.98^{c} \pm 0.01$	$4.78^{c} \pm 0.01$	$4.40^{bc} \pm 0.005$	$4.25^{b} \pm 0.04$	$4.21^{bc} \pm 0.01$
7	AM	$4.81^{b} \pm 0.02$	$4.73^{b} \pm 0.02$	$4.36^{b} \pm 0.03$	$4.21^{b} \pm 0.01$	$4.16^{b} \pm 0.05$
8	MS	$4.96^{c} \pm 0.01$	$4.83^{cde} \pm 0.02$	$4.53^{de} \pm 0.02$	$4.36^{c} \pm 0.03$	$4.25^{c} \pm 0.03$
9	NB	$4.96^{c} \pm 0.01$	$4.84^{de} \pm 0.02$	$4.84^{f} \pm 0.02$	$4.34^{c} \pm 0.04$	$4.26^{cd} \pm 0.05$
10	CF	$4.82^{b} \pm 0.01$	$4.79^{cd} \pm 0.01$	$4.58^{e} \pm 0.02$	$4.23^{b} \pm 0.02$	$4.20^{bc} \pm 0.01$

Different letters within a column indicate significant differences ($p < 0.05$).

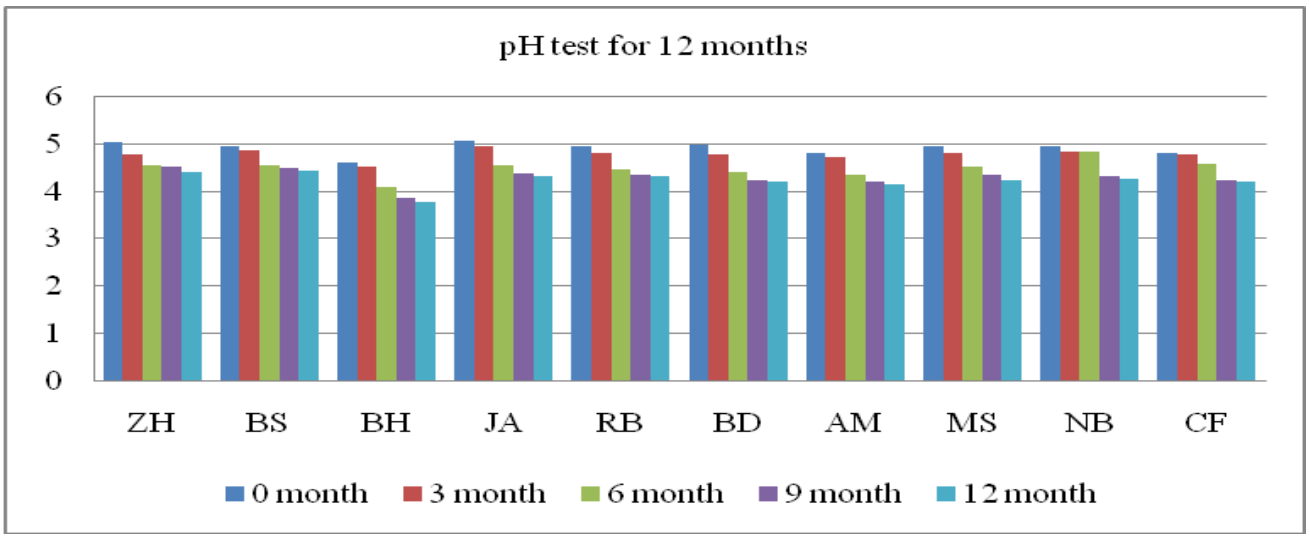

Fig. 5 Effect of storage time on pH of 10 olive oils samples

3.1.6 Saponification values

Table 6 shows Saponification values after 0 month, 3 month, 6 month, 9 month and 12 month they were ranged (187.05 – 194.85), (184.35 – 192.13), (183.33 – 189.33), (181.73 – 187.33) and (175.06 – 184.87) respectively were not below acceptable limits according to IOOC [11]. Figure 6 was shown samples coded RB and BD had lowest saponification values in different storage periods and samples coded MS, BS, NB and CF had a highest saponification values during different storage times.

