RESULTS AND DISCUSSION

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4.1. Tomato and tomato products:

Tomato is considered to be one of the main vegetable crops in Egypt, it is consumed either fresh or processed. The tomato products are different such as, tomato juice, tomato concentrate, tomato soup, tomato sauces, **(Wilbure, 1983)**.

4.1.1. Chemical constituents of fresh tomato and tomato sauces:

Data from Table (1) and Figure (1) indicated that the chemical constituents of fresh tomato juice were 6.15%, 5.3%, 2.43%, 3.76%, 0.43%, 3.9 and 0.323% for total solids, total soluble solids, reducing sugar, total sugar, total acidity, pH value and ash content, respectively. These results were agreement with those obtained by **El-Atawy (1979), Lui and Luh (1979), Bajaja and Mahajan (1982), El-Sherrbiny et al . (1983), Villanueva (1985), Soliman (1991) and Shouman et al. (1992).**

The same table and Figure (2) show that serum color and browning index of fresh tomato juice are the highest and lowest values, respectively. This means that there is no change in chemical constituents and no chemical reaction is developed **(O' Beirne, 1986 and Shaw & Mashones (1991).**

From the same table and Figure (3) it could be seen that lead, aluminum and zinc of fresh tomato juice were 105, 60 and 65 ppb, respectively. These results were less than either the recommended national and international standard, or the results obtained **Villanuev, (1985), Kula & Losota (1986) and Romieu, et al. (1994)**.

Table (1): Chemical constituents of tomato juice and tomato sauces.

	Total solids (%)	Total soluble solids (%)	Reducing sugar (%)	Total sugars (%)	Total acidity (%)	pH value	Ash (%)	Serum color*	Browning index**	Lead ppb	Aluminum ppb	Zinc ppb
Fresh tomato juice	6.15	5.3	2.43	3.76	0.43	3.9	0.323	91.2	0.08	105	60	65
Chilli tomato sauce	27.35	22.1	3.26	16.28	1.84	3.4	3.753	65.7	0.13	460	203	213
Semi hot tomato sauce	27.92	22.3	3.23	16.37	1.87	3.3	3.327	66.2	0.15	475	210	216
Hot tomato sauce	28.35	22.6	3.18	16.51	1.82	3.5	2.981	67.5	0.16	493	215	220

* Transmission at 420 nm. ** Optical density (O.D) at 420 nm.

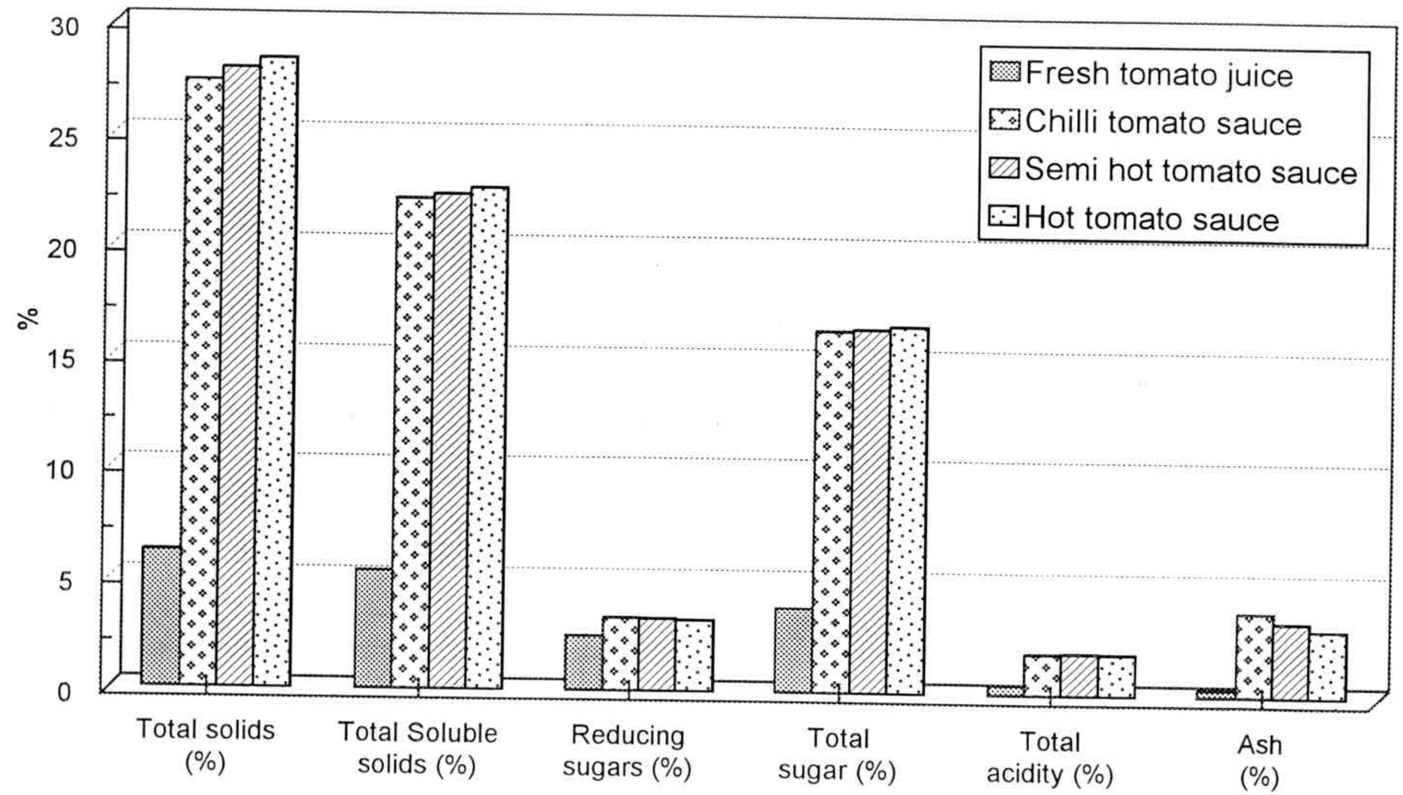

Fig. (1): Chemical constituents of tomato and tomato sauces.

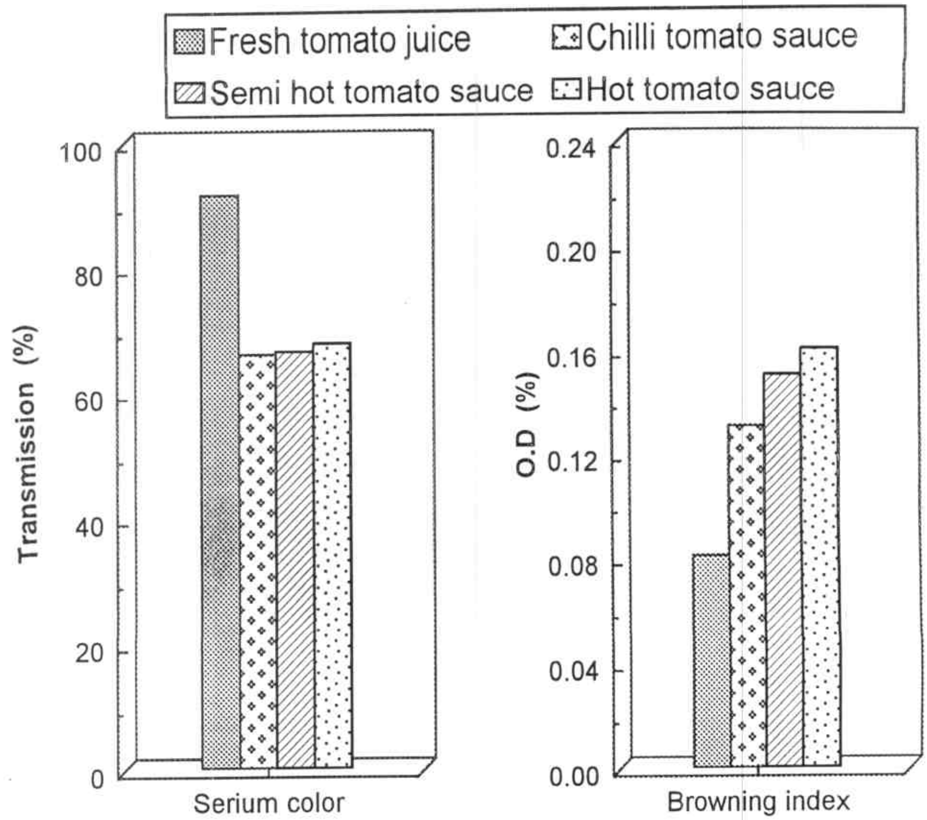

Figure (2): Serum color and browning index of tomato and tomato sauces.

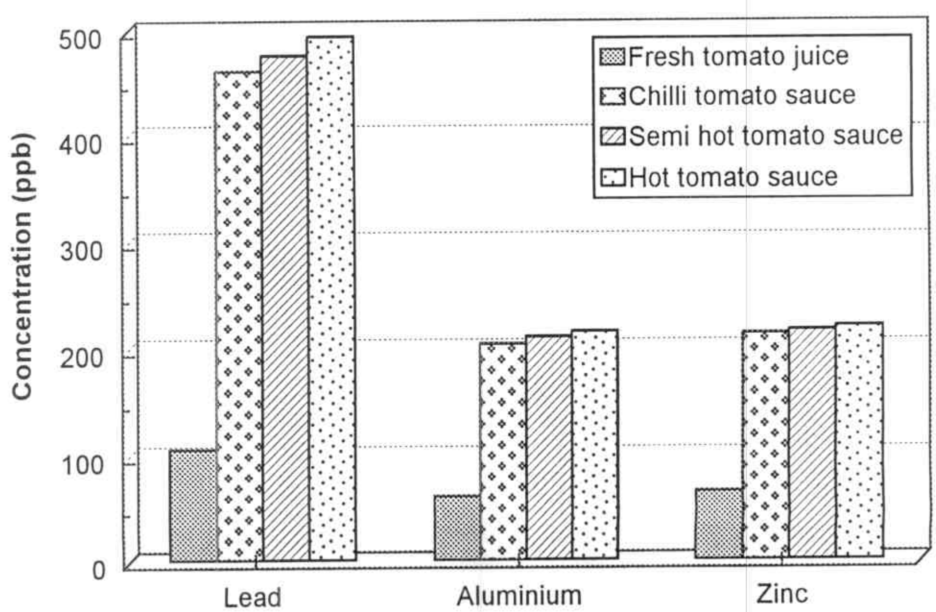

Figure (3): Minerals content of tomato and tomato sauces.

Tomato sauces contain sugars, onion, garlic, spices and pepper **(Wilbur, 1983, and Ramirez, et al. 1990)**. So, the total solids were raised from 6% to 27%. Data in Table (1) and Fig. (1) showed that total solids were 27.35%, 27.99% and 28.35% for treatments A (chilli tomato sauce), B (semi hot tomato sauce) and C (hot tomato sauce) respectively. It could be concluded that hot tomato sauce has the highest total solids this due to that the hot tomato sauce had more dried pepper than semi hot tomato sauce and chilli sauce had no dried pepper. Consequently, the data showed also that total soluble solids were higher in hot sauce than chilli and semi hot tomato sauces whereas they contain 22.6%, 22.1% and 22.3% respectively.

Reducing sugar in tomato sauces show a slight increase than fresh tomato, whereas total sugars were higher than fresh tomato this due to that sucrose was added to sauces and also non reducing sugars from different ingredient , also there is no heating was carried out during mixing to change non reducing to reducing sugar. Data in Table (1) and Fig. (1) showed that reducing sugar was 3.26%, 3.23% and 3.18% for chilli, semi hot and hot tomato sauces respectively. Whereas total sugars were 16.28%, 16.37% and 16.5% for chilli, semi hot and hot tomato sauces respectively.

Sauces were processed with adding acetic acid, so this due to increment the total acidity and decrease the pH value. Results in Table (1) and Figure (1) showed that the total acidity percentage was 0.43%, 1.84%, 1.87% and 1.82% for tomato juice, chilli, semi hot and hot tomato sauces, respectively. Consequently pH value were 3.9, 3.4, 3.5 and 3.5 for fresh tomato chilli, semi hot and hot tomato sauces, respectively.

Sauces contained tomato sodium salts and spices, which raised the ash content in the sauces product. Results in Table (1) and Fig (1) showed that the ash content was 0.323%, 3.753%, 3.327% and 2.981% for tomato juice, chilli, semi hot and hot tomato sauces, respectively.

Serum color of tomato juice and/or tomato sauces is an important quality factor, susbended matter are responsible for the cloud serum color in serum of products after diluted and centrifugated. The serum color depend on the change of high insoluble molecules to small insoluble ones. Serum color is measured by the transmission at 420 nm. Data from Table (1) and Figure (2) showed that the serum color of tomato juice, chilli, semi hot and hot tomato sauces were 91.2%, 65.7%, 66.2% and 67.5% respectively. These results clear that juice had a high weight molecules but in tomato sauces had a small soluble molecules from fine powder added which case a turbidity and low transmission.

Browning index of tomato products is a very important quality factor, carotenoids (Lycopene and carotene) are responsible for red and or orange colors in tomato. The color of tomato products changes from acceptable red to rejected brown which is mainly due to enzymatic reactions, while other products due to non enzymatic reaction **(O' Beirne, 1986 and Shaw & Mashanas 1991)**. Browning index is measured by the optical density at 420 nm. From table (1) and figure (2) it could be seen that the browning index were 0.08, 0.13, 0.15 and 0.16 for tomato juice, chilli, semi hot and hot tomato juices, respectively.

Heavy metals especially lead, zinc and aluminum are contaminated foods from different sources, these menials are very dangerous specially if increased than regulated standard laws. It could be seen from Table (1) that the level of lead, aluminum and zinc were lower than the international laws. It could be concluded that hot tomato sauce and semi hot sauce were higher in minerals that chilli sauces , this may be due to the mineral content in dried hot pepper and also the sauces were higher than tomato juice because the spices and another ingredient were added to sauces had high level of these minerals.

4.1.2. Chemical constituents of tomato sauces during storage in different packaging materials:

tomato sauces were packed in glass jar and aluminum tube packs then pasteurized and storage in ambient temperature (20-30 °C) for 12 months, chemical, microbiological and organoleptic evaluation were carried out every three months **(Robe, 1991)**.

4.1.2.1. Total solids:

Data from Table (2) and Figure (4) showed that the total solids in zero time (after pasteurization) are nearly similar and there is no change in treatments wherever total solids ranged between 27.36% and 28.57% and this small increase due to adding hot pepper in hot tomato sauce. The data also, showed that there is no change occur during storage and the results are fluctuated in different treatments in both packaging materials during storage, wherever the results ranged between 27.36% to 27.50 % in chilli tomato sauce, ranged between 27.95 % and 28.29% in semi hot tomato sauce and ranged between 28.43% to 28.86 % in hot tomato sauce for both glass jar and aluminum tube.

4.1.2.2. Total soluble solids :

Total soluble solids in tomato sauce treatments were determined by suing refractometer. The presented data that given in Table (3) and Figure (5) showed that there is a very slight increment in total soluble solids between treatments in zero time whereas it ranged from 22.3% to 22.8%, but during storage, it could be seen that an increase in all treatments, total soluble solids in chilli tomato sauce increased gradually from 22.3% in zero time to 26.4% after 12 months of storage and from 22.4% in zero time to 26.8% after 12 months of storage in both glass jar and aluminum tube, respectively. The same trend was observed in semi hot tomato sauces and hot tomato sauces whereas an increase gradually from 22.6% to 26.7% from 22.5% to 27.1%, from 22.8% to 27.2% and from 22.7% to 27.5% for semi hot sauces and hot sauces from zero time to after 12 month in both glass jar and aluminum tube, respectively. These may be perhaps due to the degradation of some insoluble solids to soluble solids in acidic media and the period of storage at ambient temperature.

4.1.2.3. Reducing and total sugars:

The obtained results in Table (4) and Figure (6) revealed that there was no change in reducing sugars for all treatments in the beginning of storage, in both packaging materials. But there was an increase in the reducing sugars in tomato sauce treatments which were linear relate to the storage period. Wherever the results showed that in glass jar containers the reducing sugars were increased gradually from 7.36% to 11.35%, from 7.27% to 12.31% and from 7.12 to 10.98% for chilli, semi hot and hot tomato sauces respectively, during

Table (2): Total solids percentage in tomato sauces products stored for 12 months in different packaging materials.