Table.6 shows saponification values of 10 olive oils sample

Sample No.	Sample code	saponification values after 0 month (Mean ± SD)	saponification values after 3 month (Mean ± SD)	saponification values after 6 month (Mean ± SD)	saponification values after 9 month (Mean ± SD)	saponification values after 12 month (Mean ± SD)
1	ZH	$188.71^{ab} \pm 1.63$	$184.66^{a} \pm 4.52$	$183.33^{a} \pm 2.97$	$182.53^{ab} \pm 2.75$	$178.37^{bc} \pm 0.69$
2	BS	$192.48^{c} \pm 0.97$	$189.77^{cd} \pm 0.94$	$186.97^{b} \pm 1.48$	$185.97^{cd} \pm 1.41$	$184.87^{e} \pm 0.42$
3	BH	$187.05^{a} \pm 1.81$	$184.35^{a} \pm 0.17$	$184.00^{a} \pm 0.005$	$182.90^{ab} \pm 0.18$	$180.56^{cd} \pm 1.91$
4	JA	$189.55^{b} \pm 0.65$	$186.68^{ab} \pm 0.32$	$185.31^{ab} \pm 0.33$	$184.30^{bc} \pm 0.40$	$177.96^{b} \pm 0.65$
5	RB	$187.15^{a} \pm 0.78$	$185.74^{a} \pm 0.63$	$184.64^{a} \pm 0.63$	$183.94^{bc} \pm 0.72$	$181.38^{d} \pm 2.04$
6	BD	$187.59^{a} \pm 0.70$	$185.26^{a} \pm 0.91$	$184.72^{a} \pm 0.07$	$183.43^{ab} \pm 0.54$	$175.06^{a} \pm 1.38$
7	AM	$187.93^{ab} \pm 0.21$	$185.24^{a} \pm 0.38$	$184.07^{a} \pm 0.02$	$181.73^{a} \pm 0.64$	$177.74^{b} \pm 2.46$
8	MS	$192.48^{c} \pm 0.52$	$188.66^{bc} \pm 1.34$	$187.29^{bc} \pm 0.57$	$185.99^{cd} \pm 0.06$	$184.53^{e} \pm 0.61$
9	NB	$194.85^{d} \pm 0.42$	$191.69^{d} \pm 0.70$	$189.33^{c} \pm 0.90$	$187.33^{d} \pm 1.04$	$184.40^{e} \pm 0.60$
10	CF	$194.82^{d} \pm 0.59$	$192.13^{d} \pm 1.00$	$189.30^{c} \pm 0.91$	$187.28^{d} \pm 0.89$	$184.50^{e} \pm 0.56$

Different letters within a column indicate significant differences ($p < 0.05$).

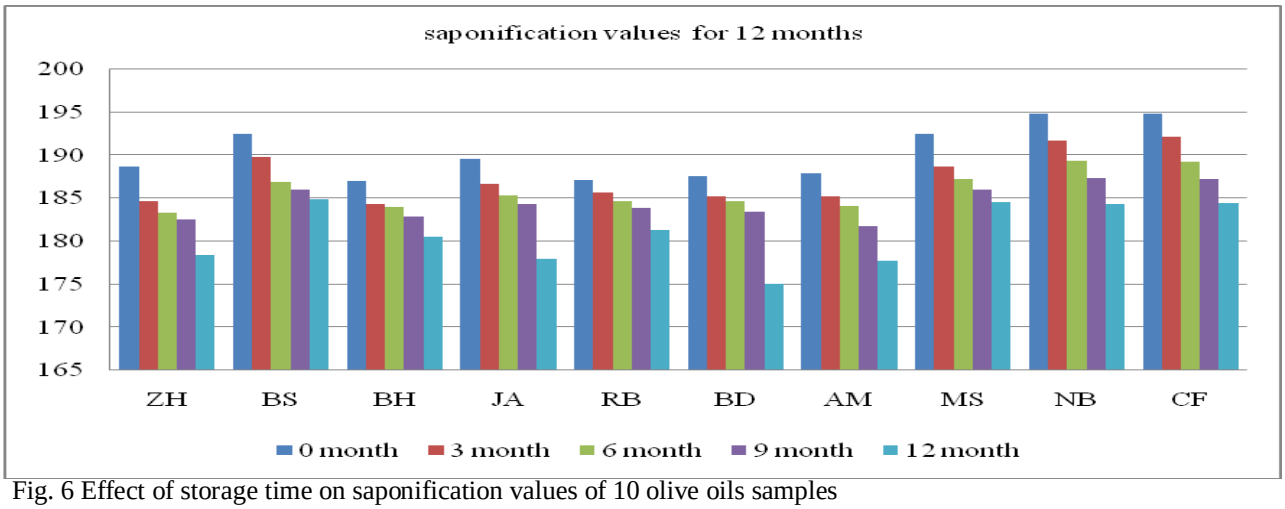

Fig. 6 Effect of storage time on saponification values of 10 olive oils samples

3.1.7 Iodine value

Table 6 shows iodine values after 0 month, 3 month, 6 month, 9 month and 12 month they were ranged (79.44 – 91.38), (72.93 – 84.98), (71.87 – 80.74), (70.27 – 79.32) and (69.17 – 77.09) respectively they were not exceeding limits that give very strong indication of degree of instauration of a molecule [16]. Figure 7 showed sample coded ZH, JA and RB had lowest iodine value.

Table.7 Effect of storage time on iodine value of 10 olive oils samples

Sample No.	Sample code	iodine value after 0 month (Mean ± SD)	iodine value after 3 month (Mean ± SD)	iodine value after 6 month (Mean ± SD)	iodine value after 9 month (Mean ± SD)	iodine value after 12 month (Mean ± SD)
1	ZH	$79.44^{a} \pm 0.68$	$73.88^{a} \pm 1.27$	$72.79^{ab} \pm 1.29$	$72.11^{ab} \pm 0.38$	$70.51^{a} \pm 0.85$
2	BS	$83.12^{ab} \pm 3.16$	$77.01^{ab} \pm 1.79$	$77.01^{abc} \pm 1.79$	$76.67^{cd} \pm 1.34$	$74.65^{bc} \pm 0.51$
3	BH	$81.21^{ab} \pm 4.12$	$77.53^{ab} \pm 4.31$	$75.72^{abc} \pm 3.07$	$74.72^{bc} \pm 1.76$	$74.12^{b} \pm 1.25$
4	JA	$81.50^{ab} \pm 0.20$	$72.93^{a} \pm 3.41$	$71.87^{a} \pm 2.51$	$70.27^{a} \pm 0.39$	$69.93^{a} \pm 0.83$
5	RB	$82.59^{ab} \pm 4.58$	$73.90^{a} \pm 2.97$	$73.07^{ab} \pm 2.71$	$72.17^{ab} \pm 1.62$	$69.17^{a} \pm 1.15$
6	BD	$85.95^{bc} \pm 0.25$	$80.85^{bc} \pm 1.88$	$76.91^{abc} \pm 1.57$	$75.71^{c} \pm 0.43$	$74.71^{bc} \pm 0.86$
7	AM	$84.86^{b} \pm 3.63$	$73.19^{a} \pm 4.30$	$72.12^{ab} \pm 2.68$	$71.76^{ab} \pm 2.13$	$70.16^{a} \pm 1.02$
8	MS	$90.43^{cd} \pm 1.30$	$84.44^{c} \pm 3.76$	$77.24^{bc} \pm 2.72$	$75.58^{c} \pm 1.25$	$74.91^{bc} \pm 0.68$
9	NB	$90.66^{cd} \pm 1.75$	$84.98^{c} \pm 2.04$	$80.74^{c} \pm 2.44$	$79.32^{c} \pm 1.12$	$77.09^{d} \pm 1.13$
10	CF	$91.38^{e} \pm 2.82$	$83.68^{c} \pm 4.74$	$80.61^{c} \pm 4.67$	$79.31^{c} \pm 3.58$	$76.54^{cd} \pm 1.87$

Different letters within a column indicate significant differences ($p < 0.05$).