Storage Periods (month)	Glass jar			Aluminum tube		
	Chilli tomato sauce	Semi hot tomato sauce	Hot tomato sauce	Chilli tomato sauce	Semi hot tomato sauce	Hot tomato sauce
0	27.39	27.99	28.43	27.36	27.95	28.57
3	27.40	28.21	28.44	27.48	27.98	28.59
6	27.43	28.15	28.52	27.41	27.98	28.63
9	27.41	28.29	28.49	27.45	28.85	28.86
12	27.46	28.24	28.53	27.50	28.13	28.75

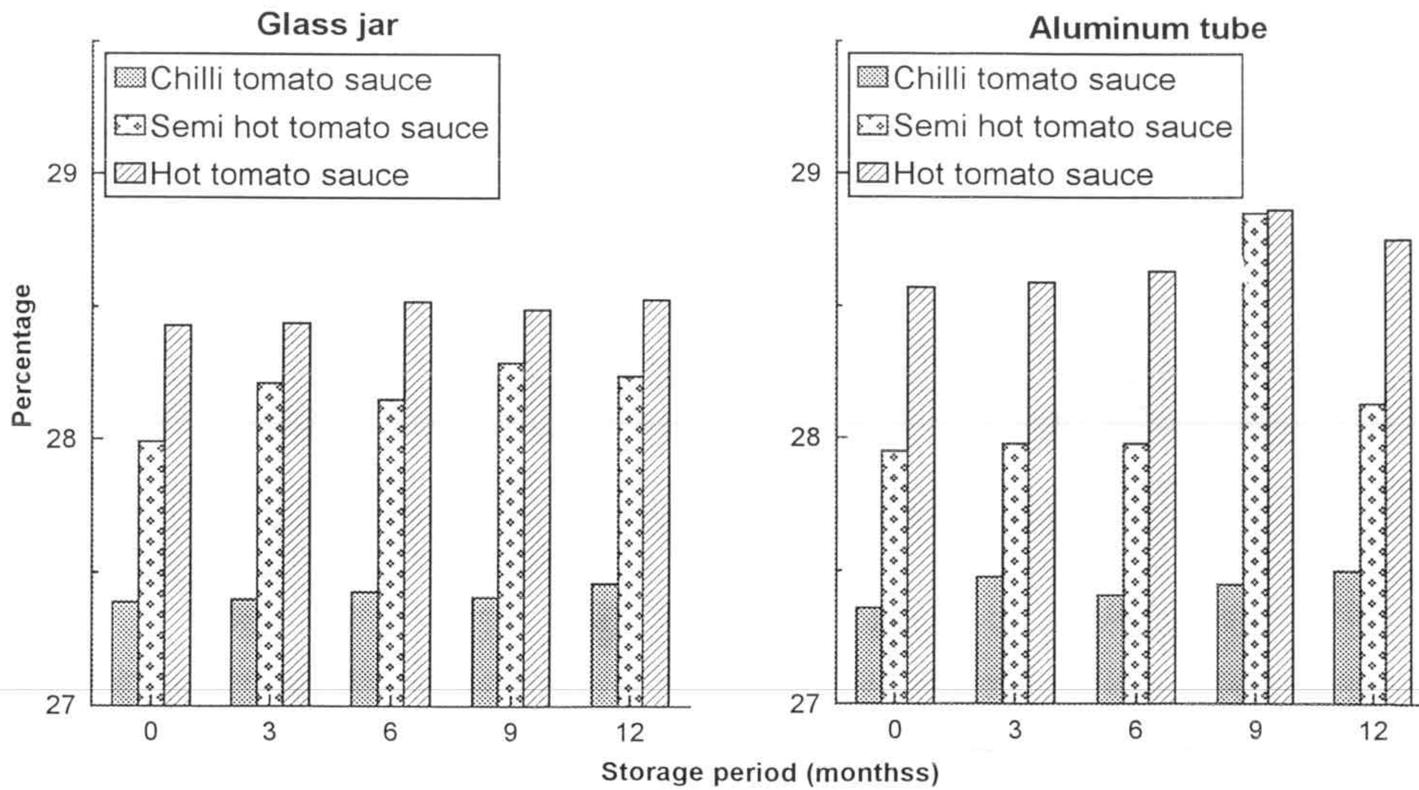

Figure (4): Total solids percentage in tomato sauces products stored for 12 months in different packaging materials.

Table (3): Total soluble solids percentage in tomato sauces products stored for 12 months in different packaging materials.

Storage Periods (month)	Glass jar			Aluminum tube		
	Chilli tomato sauce	Semi hot tomato sauce	Hot tomato sauce	Chilli tomato sauce	Semi hot tomato sauce	Hot tomato sauce
0	22.3	22.6	22.8	22.4	22.5	22.7
3	22.9	23.1	23.4	23.1	23.2	23.4
6	23.7	24.0	24.3	23.8	24.1	24.3
9	24.9	25.1	25.6	25.1	25.4	25.8
12	26.4	26.7	27.2	26.8	27.1	27.5

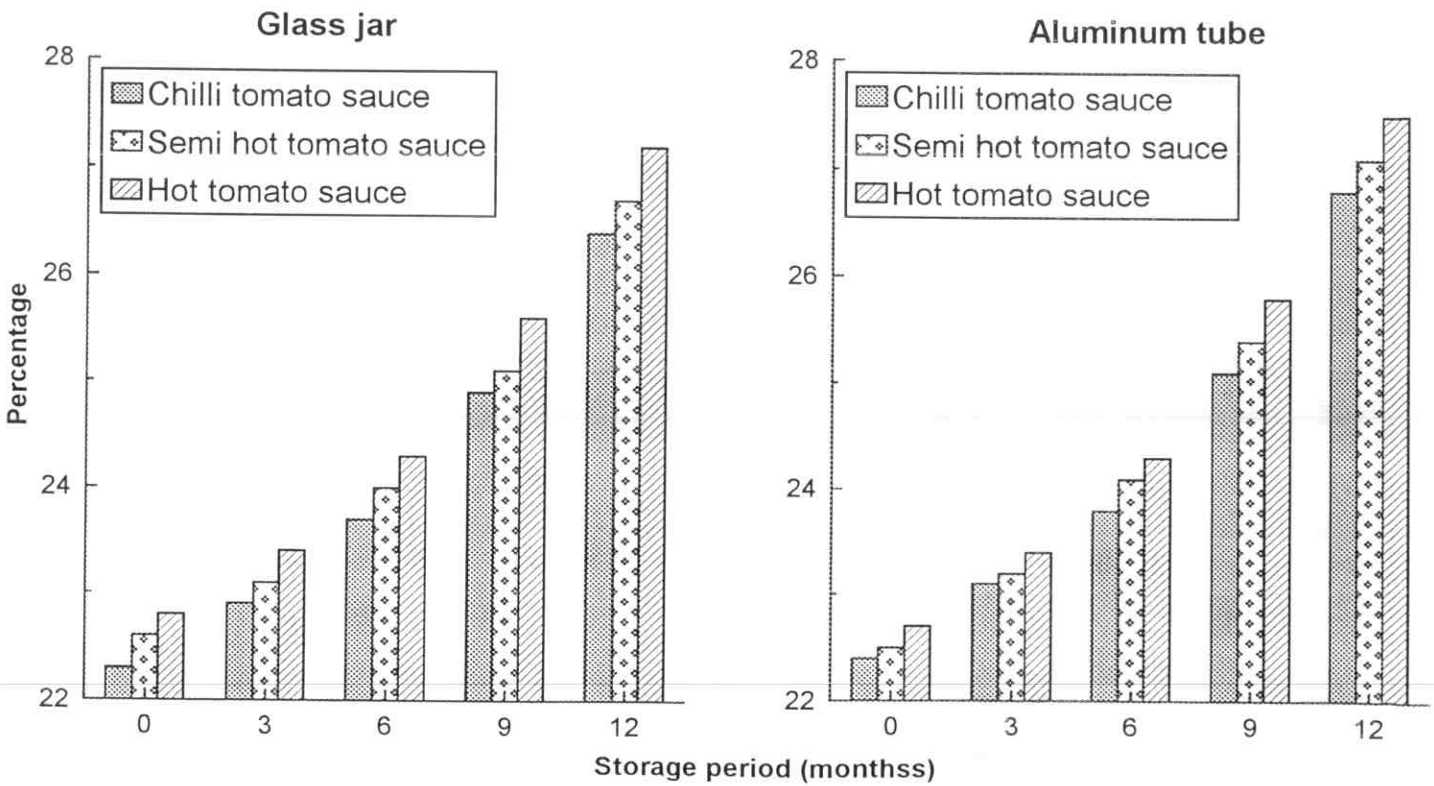

Figure (5): Total soluble solids percentage in tomato sauces products stored for 12 months in different packaging materials.

storage for 12 months, whereas storage in aluminum tube containers the reducing sugars increased from 7.73% to 11.55%. from 7.65% to 12.36% and from 7.52% to 11.50 5 for chilli semi hot and hot tomato sauces, respectively during storage for 12 months. The increase in reducing sugars may be attributed to the hydrolysis of the sucrose and non reducing sugars under the storage conditions to reducing sugar.

Total sugars of different tomato sauces packaging in glass jar and aluminum tube were studied during storage for 12 months at room temperature (Table 5) and (Figure 7). It could be noticed that there were no different appear in different treatments packaging in both glass jar and aluminum tube in the beginning of storage , but there were slightly decreased during the whole period of storage (12 months) for all the tested samples which were decreased from 16.18% to 16.10%, from 16.36% to 16.26% and from 16.49% to 16.38% for chilli, semi hot and hot tomato sauces packaging in glass jar, respectively in the end of storage periods (12 months), whereas total sugars decreased from 16.17% to 16.11%, from 16.35% to 16.24 % and from 16.48% to 16.37% for chilli, semi hot and hot tomato sauces packaging in aluminum tube, respectively at the end of storage periods (12 months). This may be due to that Millard brown reaction between reducing sugar react and amino acids.

4.1.2.4. Total acidity and pH value:

With respect to the slight fluctuated changes in acidity and pH during storage under the tested condition, Table (6) and Figure (8) also, Table (7) and Figure (9) showed that a fluctuated results with a slight increase in the end of storage in acidity for all treatments and a fluctuated results with slight

Table (4): Reducing sugars percentage in tomato sauce products stored for 12 months in different packaging materials.

Storage Periods (month)	Glass jar			Aluminum tube		
	Chilli tomato sauce	Semi hot tomato sauce	Hot tomato sauce	Chilli tomato sauce	Semi hot tomato sauce	Hot tomato sauce
0	7.54	7.46	7.32	7.54	7.46	7.32
3	8.00	8.90	7.65	8.32	8.27	8.45
6	8.82	8.85	8.59	9.19	9.95	9.39
9	9.97	10.82	9.83	10.21	10.92	10.61
12	11.35	12.31	10.98	11.55	12.36	11.50

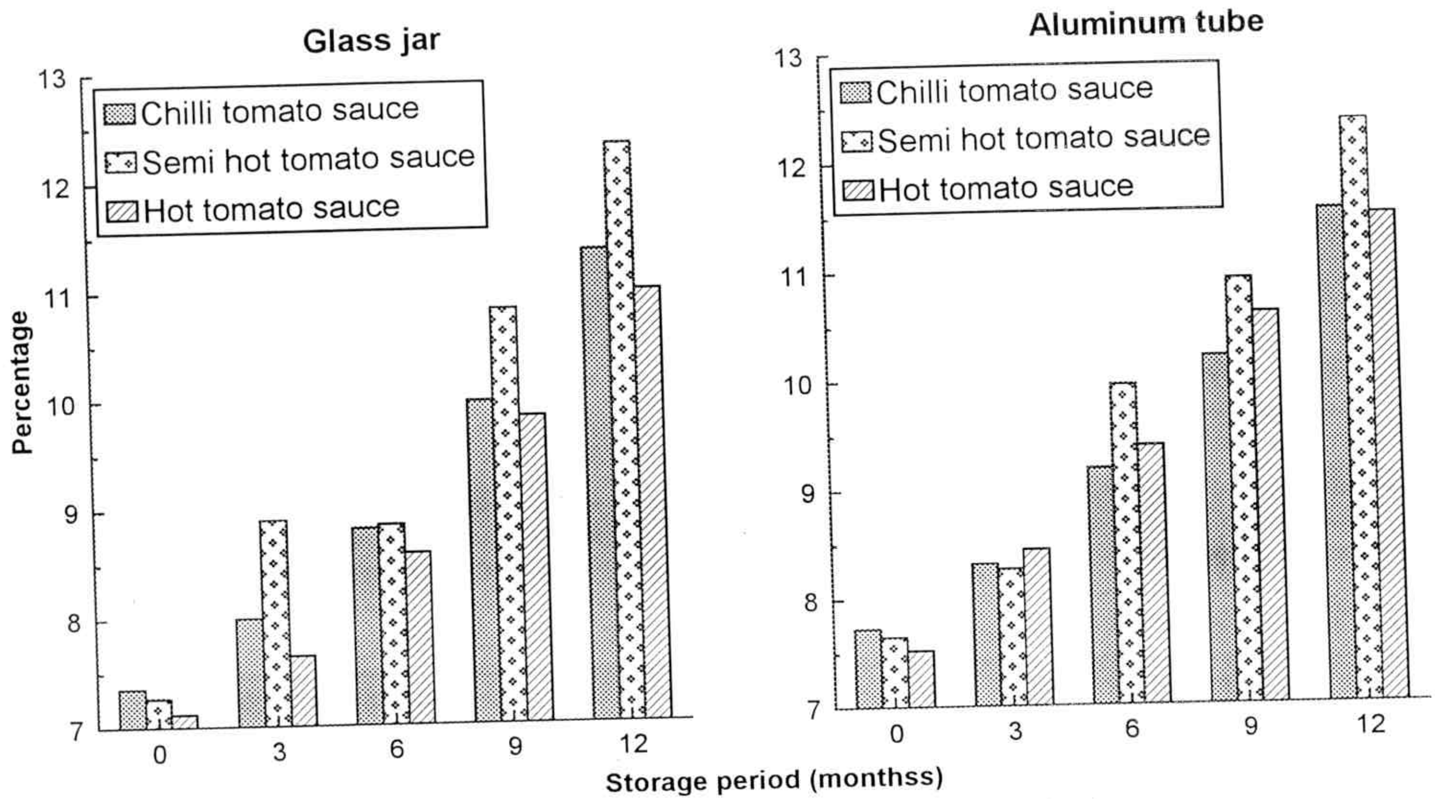

Figure (6): Reducing sugars percentage in tomato sauces products stored for 12 months in different packaging materials.

Table (5): Total sugars percentage in tomato sauce products stored for 12 months in different packaging materials.

Storage Periods (month)	Glass jar			Aluminum tube		
	Chilli tomato sauce	Semi hot tomato sauce	Hot tomato sauce	Chilli tomato sauce	Semi hot tomato sauce	Hot tomato sauce
0	16.18	16.36	16.49	16.17	16.35	16.48
3	16.17	16.34	16.45	16.16	16.38	16.45
6	16.18	16.30	16.47	16.18	16.33	16.48
9	16.14	16.32	16.46	16.13	16.30	16.44
12	16.10	16.26	16.38	16.11	16.24	16.37

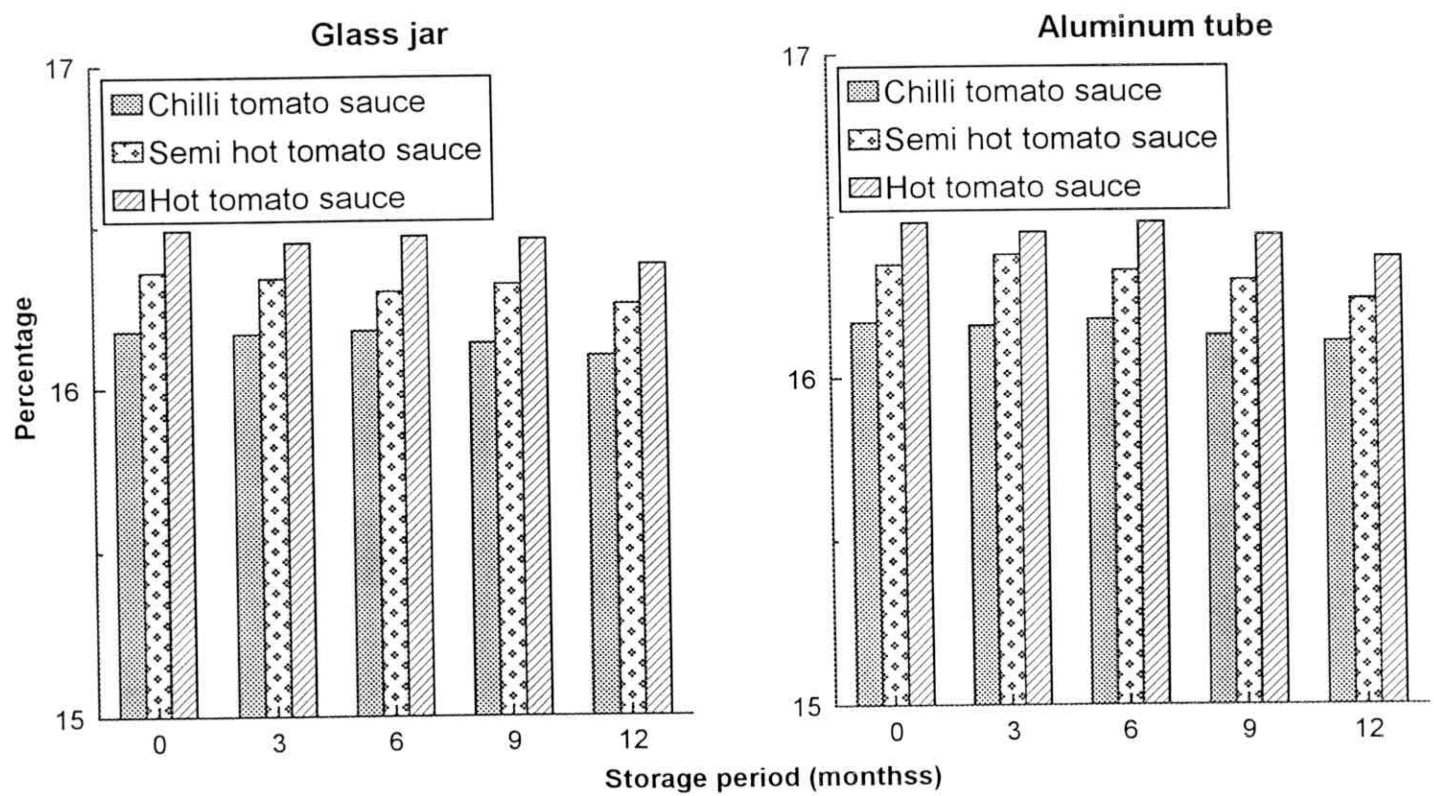

Figure (7): Total sugars percentage in tomato sauces products stored for 12 months in different packaging materials.

decrease in the end of storage (12 months) in pH values for all treatments. The obtained data showed that there is no different in acidity and/or pH between treatments in different packaging at the beginning of storage, but an increase acidity and decrease in pH showed between zero time and the end of storage (12 months) wherever the increase of acidity from 1.86 % to 1.96%, from 1.88% to 1.99% and from 1.84% to 1.96% for chilli, semi hot and hot tomato sauces packaging in glass jar, respectively as well as from 1.85% to 1.95%, from 1.89% to 2.01% and from 1.83% to 1.96% for chilli, semi hot and hot tomato sauces packaging in aluminum tube, respectively. Data in Table (7) showed decrease in pH values during storage from 3.3 to 3.2, 3.2 to 3.1 and from 3.4 to 3.2 for chilli, semi hot and hot tomato sauces packaging in glass jar, respectively and from 3.3 to 3.1, from 3.2 to 3.0 and from 3.4 to 3.2 for chilli, semi hot and hot tomato sauces packaging in aluminum tube, respectively.

4.1.2.5. Serum color:

Serum color means cloudiness it is considered an important factor for tomato sauces. The higher percent transmission, the lower and less desirable the cloud, therefore changes in serum color of different treatments during storage are shown in Table (8) and Figure (10) it could be noticed that there was a continuos decrease in serum color of the concentrates with the progress in the storage period. The available data given in the same table showed that serum color was changed to higher values by extending storage period. With respect to the tabulated data, the results showed that the serum color of tomato sauces were decreased from 65.1% to 61.72%, from 65.6% to 58.1% and from 66.9% to 58.8% for tomato

Table (6): Total acidity percentage in tomato sauces products stored for 12 months in different packaging materials.

Storage Periods (month)	Glass jar			Aluminum tube		
	Chilli tomato sauce	Semi hot tomato sauce	Hot tomato sauce	Chilli tomato sauce	Semi hot tomato sauce	Hot tomato sauce
0	1.86	1.88	1.84	1.85	1.89	1.83
3	1.85	1.90	1.88	1.84	1.90	1.85
6	1.89	1.95	1.91	1.88	1.95	1.82
9	1.91	1.93	1.90	1.89	1.93	1.89
12	1.96	1.99	1.96	1.95	2.01	1.96

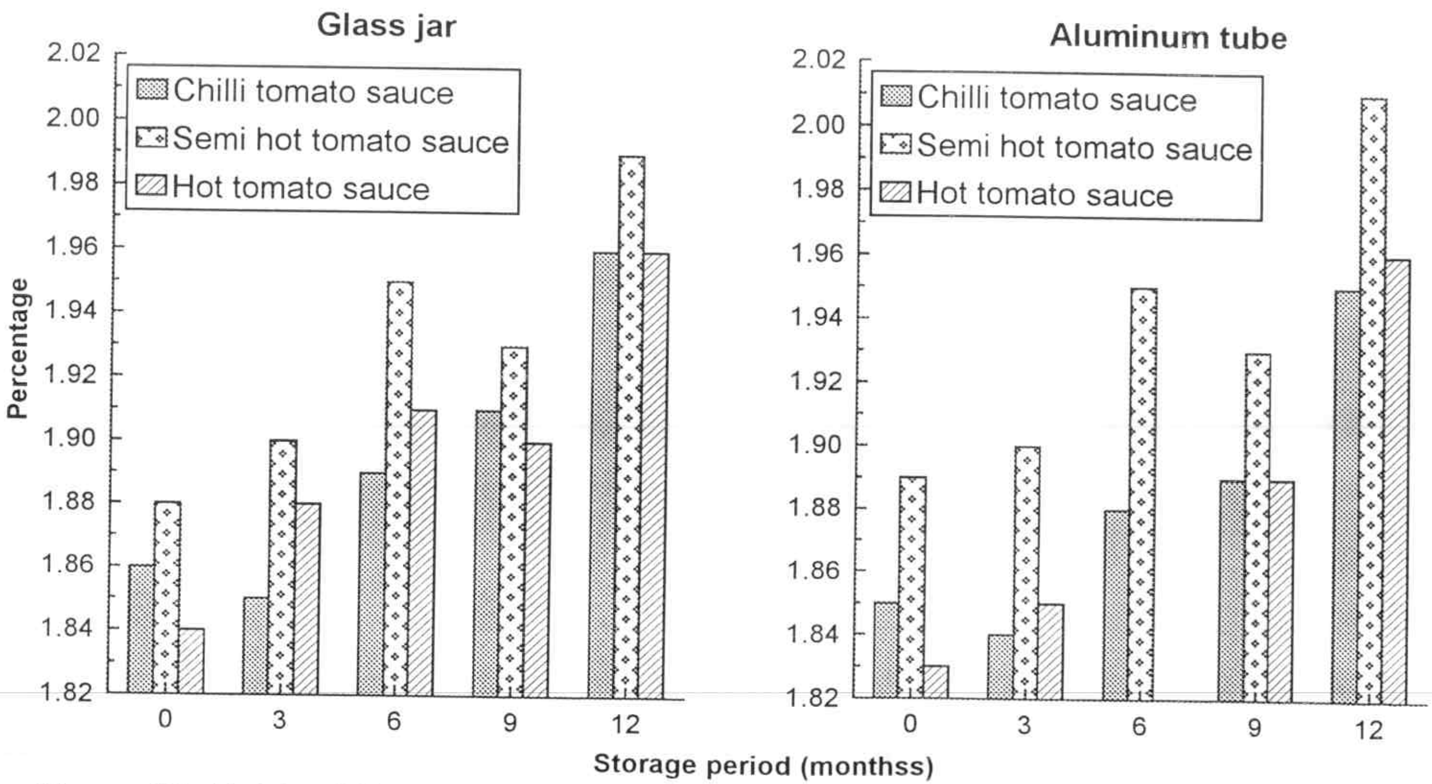

Figure (8): Total acidity percentage in tomato sauces products stored for 12 months in different packaging materials.

Table (7): pH values in tomato sauces products stored for 12 months in different packaging materials.

Storage Periods (month)	Glass jar			Aluminum tube		
	Chilli tomato sauce	Semi hot tomato sauce	Hot tomato sauce	Chilli tomato sauce	Semi hot tomato sauce	Hot tomato sauce
0	3.3	3.2	3.4	3.3	3.2	3.4
3	3.4	3.3	3.3	3.3	3.2	3.4
6	3.3	3.2	3.3	3.2	3.1	3.3
9	3.3	3.2	3.2	3.1	3.1	3.3
12	3.2	3.1	3.2	3.1	3.0	3.2

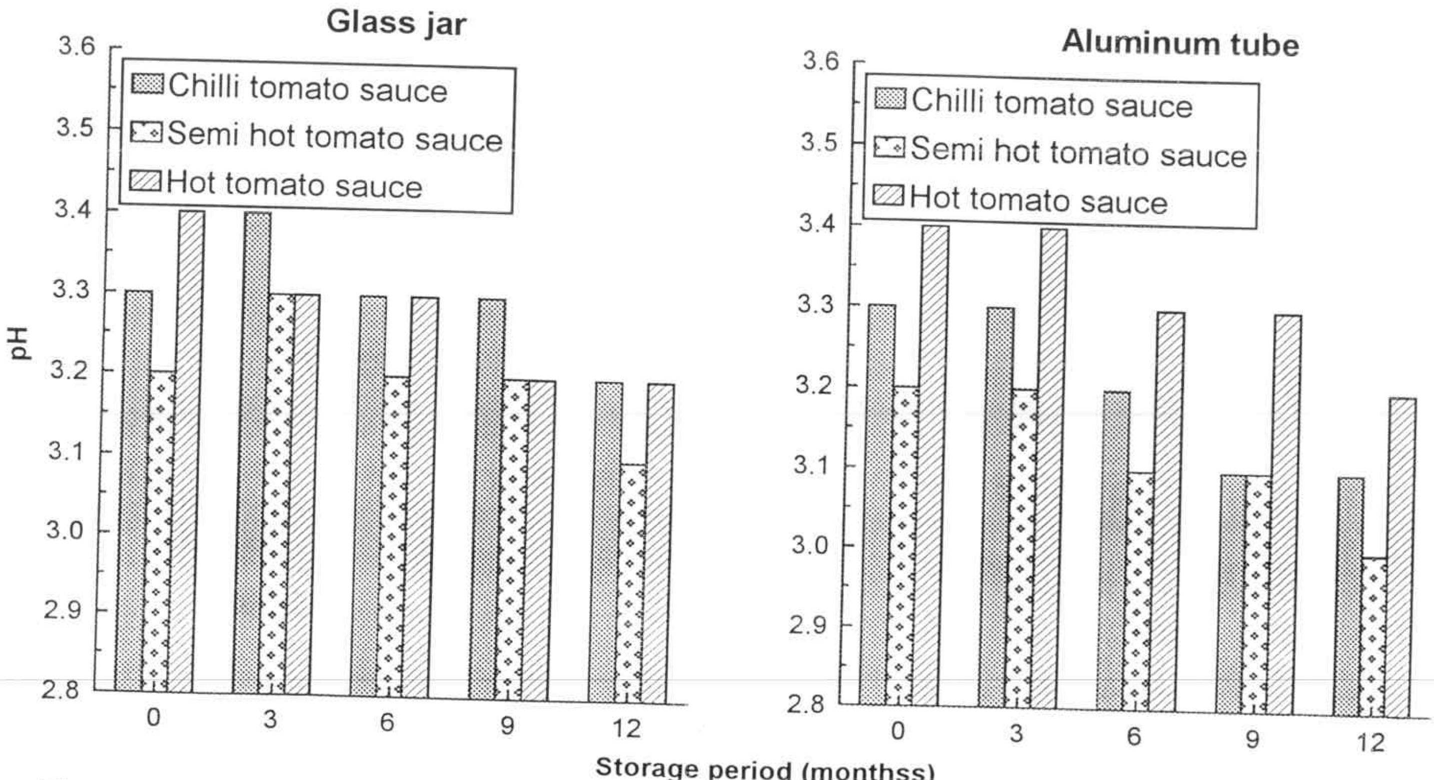

Figure (9): pH values in tomato sauces products stored for 12 months in different packaging materials.

sauces A, B and C treatments, respectively, packaging in glass jar, while samples packaging in aluminum tube the decrement of serum color were from 65.2% to 61.2%, from 65.8% to 58.0% and from 67.0% to 58.7% for tomato sauces A, B and C treatments, respectively. These decrement of transmission may be due to increase in clowdly moleculed suspended in serum which increased by increasing of changes high molecule to small molecule during storage.

4.1.2.6. Browning index:

The non enzymatic browning reaction are generally believed to cause a brown color, this is mainly based on the well- known correlation of browning increment with the prolongation of storage time and temperature **(Trammell et al. 1986)**. Changes in browning index (as O.D. at 420 nm) of the tested tomato sauces treatments are given in Table (9). The percentage of brown increment of tomato sauces during storage was shown also in the same Table (9) and Figure (11). The obtained data show that the increment in optical density was from 0.142 to 0.157, from 0.162 to 0.179 and from 0.174 to 0.196 for tomato sauces treatments packaging in glass jar during storage, respectively. Whereas browning index of tomato sauces treatments packaging in aluminum tube increased from 0.143 to 0.160, from 0.163 to 0.183 and from 0.175 to 0.199 for tomato sauces treatments during storage, respectively. These results for brown increment during storage in both glass jar and aluminum tube may be due to enzymatic browning reaction and/or non-enzymatic browning reaction and/or ascorbic acid degradation **(Miki, 1974; Babie et al. 1993; Bian et al. 1994; Bolin and Steele, 1987; O'Beirne, 1986 and Show and Moshonas, 1991)**

Table (8): Transmission and decrement percentage of tomato sauce products stored for 12 months in different packaging materials .

Storage Periods (month)	Glass jar						Aluminum tube					
	Chilli tomato sauce		Semi hot tomato sauce		Hot tomato sauce		Chilli tomato sauce		Semi hot tomato sauce		Hot tomato sauce	
	% Serum color*	% decre-ment	% Serum color	% decre-ment	% Serum color	% decre-ment	% Serum color	% decre-ment	% Serum color	% decre-ment	% Serum color	% decre-ment
0	65.10	0.91	65.6	0.91	66.9	0.90	65.8	0.76	65.8	0.61	67.0	0.74
3	64.30	2.13	64.4	2.72	66.1	2.07	64.5	1.83	64.8	2.11	66.2	1.93
6	63.40	3.50	62.9	5.00	64.7	4.15	63.7	3.05	62.7	5.29	64.5	4.45
9	62.60	4.72	60.9	8.01	62.1	8.00	62.9	4.26	60.0	9.37	61.4	9.04
12	61.72	7.00	58.1	12.23	58.8	12.89	61.2	6.85	58.0	12.39	58.7	13.04

* Transmission at 420 nm.