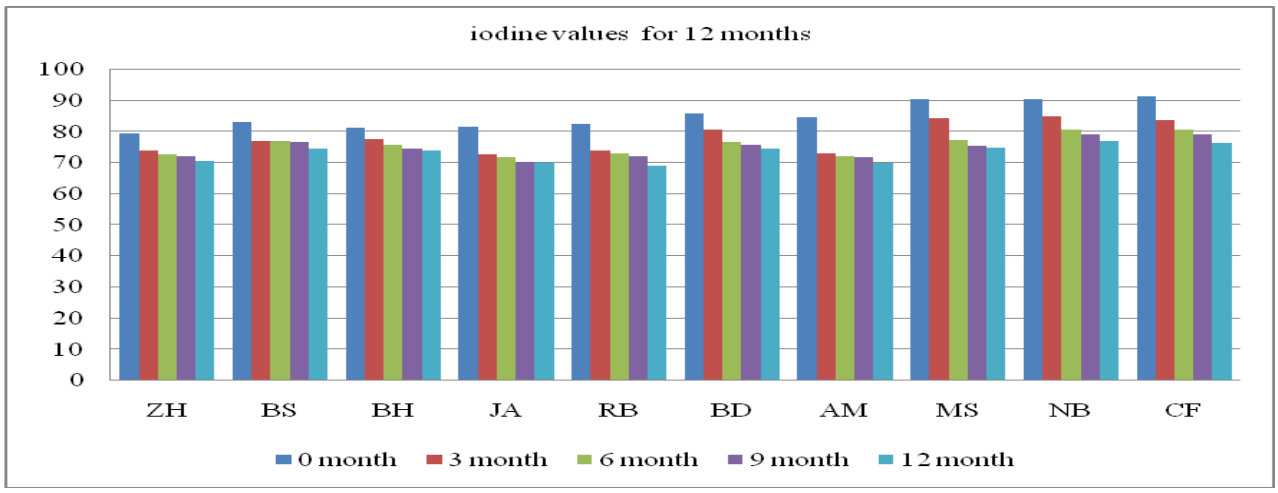

Fig.7 Effect of storage time on iodine value of 10 olive oils samples

3.1.8 Refractive index

Table 8 shows refractive index after 0 month, 3 month, 6 month, 9 month and 12 month they were ranged (1.4688 – 1.4702), (1.4682– 1.4693), (1.4679– 1.4683), (1.4677 – 1.4679) and (1.4675 – 1.4681) respectively were within permitted limits for olive oils according to olive oils council. Figure 8 shown refractive high in earlier months and decrease gradually in latest months. These parameters have important roles which were influence on the quality of olive oils in the North of Morocco [17].

Table.8 Effect of storage time on refractive index of 10 olive oils samples

Sample code	refractive index after 0 month (Mean ± SD)	refractive index after 3 month (Mean ± SD)	refractive index after 6 month (Mean ± SD)	refractive index after 9 month (Mean ± SD)	refractive index after 12 month (Mean ± SD)
ZH	$1.4701^{e} \pm 0.00005$	$1.4692^{c} \pm 0.0002$	$1.4682^{abc} \pm 0.0002$	$1.4679^{ab} \pm 0.0001$	$1.4681^{b} \pm 0.0007$
BS	$1.4702^{e} \pm 0.0002$	$1.4693^{c} \pm 0.0002$	$1.4680^{ab} \pm 0.0001$	$1.4679^{ab} \pm 0.0001$	$1.4677^{ab} \pm 0.0001$
BH	$1.4688^{a} \pm 0.0001$	$1.4682^{a} \pm 0.0002$	$1.4679^{a} \pm 0.00005$	$1.4677^{a} \pm 0.0001$	$1.4675^{a} \pm 0.00005$
JA	$1.4700^{e} \pm 0.00005$	$1.4693^{c} \pm 0.0002$	$1.4682^{abc} \pm 0.0002$	$1.4679^{ab} \pm 0.00005$	$1.4678^{ab} \pm 0.0002$
RB	$1.4693^{bc} \pm 0.0002$	$1.4683^{a} \pm 0.0003$	$1.4680^{ab} \pm 0.0001$	$1.4678^{ab} \pm 0.0001$	$1.4678^{ab} \pm 0.0001$
BD	$1.4692^{bc} \pm 0.0002$	$1.4685^{ab} \pm 0.0003$	$1.4681^{abc} \pm 0.0002$	$1.4679^{ab} \pm 0.0001$	$1.4677^{ab} \pm 0.0001$
AM	$1.4689^{ab} \pm 0.00005$	$1.4684^{a} \pm 0.0003$	$1.4680^{ab} \pm 0.0001$	$1.4679^{ab} \pm 0.0001$	$1.4679^{ab} \pm 0.0001$
MS	$1.4697^{d} \pm 0.0002$	$1.4691^{c} \pm 0.0001$	$1.4683^{bc} \pm 0.0002$	$1.4680^{b} \pm 0.0001$	$1.4677^{ab} \pm 0.0001$
NB	$1.4693^{c} \pm 0.0003$	$1.4689^{bc} \pm 0.0001$	$1.4684^{c} \pm 0.0003$	$1.4679^{ab} \pm 0.0002$	$1.4678^{ab} \pm 0.0001$
CF	$1.4691^{abc} \pm 0.0002$	$1.4685^{ab} \pm 0.0003$	$1.4681^{abc} \pm 0.000$	$1.4678^{a} \pm 0.00005$	$1.4677^{ab} \pm 0.00005$

Different letters within a column indicate significant differences ($p < 0.05$).