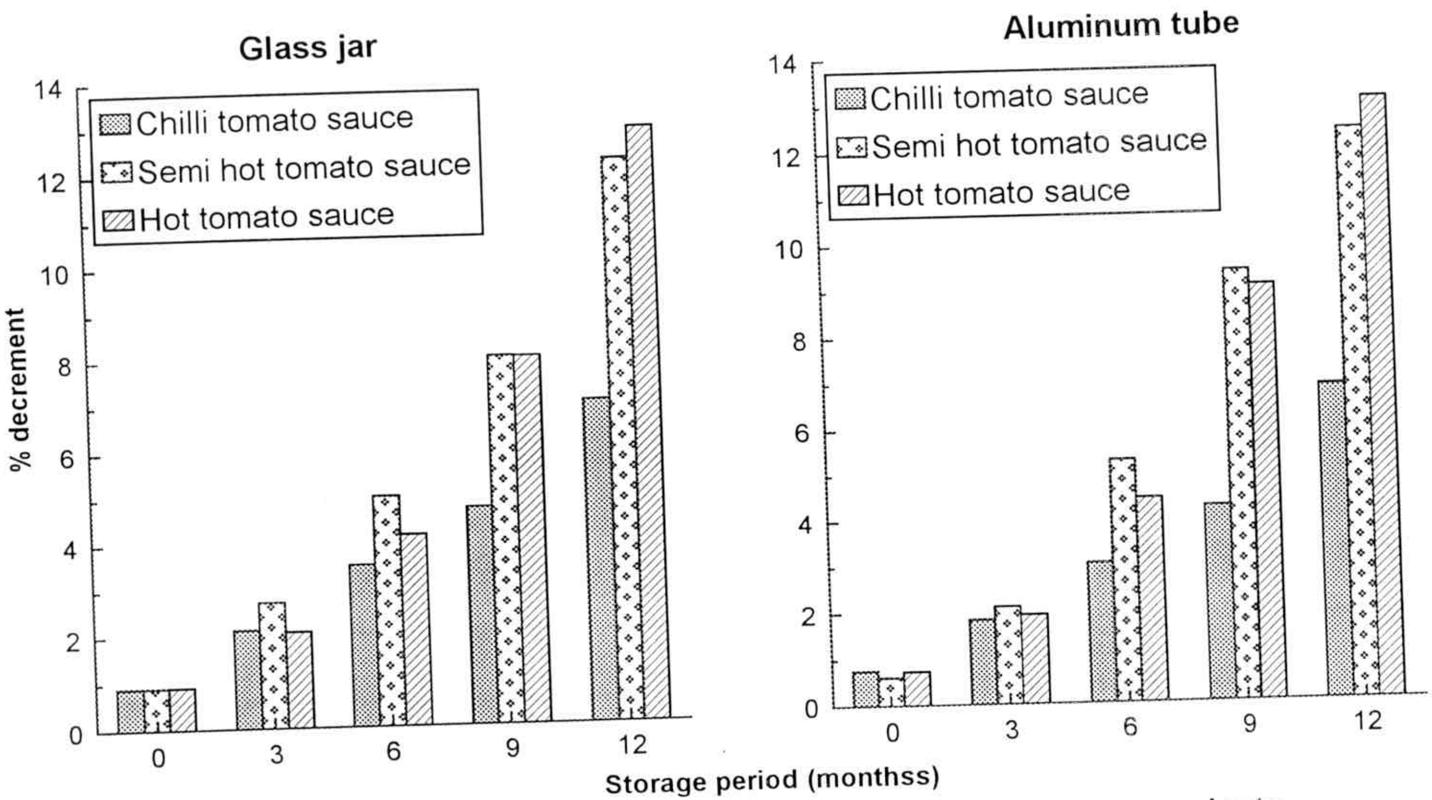

Figure (10): Percentage drecement of serum color in tomato sauces products stored for 12 months in different packaging materials.

Table (9): Browning index and increment percentage in tomato sauce products stored for 12 months in different packaging materials.

Storage Periods (month)	Glass jar						Aluminum tube					
	Chilli tomato sauce		Semi hot tomato sauce		Hot tomato sauce		Chilli tomato sauce		Semi hot tomato sauce		Hot tomato sauce	
	O.D Serum color	O.D incre-ment	O.D Serum color	O.D incre-ment	O.D Serum color	O.D incre-ment	O.D Serum color	O.D incre-ment	O.D Serum color	O.D incre-ment	O.D Serum color	O.D incre-ment
0	0.142	2.90	0.162	3.18	0.174	4.800	0.143	3.02	0.163	3.80	0.175	5.42
3	0.143	3.62	0.162	3.18	0.175	5.145	0.143	3.62	0.164	4.27	0.175	5.42
6	0.145	4.83	0.165	4.85	0.177	6.210	0.146	5.48	0.167	6.00	0.178	6.74
9	0.150	8.00	0.171	8.18	0.185	10.270	0.152	9.21	0.173	9.29	0.187	11.23
12	0.157	12.10	0.179	12.29	0.196	15.310	0.160	13.75	0.183	14.21	0.199	16.58

O.D = Optical density

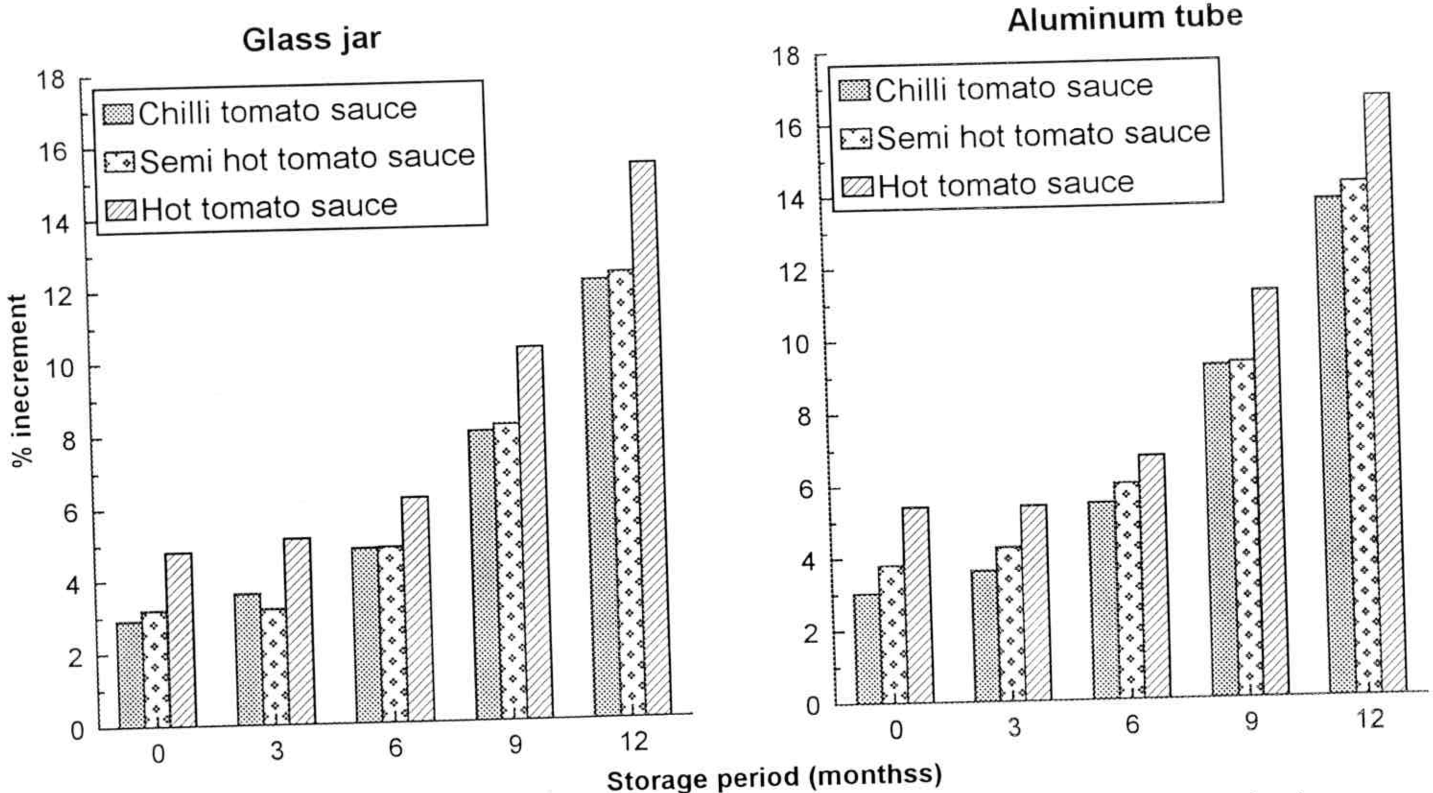

Figure (11):Increment percentage of browning index in tomato sauces products stored for 12 months in different packaging materials.

4.1.2.7. Minerals :

Aluminum, zinc and lead were determined in ash of treatments A, B and C tomato sauces samples packaging in both glass jars and aluminum tubes during storage periods the concentrate of minerals were estimated as ppb. Data presented in Table (10). Aluminum is one of minerals which contaminate the products. The main sources are raw materials, packaging and environment. Data from Table (10) and Figure (12) showed that aluminum in different samples ranged from 206 ppb to 218 ppb at zero storage time while it ranged from 210 ppb to 245 ppb after 12 months of storage. This result is considered a fluctuated results in glass jars, but it a slight increase in aluminum tube, may be due to immigration of aluminum from the packaging materials to the tomato sauces **(Mueller et al. 1993)**. Lead also, was high content I tomato sauce samples as presented in Table (10) and Figure (13) which it ranged from 462 ppb to 493 ppb at zero time, but after 12 months of storage lead ranged from 508 ppb to 513 ppb, this slight increment during storage may be due to the increasing the acidity **(Noirfaise and collinge, 1984; Soni et al. 1986; Hyldon and Bhatia, 1989 and Romieu et al. 1994)**. Data in the same table and Figure (14) showed the zinc concentrate in different tomato sauces treatments which it ranged from 215 ppb to 219 ppb in the beginning of storage but after 12 months of storage zinc concentrate ranged from 218 ppb to 223 ppb, the results nearly indicate that products did not had an increase or decrease in zinc **(Noirfaise and collinge, 1984, and Kola and Lasota, 1986)**.

Table (10): Mineral content (ppb) in tomato sauce products stored for 12 months in different packaging materials.

Storage periods (month)	Minerals	Glass jar			Aluminum tube		
		Chilli tomato sauce	Semi hot tomato sauce	Hot tomato sauce	Chilli tomato sauce	Semi hot tomato sauce	Hot tomato sauce
0	Aluminum	206	210	208	213	216	218
	Lead	462	478	495	463	479	493
	Zinc	216	215	219	215	215	219
3	Aluminum	205	211	208	215	216	220
	Lead	470	486	496	465	482	495
	Zinc	213	217	220	217	218	218
6	Aluminum	207	211	210	221	227	226
	Lead	479	491	496	471	492	492
	Zinc	218	214	218	216	216	219
9	Aluminum	209	213	209	228	233	232
	Lead	491	509	507	473	490	499
	Zinc	219	216	219	218	220	222
12	Aluminum	210	215	212	237	242	245
	Lead	508	517	514	510	521	513
	Zinc	218	219	223	218	221	223

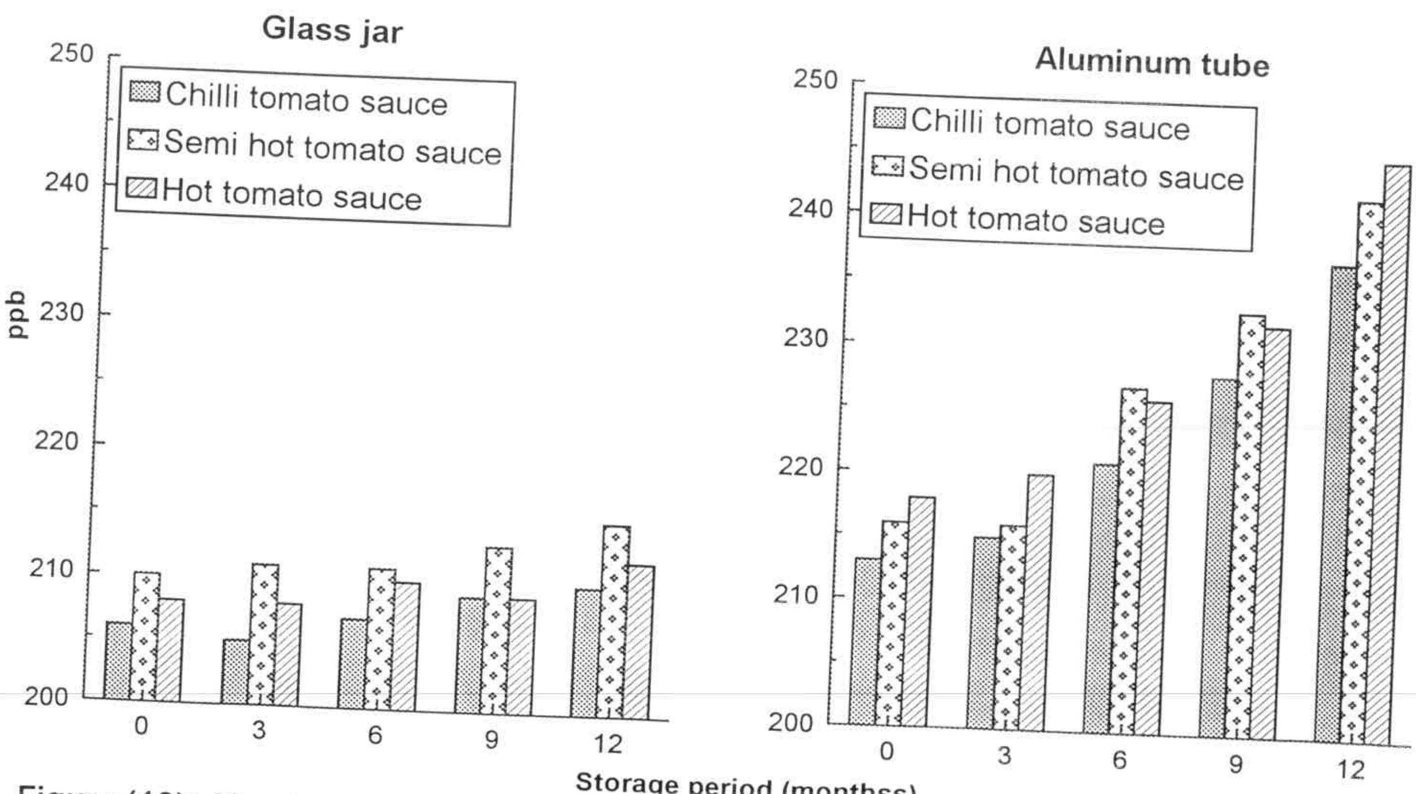

Figure (12): Aluminum content (ppb) in tomato sauces products stored for 12 months in different packaging materials.

4.1.3. Organolyptic Evaluation:

Data of tables (11, 12, 13 and 14) show the mean scores of organolyptic evaluation (color, odor, taste and over all acceptability).

Statistical analysis indicated that scores of color decreased significantly ($p < 0.05$) after 6 months storage period. There was no significant difference ($p > 0.05$) in color scores of semi hot and hot tomato sauces which have the highest scores (18.82 and 18.86, respectively).

In the same time chilli tomato sauce obtained the lowest score (18.65) and differed significantly ($P < 0.05$) from the other two products.

With respect to the packaging material, there was significant difference ($P < 0.05$) between tomato sources packed in glass jars (18.87) and aluminum tube (18.88). Analysis of variance is summarized in Table (15).

Concerning to odor, there are a significant differences ($P<0.05$) between mean values of odor due to the effect of storage period, it means that the storage period is important on the odor of tomato sauces. On the other hand, there are a significant differences ($P < 0.05$) between glass jars and aluminum tubes and there are a significant differences ($P<0.05$) between hot tomato sauces and both chilli tomato sauces and semi hot tomato sauces, whereas, there is no significant differences ($P > 0.05$) between chilli tomato sauces and semi hot tomato sauces. Analysis of variance is summarized in Table (15).

For the taste, there are a significant differences between ($P<0.05$) mean values of tomato taste due to the effect of storage period and there is no significant differences ($P>0.05$) between glass jars and aluminum tubes. On the other hand, there are a significant differences ($P<0.05$) between hot tomato sauces and both of chilli tomato sauces and semi hot tomato sauces, whereas, there is no significant differences ($P<0.05$) between chilli tomato sauces and semi hot tomato sauces. Analysis of variance is summarized in Table (15).

Concerning the over all acceptability, there are a significant differences ($P<0.05$) mean values of over all acceptability due to the effect of storage period and there are significant differences ($P<0.05$) between glass jar and aluminum tubes, on the other hand, there are a significant differences ($P<0.05$) between hot tomato sauces and both of chilli tomato sauces and semi hot tomato sauces. Whereas, there are no significant differences ($P>0.05$) between chilli tomato sauces and semi hot tomato sauces. Analysis of variance is summarized in Table (15).

Finally, it can be concluded that the best packaging materials is the glass jars.

4.1.4. Microbial count:

The obtained lower bacterial load could be attributed to the various factors, so the tomato sauces products were processed under control of sanitation beginning from fruits to storage tomato sauces after pasteurization. Data from Table (16) showed a high total bacterial count as well as mold and yeast after harvesting, but the bacterial load was reduced after processed to different tomato sauces. Whereas after flash pasterized and packaging under sterilized condition then pasterilized the packaging with products the bacterial load was

Table (11): Mean of color scores for tomato sauce products stored for 12 months in different packaging materials.

Storage period (months)	Tomato sauce products					
	Chilli tomato sauce packed in		Semi hot tomato sauce packed in		Hot tomato sauce packed in	
	Glass jars	Aluminum tubes	Glass jars	Aluminum tubes	Glass jars	Aluminum tubes
0	19.20	19.57	19.43	19.63	19.53	19.50
3	19.03	19.43	19.20	19.40	19.40	19.30
6	18.57	18.93	18.97	19.00	19.10	18.97
9	17.93	18.33	18.37	18.57	18.43	18.43
12	17.53	18.00	17.60	18.03	17.77	18.17

Mean of main factors:

1- Storage period:

Storage period	Mean
0	19.48 a
3	19.29 a
6	18.93 b
9	18.34 c
12	17.85 d

L.S.D (P<0.05) = 0.192

2- Tomato sauce products:

Tomato sauce products	Mean
Chilli tomato sauce	18.65 b
Semi hot tomato sauce	18.82 a
Hot tomato sauce	18.86 a

L.S.D (P<0.05) = 0.149

3- Packaging materials	Mean
Aluminum tubes	18.67 b
Glass jar	18.88 a

L.S.D (P<0.05) = 0.122

There is no significance difference (P>0.05) between any two means, within the same factor, have the same superscript letter.

Table (12): Mean of odor scores for tomato sauce products stored for 12 months in different packaging materials.

Storage period (months)	Tomato sauce products					
	Chilli tomato sauce packed in		Semi hot tomato sauce packed in		Hot tomato sauce packed in	
	Glass jars	Aluminum tubes	Glass jars	Aluminum tubes	Glass jars	Aluminum tubes
0	19.27	19.27	19.47	19.43	19.63	19.53
3	19.13	19.03	19.33	19.03	19.33	19.33
6	18.77	18.67	19.10	18.47	18.93	19.10
9	18.50	18.10	18.50	18.00	18.80	18.73
12	18.70	17.50	18.23	17.57	18.47	18.40

Mean of main factors:

1- Storage period:

Storage period	Mean
0	19.43 a
3	19.20 b
6	18.84 c
9	18.44 d
12	18.06 e

L.S.D (P<0.05) = 0.186

2- Tomato sauce products:

Tomato sauce products	Mean
Chilli tomato sauce	18.64 b
Semi hot tomato sauce	18.71 b
Hot tomato sauce	19.03 a

L.S.D (P<0.05) = 0.144

3- Packaging materials

Packaging materials	Mean
Aluminum tubes	18.94 a
3Glass jar	18.68 b

L.S.D (P<0.05) = 0.118

There is no significance difference (P>0.05) between any two means, within the same factor, have the same superscript letter.

Table (13): Mean of taste score for tomato sauce products stored for 12 months in different packaging materials.

Storage period (months)	Tomato sauce products					
	Chilli tomato sauce packed in		Semi hot tomato sauce packed in		Hot tomato sauce packed in	
	Glass jars	Aluminum tubes	Glass jars	Aluminum tubes	Glass jars	Aluminum tubes
0	19.40	19.60	19.50	19.50	19.27	19.27
3	19.23	19.37	19.10	19.13	19.07	18.87
6	18.80	18.77	18.93	18.90	18.77	18.37
9	18.23	18.13	18.63	18.37	18.30	18.00
12	17.73	17.60	18.37	17.87	17.70	17.33

Mean of main factors:

1- Storage period:

Storage period	Mean
0	19.42 a
3	19.13 b
6	18.76 c
9	18.28 d
12	17.77 e

L.S.D (P<0.05) = 0.210

2- Tomato sauce products:

Tomato sauce products	Mean
Chilli tomato sauce	18.69 a
Semi hot tomato sauce	18.83 a
Hot tomato sauce	18.50 b

L.S.D (P<0.05) = 0.163

3- Packaging materials

Packaging materials	Mean
Aluminum tubes	18.74 a
3Glass jar	18.61 a

L.S.D (P<0.05) = 0.133

There is no significance difference (P>0.05) between any two means, within the same factor, have the same superscript letter.

Table (14): Mean of over all acceptability scores for tomato sauce products stored for 12 months *in different* packaging materials.

Storage period (months)	Tomato sauce products					
	Chilli tomato sauce packed in		Semi hot tomato sauce packed in		Hot tomato sauce packed in	
	Glass jars	Aluminum tubes	Glass jars	Aluminum tubes	Glass jars	Aluminum tubes
0	39.33	39.47	39.37	39.40	39.40	39.16
3	39.17	39.30	39.03	38.87	38.93	38.97
6	38.70	38.73	38.77	38.37	38.63	38.13
9	38.27	38.20	38.40	37.97	38.33	37.87
12	38.00	37.80	38.00	37.53	37.80	37.33

Mean of main factors:

1- Storage period:

Storage period	Mean
0	39.36 a
3	38.95 b
6	38.56 c
9	38.18 d
12	37.74 e

L.S.D (P<0.05) = 0.308

2- Tomato sauce products:

Tomato sauce products	Mean
Chilli tomato sauce	38.70 a
Semi hot tomato sauce	38.57 a
Hot tomato sauce	38.40 b

L.S.D (P<0.05) = 0.169

3- Packaging materials	Mean
Aluminum tubes	38.68 a
3Glass jar	38.47 b

L.S.D (P<0.05) = 0.138

There is no significance difference (P>0.05) between any two means, within the same factor, have the same superscript letter.

Table (15): Analysis of variance for degrees of freedom organolyptic evaluation data.

Source of variance	D.F	F-value for			
		Color	Odor	Taste	Over all
Storage periods (A)	4	99.15	68.04	79.31	67.44
Tomato sauce products (B)	2	4.35	17.03	8.61	6.52
Packaging materials (C)	1	12.35	16.62	3.89	12.14
A*B	8	0.32	0.78	1.05	0.49
A*C	4	0.92	1.95	1.17	0.80
B*C	2	3.15	4.22	1.37	3.62
A*B/*C	8	0.16	0.56	0.16	0.18
Error	420				
Total	449				

Table (16): Total bacterial count, mold and yeast in fresh tomato and tomato sauces.

Microbiological examination	Fresh tomato	Tomato sauces		
		Chilli tomato sauce	Semi hot tomato sauce	Hot tomato sauce
Total bacterial count (cell/g)	$2.8X10^4$	$2.6X10^3$	$2.7X10^3$	$2.9X10^3$
Molds yeasts and yeasts (cell/g)	$9.10X10^2$	$4.5X10^2$	$2.7X10^3$	$4.8X10^2$

Table (17): Total bacterial count, mold and yeast in tomato sauce products stored for 12 months in different packaging materials.

Storage Periods (month)	Microbial examination	Glass jar			Aluminum tube		
		Chilli tomato sauce	Semi hot tomato sauce	Hot tomato sauce	Chilli tomato sauce	Semi hot tomato sauce	Hot tomato sauce
0	Total count	180	170	150	183	175	160
	Mold & yeast	< 10	< 10	< 10	< 10	< 10	< 10
3	Total count	120	110	< 100	125	115	< 100
	Mold & yeast	< 10	< 10	n.d	< 10	< 10	n.d
6	Total count	< 100	< 50	< 50	< 100	< 50	< 50
	Mold & yeast	n.d	n.d	n.d	n.d	n.d	n.d
9	Total count	< 50	< 10	< 10	< 100	< 50	< 10
	Mold & yeast	n.d	n.d	n.d	n.d	n.d	n.d
12	Total count	< 50	< 10	< 10	< 50	< 10	< 10
	Mold & yeast	n.d	n.d	n.d	< 10	n.d	n.d

n.d = Not detected.

reduced to less than 200 c/g for total bacterial count and less than 10 c/g for mold and yeast (Table 17). But after 12 months of storage under suitable conditions the load was reduced to less than 10 in the same treatments for total plat count and absent for mold and yeast in some treatments. These results were agreement with those obtained by **Foda et al. 1976, Khalaf 1977 and Taiwo et al. 1997)**

4.2. Fig and Fig products:

Fig is one of the famous fruits consumed either fresh and /or processed. Fig jam, canned fig and dried fig are the famous products for consumed.

4.2.1. Chemical constituents of fresh fig:

Data of Table (18) and Figure (15) showed that moisture content, total soluble solids, reducing sugar, total sugar, total acidity (as citric acid), pH value and ash content for fresh figs were 78.7%, 19.8%, 8.6%, 17.1%, 0.31% 4.6 and 0.113%, respectively. These results were agreement with those obtained by **Gouda (1974), Woodburn, (1982), Traunter et al. (1989) and Tsantili (1990).** Serum color for fresh figs was 89.8% measured in serum figs after centrifugation and measured as transmission at 420 nm, whereas browning index (Fig. 16) was 0.04 measured as optical density at 420 nm. Heavy metals in fresh fig were calculated as part per bellion (ppb). They were 42, 96 and 51 ppb for aluminum, lead and zinc, respectively (Figure 17).

With respect to fig jam, it could be notice that the fig jam is differ for its constituents and properties which the concentration of fig and adding sugars, pectins and citric acid

Table (18): Chemical constituents of fresh fig and fig jam.

Product	Moisture %	Total Soluble Solids %	Reducing Sugar %	Total Sugars %	Total* Acidity %	pH Values	Ash Content %	Serum** Color %	Browning Index O.D 420 nm	Al ppb	Zn ppb	Pb ppb
Fresh fig	78.7	19.8	8.6	17.1	0.31	4.6	0.113	89.8	0.04	42	96	51
Fig jam	28.4	68.2	56.8	62.9	2.52	4.2	0.267	56.7	0.21	94	202	166

* As citric acid ** Transmission at 420 nm.

Al: Aluminum **Zn: Zinc** **Pb: Lead**

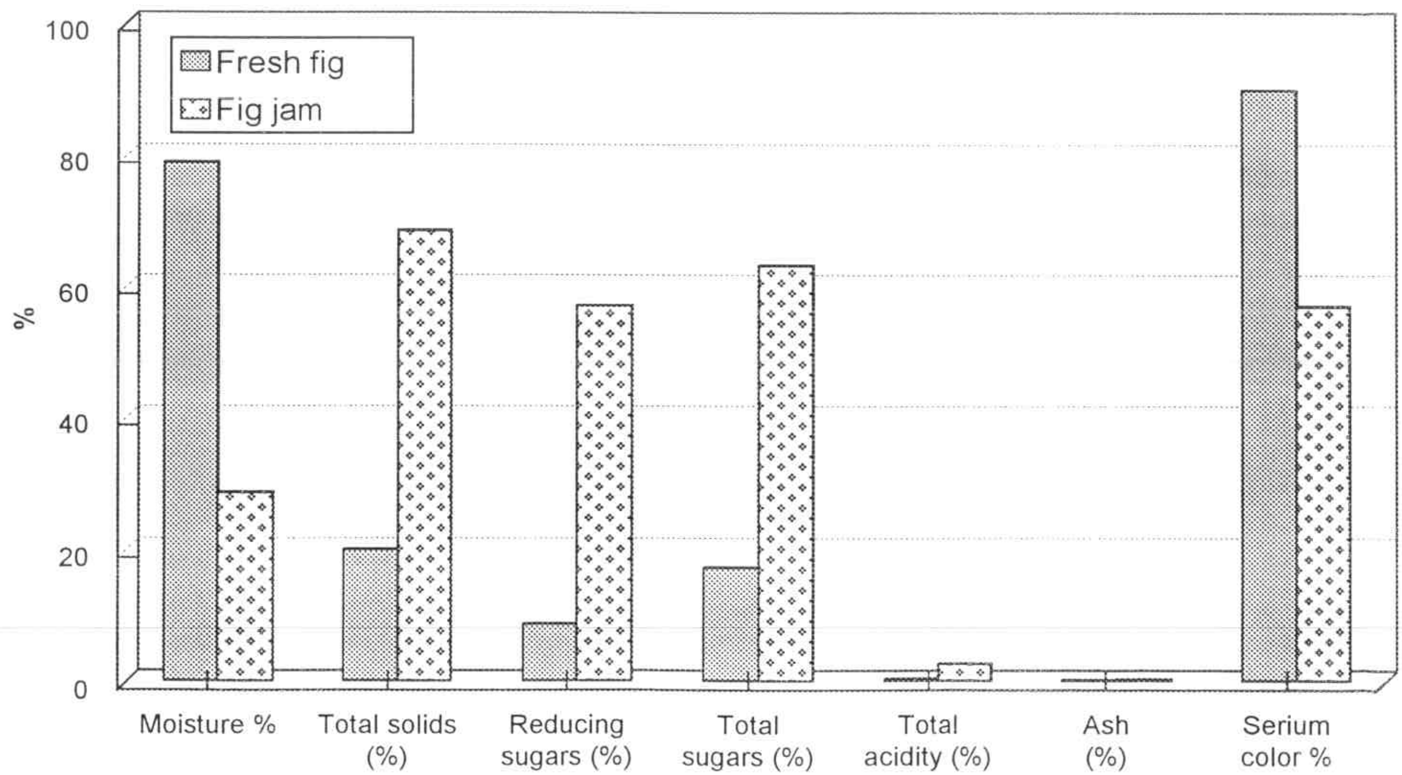

Fig. (15): Chemical constituents of fresh fig and fig jam.

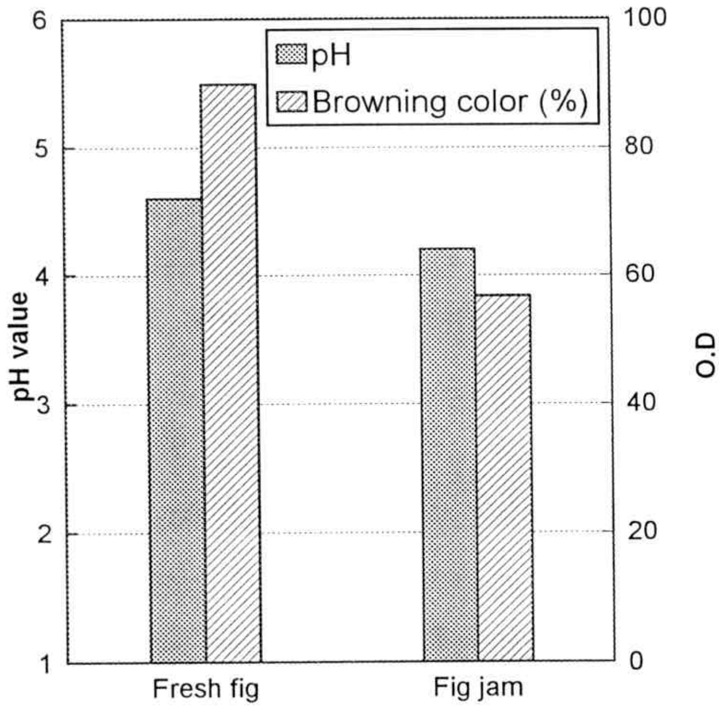

Figure (16): pH and browning color of frash fig and fig jam.