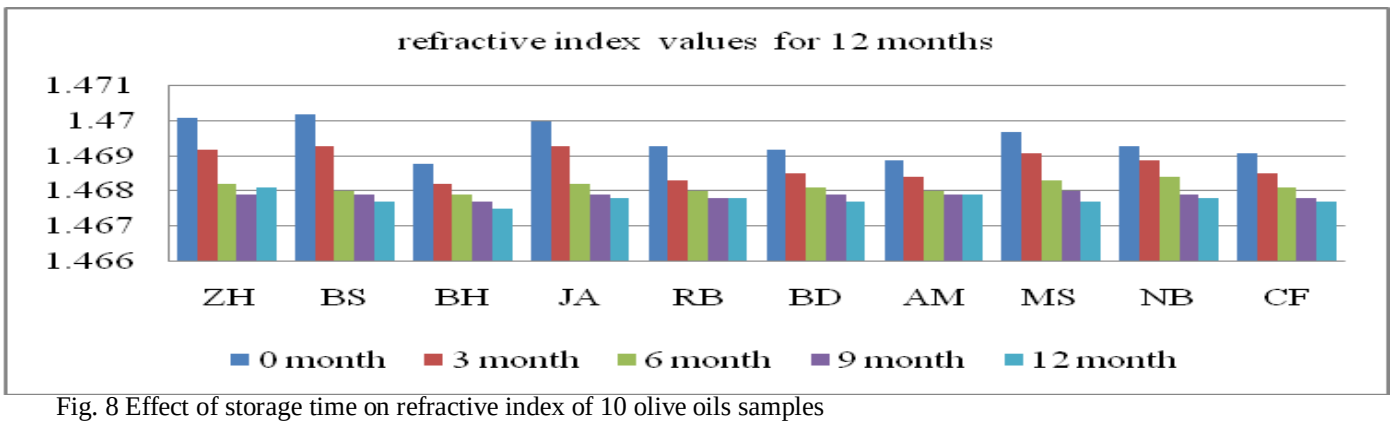

Fig. 8 Effect of storage time on refractive index of 10 olive oils samples

3.2 Total phenol content

Table 9 shows total phenol content after 0 month, 3 month, 6 month, 9 month and 12 month they were ranged (112 – 313), (88 – 271), (60 – 139), (52– 107) and (41 – 79 ppm) respectively. The proportions and speed of phenolic compounds decrease depend on variety and there was a study done in the same region shown that the dominating local Moroccan olive oil cultivar had appropriate amount of polyphenol contents but the quality was a affected by storage time, it was observed a decrease in the amounts of polyphenols during storage time [18]. Figure 9 shows sample coded BH and MS had lowest percentage of total polyphenols; whereas sample coded JA, RB and BS had a highest total polyphenols percentage during storage periods.

Table.9 Effect of storage time on Total phenol content as ppm (Gallic acid equivalent) of 10 olive oils samples