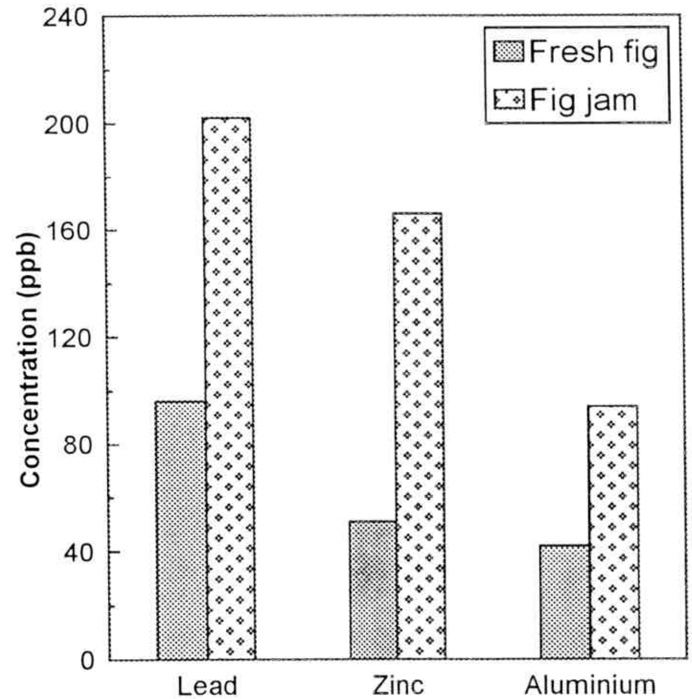

Figure (17):Lead, zinc and Alumium content of frash fig and fig jam.

forming a new products (**Carbonell et al. 1991**). The data presented showed that moisture content, total soluble solids, reducing sugar, total sugars, total acidity (as citric acid) pH value and ash content were 28.4%, 68.2% 56.8%, 62.9%, 2.52%, 4.2 and 0.267%, respectively. Also the serum color of fig jam 56.7% measured as transmission at 420 nm. Data in Table (18) and Figure (16) showed that the browning index was 0.21 calculated as optical density at 420 nm. Data in the same Table and Figure (17) presented heavy metals aluminum, lead and zinc which were 94, 202 and 166 ppb, respectively. These results were less than those recommended by Egyptian Standard and International Standard.

4.2.2. Chemical constituents of fig jam during storage:

Fig jam were processed (**Carbonnell, et al. 1991**) and directly packaging in glass jars, polyamide burchans and aluminum tube then pasteurized through the pasteuiezer line. The packaging were incubated 15 days then stored for 12 months. The fig jam samples were prepared for chemical analysis by mixing the jam and weighted for chemical determined methods. All chemical analysis were carried three times.

4.2.2.1. Moisture content:

Data presented in Table (19) and Figure (18) showed that moisture content at zero time for fig jam packaging in glass jars, polyamide burchans and aluminum tubes nearly similar it was 28.25%, 28.19% and 28.27%, respectively. During storage for 12 months moisture content had a negligible decrease that it decreased from 28.25% in zero time to 28.18 % after 12 months of storage for jams in glass jars, from 28.19% to 27.95% for

Table (19): Moisture content percentage present in fig jam stored for 12 months in different packaging materials.

Storage period (month)	Packaging materials		
	Glass jars	Polyamide burchans	Aluminum tubes
0	28.25	28.19	28.27
3	28.22	28.31	28.15
6	28.05	28.25	28.07
9	28.23	28.08	28.12
12	28.18	27.95	27.91

Table (20): Total soluble solids percentage present in fig jam stored for 12 months in different packaging materials.

Storage period (month)	Packaging materials		
	Glass jars	Polyamide burchans	Aluminum tubes
0	68.4	68.6	68.7
3	68.7	68.8	69.0
6	69.0	69.0	69.2
9	69.2	69.3	69.5
12	69.5	69.7	69.8

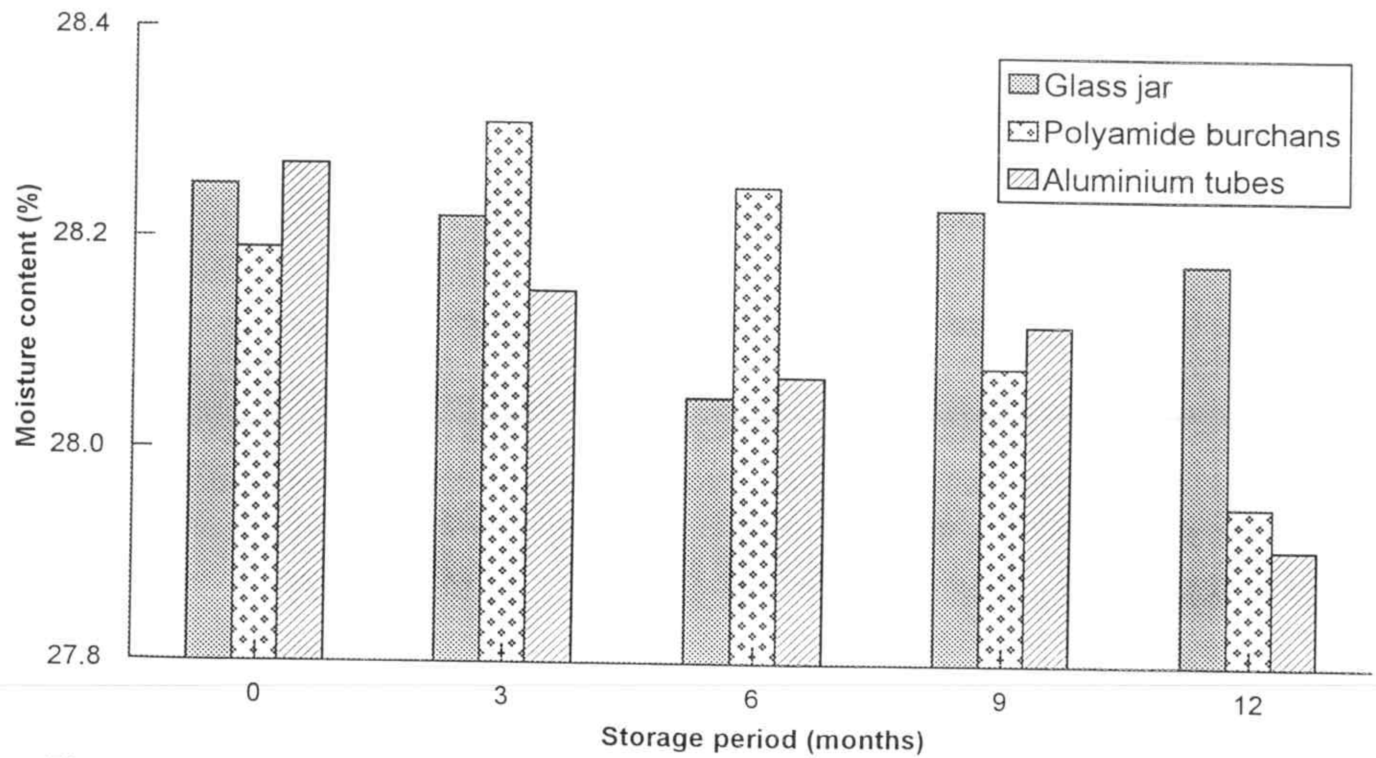

Figure (18): Moisture content percentage present in fig jam during storage period in different packaging materials.

jams in polyamide burchans and from 28.27% to 27.91% for jams in aluminum tubes. Generally the moisture content in fig jam packaging in different packaging materials had a fluctuated moisture content during storage.

4.2.2.2. Total soluble solids:

Fig jam was prepared from fig concentrate and about 50% sucrose, so it has a high total soluble solids. Data of Table (20) and Figure (19) showed that total soluble solids in different packaging in zero time were nearly similar it was ranged from 68.4% to 68.7%. whereas there was an increase during storage for all jams packaging in different packaging, however increased from 68.4% to 69.5%, from 68.6 % to 69.7% and from 68.7to 69.8% for glass jars, polyamide burehans and aluminum tubes. This increase in total soluble solids may be due to degradation insoluble compound to soluble on during storage for 12 months.

4.2.2.3. Reducing and total sugars:

During jam processing sucrose which was added nearly change to invert sugar in acidic media and heat treatment, so the reducing sugar in jam packaging in glass jars, polyamide burchans and aluminum tubes were 58.5%, 58.5% and 58.6% respectively , as data presented in Table (21) and Figure (20). Also, wherever the increase from 58.5% to 59.9% from 58.5% to 60.0% and from 58.6% to 60.2% jams packaging in glass jars, polyamide burchans and aluminum tube respectively. These may be due to that non reducing sugar were analyzed to reducing sugar in acidic media during storage for 12 months.

Total sugars were nearly similar in different packaging materials in zero time which it were 63.9%, 63.8% and 63.7%

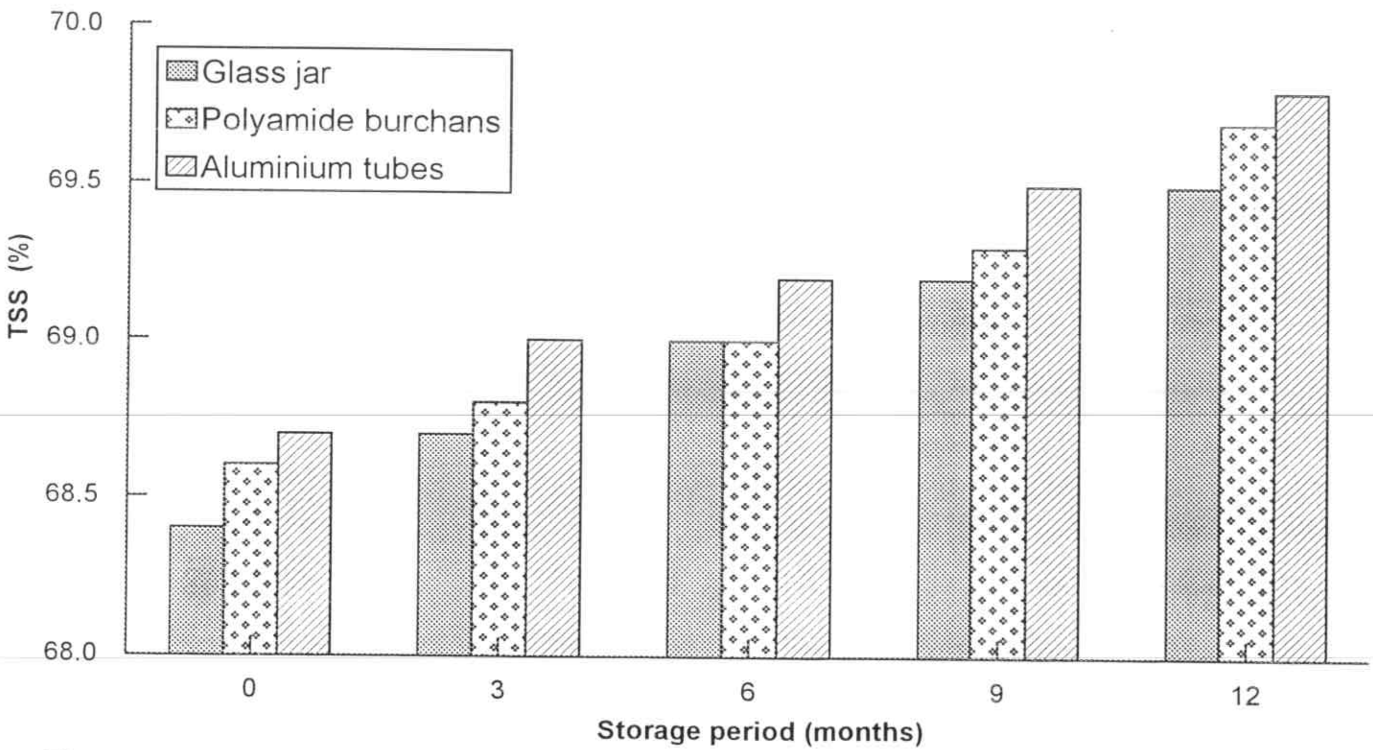

Figure (19): Total soluble solids percentage present in fig jam during storage period in different packaging materials.

Table (21): Reducing sugars percentage present in fig jam stored for 12 months in different packaging materials.

Storage period (month)	Packaging materials		
	Glass jars	Polyamide burchans	Aluminum tubes
0	58.5	58.5	58.6
3	58.8	58.8	58.8
6	58.9	59.1	59.2
9	59.1	59.6	59.7
12	59.9	60.0	60.2

Table (22): Total sugars percentage present in fig jam stored for 12 months in different packaging materials.

Storage period (month)	Packaging materials		
	Glass jars	Polyamide burchans	Aluminum tubes
0	63.9	63.8	63.7
3	63.7	63.7	63.5
6	63.3	63.4	63.2
9	63.0	63.2	62.9
12	62.8	62.9	62.6

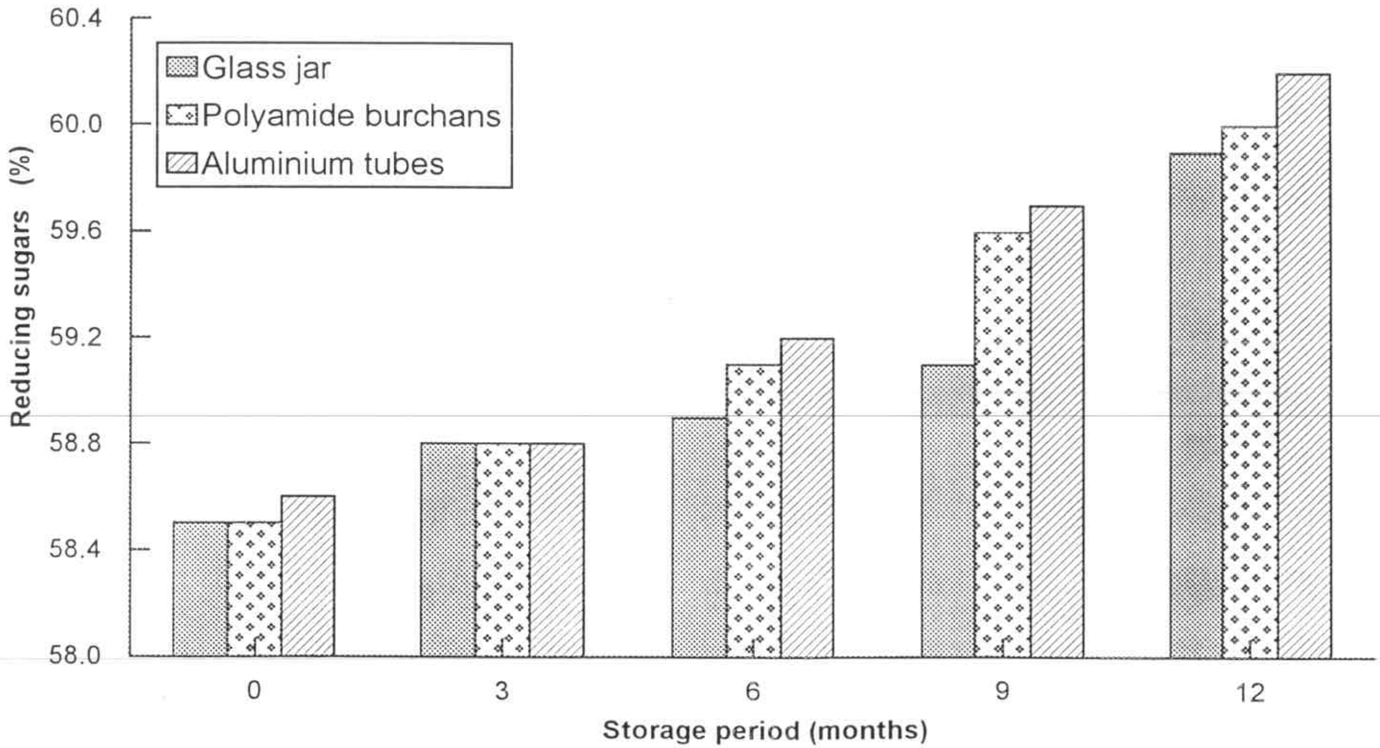

Figure (20): Reducing sugars percentage present in fig jam during storage period in different packaging materials.

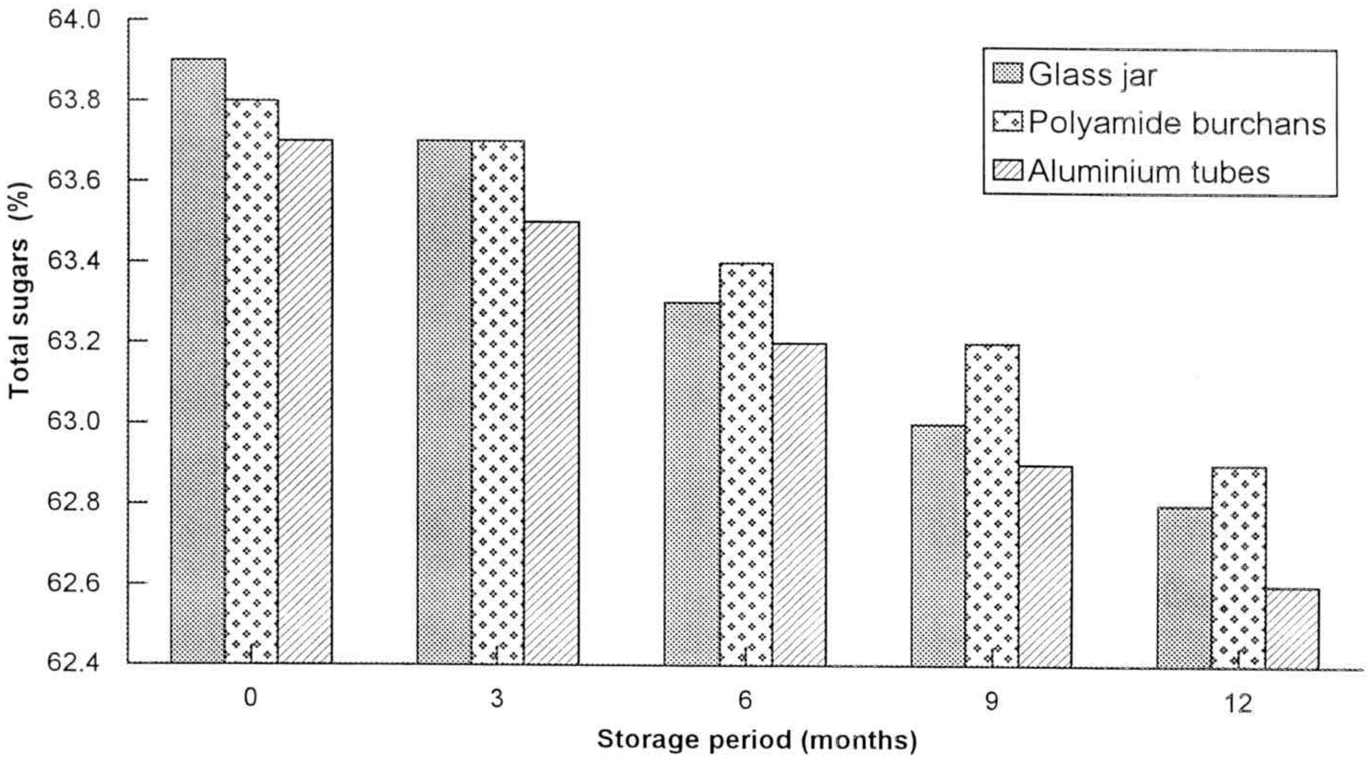

Figure (21): Total sugars percentage present in fig jam during storage period in different packaging materials.

for glass jars , polyamide burchans and aluminum tubes respectively. Table (22) and Figure (21) represent the total sugar during storage decreased from 63.9% to 62.8%, from 63.8% to 62.9% and from 63.7% to 62.6% for jam packaging in glass jars, polyamide burchans and aluminum tubes respectively.

4.2.2.4. Total acidity and pH value :

Data from Table (23) and Figure (22) showed that total acidity (as citric acid) for jam packaging in glass jar, polyamide burchans and aluminum tubes were 2.55%, 2.61% and 2.60% respectively. The acidity were increased gradually during storage which it were increased from 2.55% to 2.61% 2.61% to 2.73 and 2.60% to 2.74% for glass jar , polyamide burchans and aluminum tubes respectively. These increase may be due to degradation pectic substances to galacturonic acids.

pH value for jam packaging in glass jar, polyamide bruchans and aluminum tubes were fluctuated both after processing or during storage for 12 months as shown in Table (24) and Figure (23) whereas ranged from 4.0 to 4.2.

4.2.2.5. Serum color:

Serum color or cloudiness is an important visual attribute of jams. The higher percentage of transmission the lower and less desirable the cloud. So Table (25) show the changes in serum color of the jam packaging different packaging in during storage. The transmission decrement as well as the percentage of decrease during storage were slightly higher wherever transmission decreased from 56.5% to 51.8%, 56.2% to 51.0% and 56.2 to 50.7% for jam packaging in glass jars, polyamide burchans and aluminum tubes respectively, consequently the decreasing percentage were from 0 to 8.32%, from 0 to 9.25%

Table (23): Total acidity* percentage present in fig jam stored for 12 months in different packaging materials.

Storage period (month)	Packaging materials		
	Glass jars	Polyamide burchans	Aluminum tubes
0	2.55	2.61	2.60
3	2.58	2.66	2.62
6	2.56	2.65	2.67
9	2.59	2.68	2.70
12	2.61	2.73	2.74

* Calculated as citric acid.

Table (24): pH values present in fig jam stored for 12 months in different packaging materials.

Storage period (month)	Packaging materials		
	Glass jars	Polyamide burchans	Aluminum tubes
0	4.2	4.1	4.1
3	4.2	4.1	4.1
6	4.1	4.1	4.0
9	4.1	4.0	4.0
12	4.1	4.0	4.0

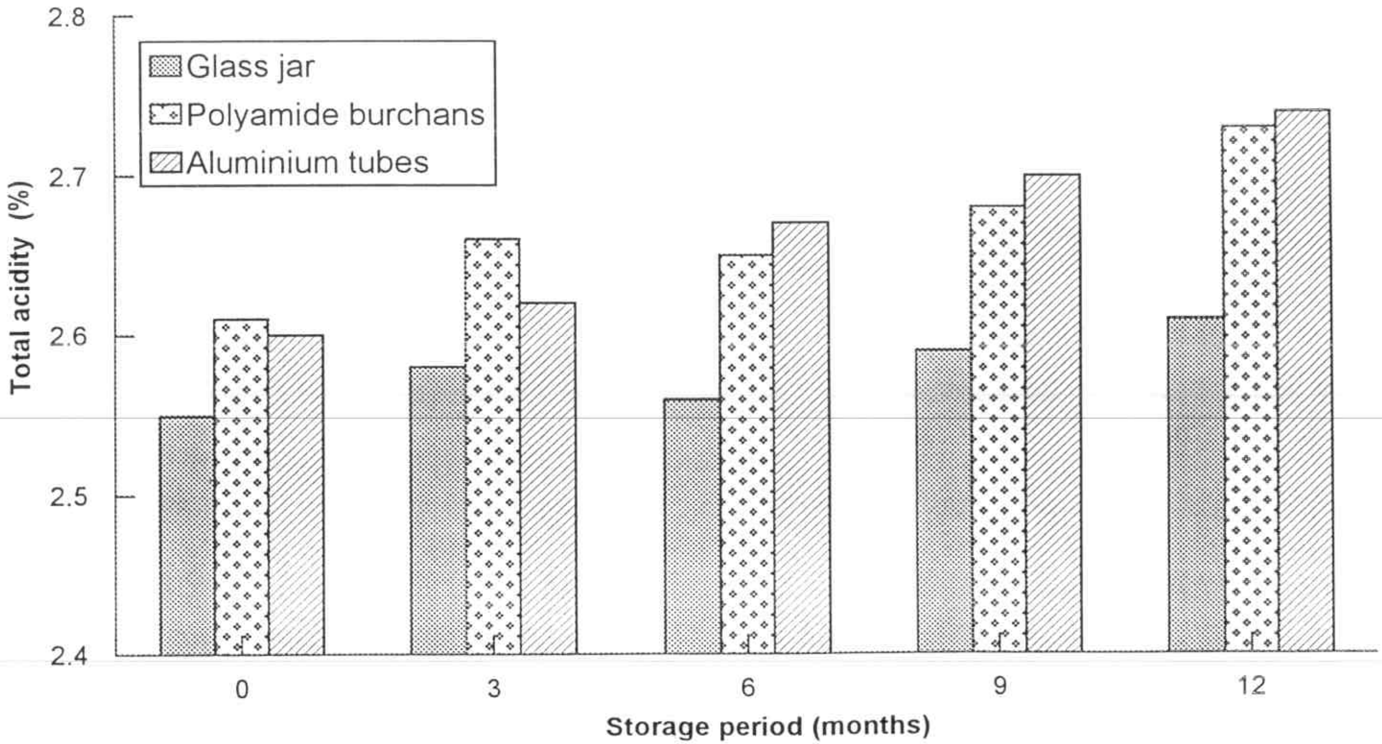

Figure (22): Total acidity percentagepresent in fig jam during storage period in different packaging materials.

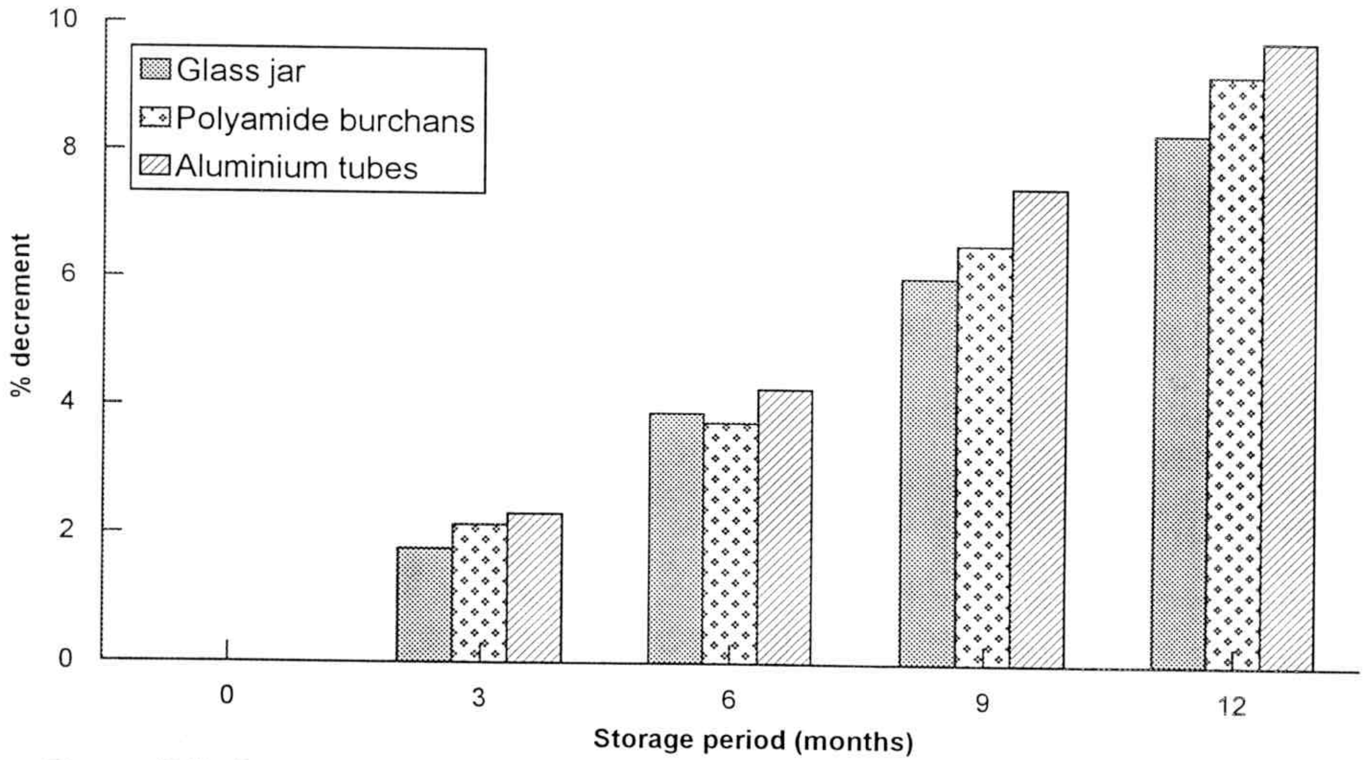

Figure (24): Percentage decrement of serum color present in fig jam during storage period in different packaging materials.

and from 0 to 9.79% respectively as shown in Figure (24) .

4.2.2.6. Browning index:

The changes in browning index (as O. D at 420 nm) of fig jam are given in Table (26) and Figure (25) . Browning index of jam packaging in glass jars, polyamide burchans and aluminum tube were 0.22, 0.23 and 0.23 measured as optical density at 420 nm respectively. The browning was increased gradually during storage , wherever the percentage of increment was from 0 to 63.63%, 0 to 65.22% and from 0 to 65.21% for jam packaging in glass jars , polyamide burchans and aluminum tubes respectively as show in Figure (25) this increment percentage during storage may be due to the non enzymatic browning reaction (**O'Beirne 1986, and Bolin and Steele, 1987**)

4.2.2.7. Mineral contents:

Aluminum lead and zinc were the dangerous heavy metals which contaminate the foods during agriculture harvest, handling, processing and packaging materials. Data presented in Table (27) showed that the aluminum, lead and zinc concentrate in Fig jam, these results mean that this concentrate heavy metals due to the raw material processing and packaging. The results that the mineral concentrate during storage were fluctuated and no change in concentrate for all packaging materials during 12 months of storage except aluminum tube which a slight increase in aluminum concentrate from 102 ppb to 112 ppb this may be due to the migrate of aluminum from aluminum tube to the jam . Generally this level of heavy metal were less than the international and National standards.

Table (26): Browning index and increasing percentage in fig jam stored for 12 months in different packaging materials.

Storage Period (month)	Packing materials					
	Glass jars		Polyamide burchans		Aluminum tubes	
	O.D at 420 nm	% increasing	O.D at 420 nm	% increasing	O.D at 420 nm	% increasing
0	0.22	0	0.23	-	0.23	0
3	0.25	13.64	0.26	13.04	0.25	8.70
6	0.27	22.73	0.29	26.09	0.28	21.74
9	0.30	36.36	0.32	39.13	0.31	34.88
12	0.36	63.63	0.38	65.22	0.38	65.21

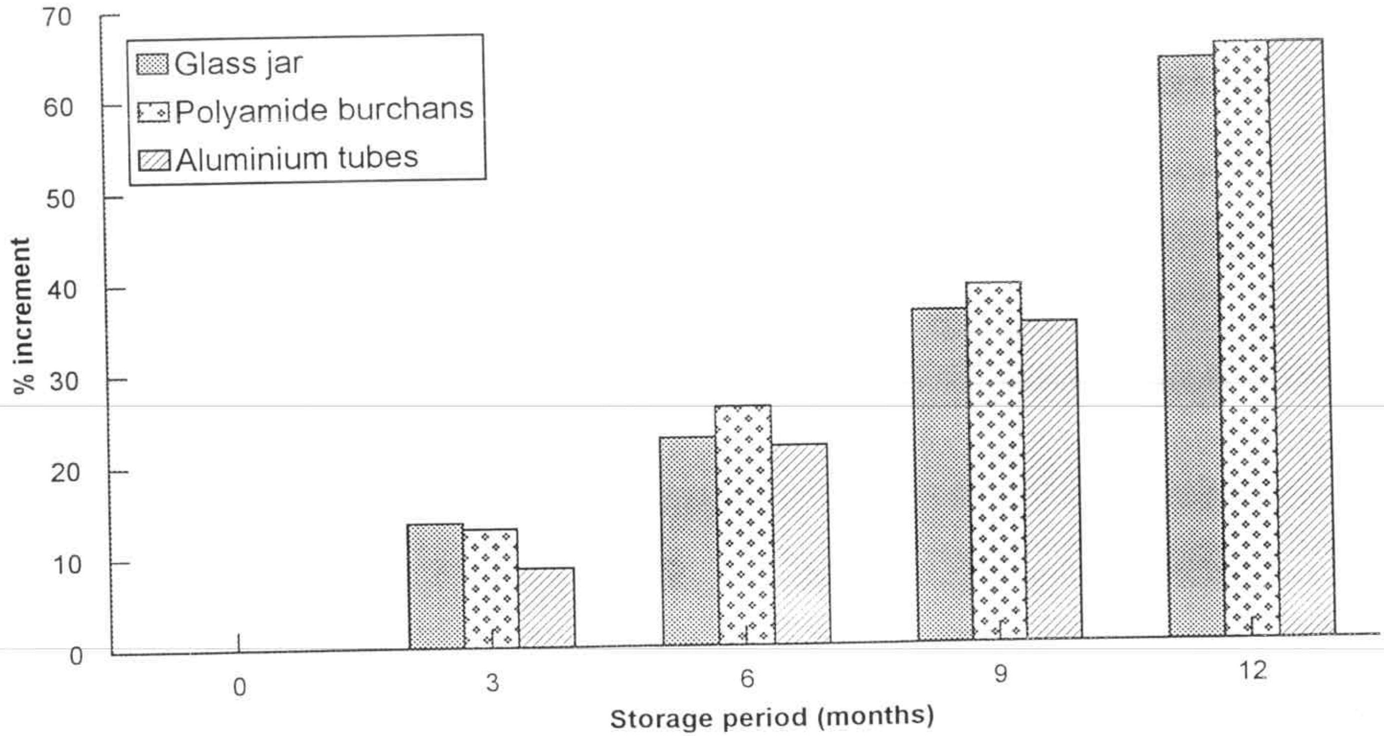

Figure (25):Browning index present in fig jam during storage period in different packaging materials.