Sample code	Total phenol content after 0 month (Mean ± SD)	Total phenol after 3 month (Mean ± SD)	Total phenol after 6 month (Mean ± SD)	Total phenol after 9 month (Mean ± SD)	Total phenol after 12 month (Mean ± SD)
ZH	$216^{cd} \pm 3.51$	$163^{c} \pm 7.09$	$116^{e} \pm 6.80$	$98^{cd} \pm 1.53$	$73^{c} \pm 3.06$
BS	$233^{e} \pm 10.11$	$190^{d} \pm 6.51$	$125^{ef} \pm 6.66$	$97^{c} \pm 4.16$	$75^{c} \pm 3.51$
BH	$112^{a} \pm 4.16$	$88^{a} \pm 9.02$	$60^{a} \pm 5.03$	$53^{a} \pm 2.65$	$41^{a} \pm 2.52$
JA	$309^{f} \pm 4.36$	$236^{e} \pm 7.64$	$134^{fg} \pm 5.03$	$104^{de} \pm 5.29$	$79^{c} \pm 2.00$
RB	$313^{f} \pm 3.05$	$271^{g} \pm 5.51$	$139^{g} \pm 4.36$	$107^{e} \pm 4.36$	$79^{c} \pm 3.00$
BD	$208^{c} \pm 2.52$	$159^{c} \pm 5.00$	$105^{d} \pm 6.03$	$74^{b} \pm 3.21$	$50^{b} \pm 2.52$
AM	$220^{d} \pm 7.63$	$249^{f} \pm 5.51$	$127^{f} \pm 5.69$	$74^{b} \pm 3.06$	$51^{b} \pm 4.04$
MS	$189^{b} \pm 8.54$	$134^{b} \pm 5.03$	$72^{b} \pm 4.73$	$52^{a} \pm 3.21$	$41^{a} \pm 2.52$
NB	$185^{b} \pm 6.02$	$132^{b} \pm 3.51$	$57^{a} \pm 4.73$	$49^{a} \pm 1.00$	$42^{a} \pm 3.51$
CF	$218^{cd} \pm 4.00$	$159^{c} \pm 3.51$	$91^{c} \pm 4.73$	$71^{b} \pm 4.04$	$51^{b} \pm 4.16$

Different letters within a column indicate significant differences ($p < 0.05$).

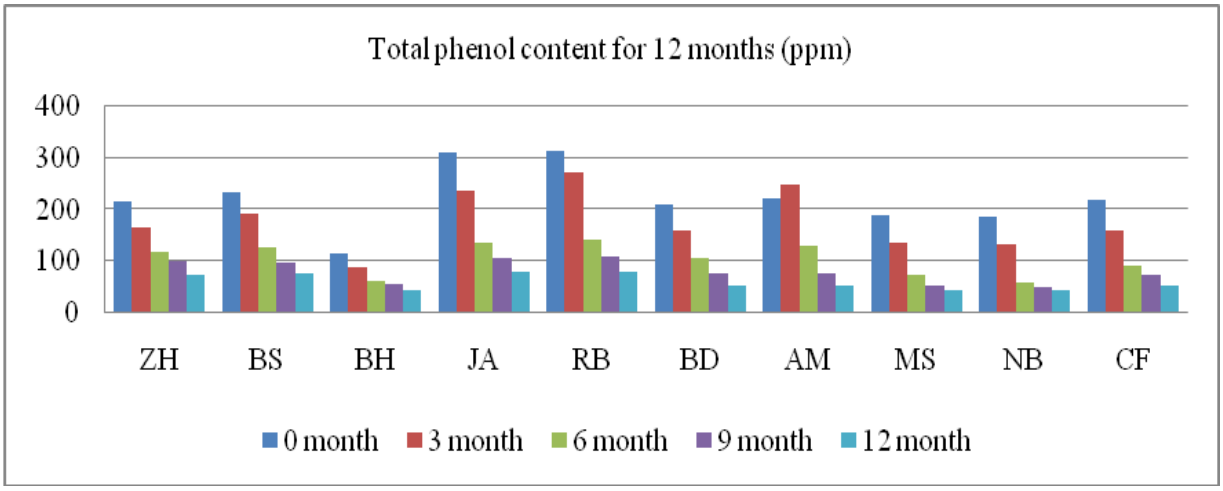

Fig. 9 Effect of storage time on total phenol content of 10 olive oils samples

4. CONCLUSION

Overall, from this study, it can be concluded that, in the storage time, the critical physical-chemical parameters of the olive oil increased significantly after 12 months. The obtained results revealed that the olive oils samples from cooperatives for olive growers were free from any defects and were classified as virgin olive oil when obtained from cooperatives for olive growers, according to international olive oils council, acidity and peroxide values were within the limits for virgin olive oil.

The physical and chemical characteristics of olive oils samples showed somewhat considerable differences, but have good properties as they contain low percentages of acidity, therefore could be utilized successfully after 12 months, as a source of edible oil for human consumption. Proper storage techniques for olive oil are very important, not only to preserve the delicate taste of the oil, but also to ensure that it does not spoil and become rancid, which will have a negative effect on its nutritional profile. Olive oil can be kept longer than any other edible oil, and if stored properly it will take years before it becomes rancid.

5. ACKNOWLEDGMENTS

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