Table (28): Mean of color and odor for fig jam stored for 12 months in different packaging materials.

Storage period (months)	Color			Odor		
	Packaging materials			Packaging materials		
	Aluminum tubes	Glass jars	Polyamide burchans	Aluminum tubes	Glass jars	Polyamide burchans
0	19.33	19.77	19.40	19.47	19.70	19.27
3	19.10	19.47	19.20	19.27	19.43	19.07
6	18.57	18.80	18.57	18.78	19.78	18.75
9	18.13	18.27	18.37	18.07	18.57	18.60
12	17.90	17.80	17.73	17.47	18.17	18.20

Mean of color of main factors:

1- Storage period:

Storage period	Mean
0	19.50 a
3	19.26 a
6	18.64 b
9	18.26 c
12	17.81 d

L.S.D ($P<0.05$) = 0.240

2- Packaging materials:

Packaging materials	Mean
Aluminum tubes	18.61 b
3Glass jar	18.82 a
Polyamide burchans	18.65 b

L.S.D ($P<0.05$) = 0.186

Mean of odor of main factors:

1- Storage period:

Storage period	Mean
0	19.48 a
3	19.27 a
6	18.77 b
9	18.41 c
12	17.95 d

L.S.D ($P<0.05$) = 0.322

2- Packaging materials:

Packaging materials	Mean
Aluminum tubes	18.61 b
3Glass jar	18.93 a
6Polyamide burchans	18.78 ab

L.S.D ($P<0.05$) = 0.250

There is no significance difference ($P>0.05$) between any two means, within the same factor, have the same superscript letter.

Table (29): Mean of taste and over all acceptability for fig jam stored for 12 months in different packaging materials.

Storage period (months)	Taste			Over all acceptability		
	Packaging materials			Packaging materials		
	Aluminum tubes	Glass jars	Polyamide burchans	Aluminum tubes	Glass jars	Polyamide burchans
0	19.43	19.53	19.43	39.27	39.47	39.33
3	19.00	19.83	19.23	38.80	39.03	39.07
6	18.53	19.10	18.97	38.55	38.73	38.77
9	17.93	18.70	18.47	38.00	38.20	38.20
12	17.47	18.37	18.20	37.20	38.00	37.70

Mean of taste of main factors:

1- Storage period:

Storage period	Mean
0	19.46 a
3	19.35 a
6	18.87 b
9	18.37 c
12	18.01 d

L.S.D (P<0.05) = 0.322

2- Packaging materials:

Packaging materials	Mean
Aluminum tubes	18.47 c
3Glass jar	19.11 a
Polyamide burchans	18.86 b

L.S.D (P<0.05) = 0.250

Mean of over all acceptability of main factors:

1- Storage period:

Storage period	Mean
0	39.36 a
3	38.96 b
6	38.68 c
9	38.13 d
12	37.63 e

L.S.D (P<0.05) = 0.244

2- Packaging materials:

Packaging materials	Mean
Aluminum tubes	38.36 b
3Glass jar	38.68 a
6Polyamide burchans	38.61 a

L.S.D (P<0.05) = 0.189

There is no significance difference (P>0.05) between any two means, within the same factor, have the same superscript letter.

Table (30): Analysis of variance table for organolyptic evaluation data

Source of variance	D.F	F-value for			
		Color	Odor	Taste	Over all
Storage periods (A)	4	69.73	31.20	28.74	64.66
Packaging materials (B)	2	7.51	3.45	28.36	17.60
A*B	8	0.21	0.36	0.06	0.07
Error	210				
Total	224				

significant differences means values acceptability due to the effect of storage period for one year and the lowest value of over all acceptability was found in 12 months, there are a significant differences ($P<0.05$) between aluminum tubes and both of glass jars and polyamide burchans. Analysis of variance is summarized in Table (30).

From the pervious discussion, it can be concluded that the best packaging materials for getting the highest values of organolyptic evaluation (color, odor, taste and over all acceptability) is the glass jars.

4.2.4. Microbial count:

The obtained lower bacterial load could be attributed to the various factors. So, the processed fig jam and packaging in different packaging were carried out under high sanitation. The data obtained from Table (31) showed that total counts ranged from not detected to <30 per gram, from < 10 to < 20 per gram and from < 10 to < 30 per gram, for fig jam packaging in glass jars, polyamide burchans and aluminum tubes during storage respectively and nearly also were not detected any growth of molds and yeasts. This reflected the efficiency of the heat treatment used in processing in addition to the conditions prerailing during preparation and packaging .

Table (31): Microbial count present in fig jam stored for 12 months in different packaging materials.

Storage Period (month)	Packing materials					
	Glass jars		Polyamide burchans		Aluminum tubes	
	Total bacterial Count (CFU/g)	Mold & Yeast (CFU/g)	Total bacterial Count (CFU/g)	Mold & Yeast (CFU/g)	Total bacterial Count (CFU/g)	Mold & Yeast (CFU/g)
0	n.d	n.d	<10	n.d	<10	n.d
3	<10	n.d	<10	n.d	<20	1
6	<10	1	<10	n.d	<10	n.d
9	<10	n.d	<30	1	<20	n.d
12	<30	1	<20	n.d	<30	2

(CFU/g): Colony forming unit per one gram.　　n.d = not detected.

4.3. Olive oil:

4.3.1. Chemical properties of olive oil:

The acid value (% as oleic acid), peroxide value, iodine value, saponification value and unsaponifiable matter percent were determined for the investigated olive oil. The obtained results in Table (32) were 0.50, 5.60, 84.60, 188.20 and 1.21 for acid value (% as oleic acid), peroxide value (meq/kg oil), iodine value, saponification value and unsaponifiable matter respectively of olive oil.

Data from Table (32) indicate that acid value in the olive oil was found to be 0.50 (% as oleic acid) in oil. This results is in accordance with **Egyptian Standard (1993) and IOOC** (1996).

Results from the same table indicate that the peroxide value of olive oil was 5.6 meq/kg oil, while **Egyptian Standard for olive oil (1993)** and **IOOC (1996)** allowed the peroxide value to be up to 20 (meq/kg oil).

From the same Table (32) the iodine value (Hanus) of the oil under investigation was 84.60, this indicates that the oil belonged to the non drying oil category. This results is in accordance with **Egyptian Standard Specification (1993) and IOOC (1996).**

Data from the same Table (29) the saponification number and unsaponifiable matter of olive oil were 188.20 and 1.21, respectively. These results agreement with those of **Egyptian Standard Specification (1993) and IOOC (1996).**

Finally, from the above results in Table (32), it could be concluded that the olive oil under investigation was of high

Table (32): Chemical properties of olive oil.

Parameter	Value
Acid value (% as oleic acid)	0.50
Peroxide value (meq/kg oil)	5.60
Iodine value (Hanus)	84.60
Saponification value	188.20
Unsaponifiable matter (%)	0.99

quality according to of **Egyptian Standard Specification (1993)** and **IOOC (1996).**

4.3.2. Chemical properties of olive oil during storage in different packaging materials:

Olive oil packed in transparent glass bottles, brown glass bottles and high density polyethylene (HDPE) bottles bags. All samples were stored at ambient temperature (20-30 °C) for 12 months. Samples were withdrawn at different intervals to measure the changes in free fatty acid, iodine value, peroxide value, saponification number and unsaponifiable matter of oil. The results are shown in Tables (33-37) and Figs. (26-30).

4.3.2.1. Free fatty acids:

Total free fatty acids is essentially a measure of the free acids in the oil. Oil is categorized into edible (≤ 3.3) and industrial (acidity more than 3.3%) according to **IOOC, (1996).**

The olive oil was packed in brown glass bottles, transparent glass bottles and high density polyethylene (HDPE) and stored in ambient temperature (20-30 °C) for one year. The samples were analyzed for free fatty acids for 3 months till the end of storage period and the obtained results are shown in Table (33) and Figure (26).

From the results mentioned in Table (33) it could be noticed that the free fatty acids of olive oil at zero time was 0.50 % and it increased gradually in all samples. After one year of storage the free fatty acids reached 0.72%, 0.74 % and 0.88% for brown glass bottles transparent glass bottles and high density polyethylene respectively. These results are agreement with those of **Unal (1978), Nkpa et al., (1990), Khalaf (1992)**

Table (33): Free fatty acids in olive oil stored for 12 months in different packaging materials.

Time (month)	High density polyethylene bottles %	Brown Glass bottles %	Transparent glass bottles %
0	0.50	0.50	0.50
3	0.38	0.54	0.55
6	0.68	0.60	0.64
9	0.72	0.65	0.66
12	0.88	0.72	0.74

Table (34): Peroxide value in olive oil stored for 12 months in different packaging materials.

Time (month)	High density polyethylene bottles	Brown Glass bottles	Transparent glass bottles
0	5.6	5.6	5.6
3	8.71	7.0	7.2
6	12.6	7.8	8.6
9	16.5	9.5	10.9
12	22.8*	11.3	13.5

*PV: Exceeded the limits of Egyptian Standard (1993) and IOOC (1996).

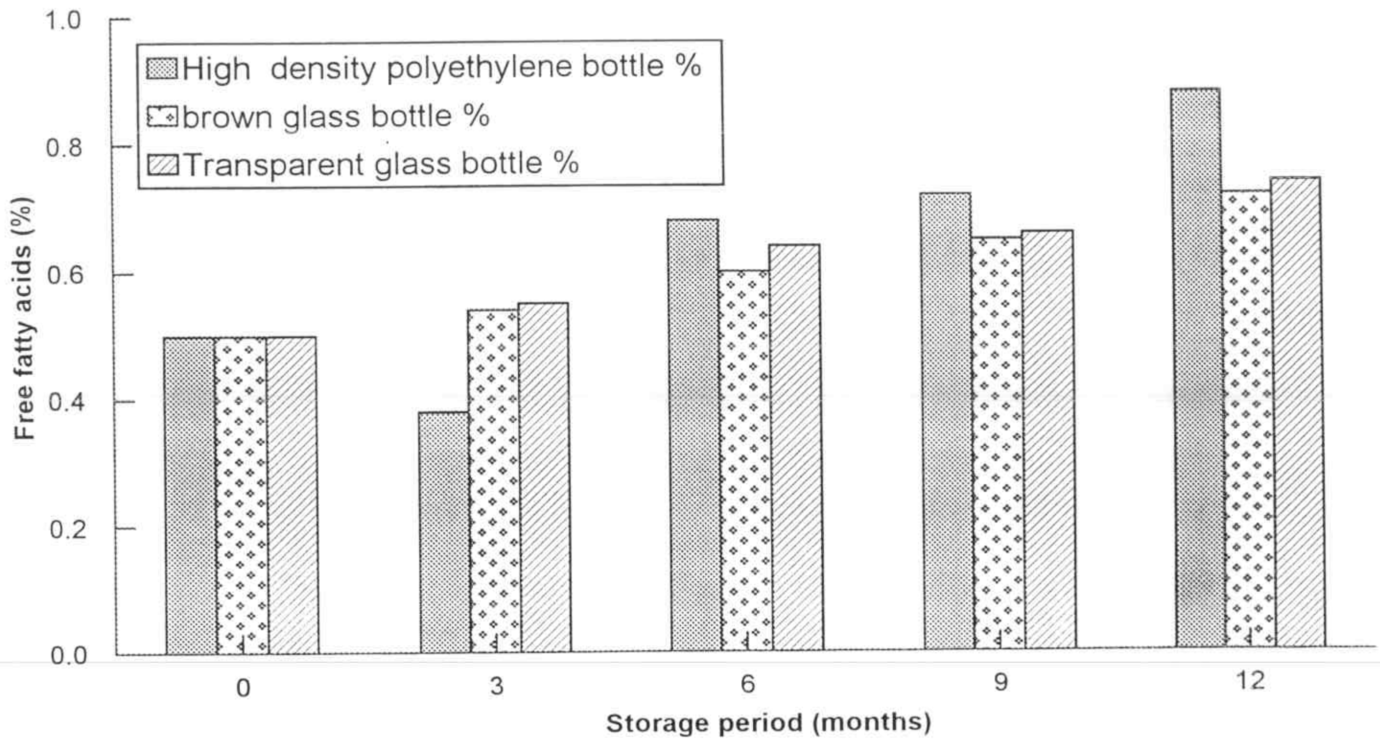

Fig. (26): Free fatty acids in olive oil stored for 12 months in different packaging materials.

and Hallabo et al., (1993).

Also from the obtained results it could be observed that packaging olive oil in different packaging in ambient temperature (20-30 °C) had a significant effect on the free fatty acids. These results are within the limits of the **Egyptian Standard Specifications (1993) and IOOC (1996).**

From the results tabulated in Table (33) it could be observed that the free fatty acids of olive oil packed in brown glass bottle and stored for 12 months was 0.72%. This value of free fatty acids was found in olive oil packed in high density polyethylene and transparent glass bottles after only nine and eleven months of storage, respectively. On the other hand, it is possible that high density polyethylene packaging materials could allow varying amount of moisture to pass and help to increase the acid value in the course of storage. These results are in agreement with those reported by **Nkpa et al., (1990)** on palm oil.

So, one can concluded that the acceleration of free fatty acids formation of olive oil packed in high density polyethylene bottles could be due to permeability of the container.

4.3.2.2. Peroxide value:

Peroxide value is the most commonly used method for measuring the total hydroperoxides formed as the oil. The peroxide value of oil under investigation was determined and the results are shown in Table (34) and Fig. (27).

Data from the Table (34) it could be noticed that the peroxide value at zero time was 5.6 meq O_2/kg oil and increased gradually in all packages during storage. After 12 months of storage the peroxide value reached (1.3, 13.5 and 22.8 meq/kg for oil stored in brown glass bottles, transparent glass bottles and high density polyethylene bottles respectively. Also, it could be observed that there were clear differences between the peroxide value of olive oil samples which had been stored in either glass bottles had been stored in either glass bottles or high density polyethylene bottles. Since the samples high density polyethylene bottles developed higher peroxide value than those which had been stored in glass bottles. These results are in agreement with those of **Gutierrez et al., (1973), Kiritsaks and Dugan (1984), Khalil and El-Agaimy (1991), Khalaf (1992) and Hallabo et al., (1993).**

From the tabulated results in Table (34), it could be observed that the initial peroxide value of the oil were relatively low, in a peroxide of 12 months the value was 22.8 in high density polyethylene bottles this value was higher than that established by **Egyptian Standard (1993) and International Olive Oil Council (IOOC) (1996).** Meanwhile, the peroxide value reached 11.3 and 13.5 meq/kg oil after 12 months of storage for brown glass bottles and transparent glass bottles, respectively. These results emphasis the effect of oxygen that may enter into the high density polyethylene packages due to its permeability.

These increments in peroxide value during storage were due to presence of dissolved oxygen in oil, oxygen permeability through the packaging materials. These results are in agreement with those reported by **Kiritsakis et al., (1983), Kiritsakis and Dugan (1984), Mastrobattista (1990), Khalil and El-Agaimy. (1991), Khalaf (1992) and Hallabo et al., (1993).**

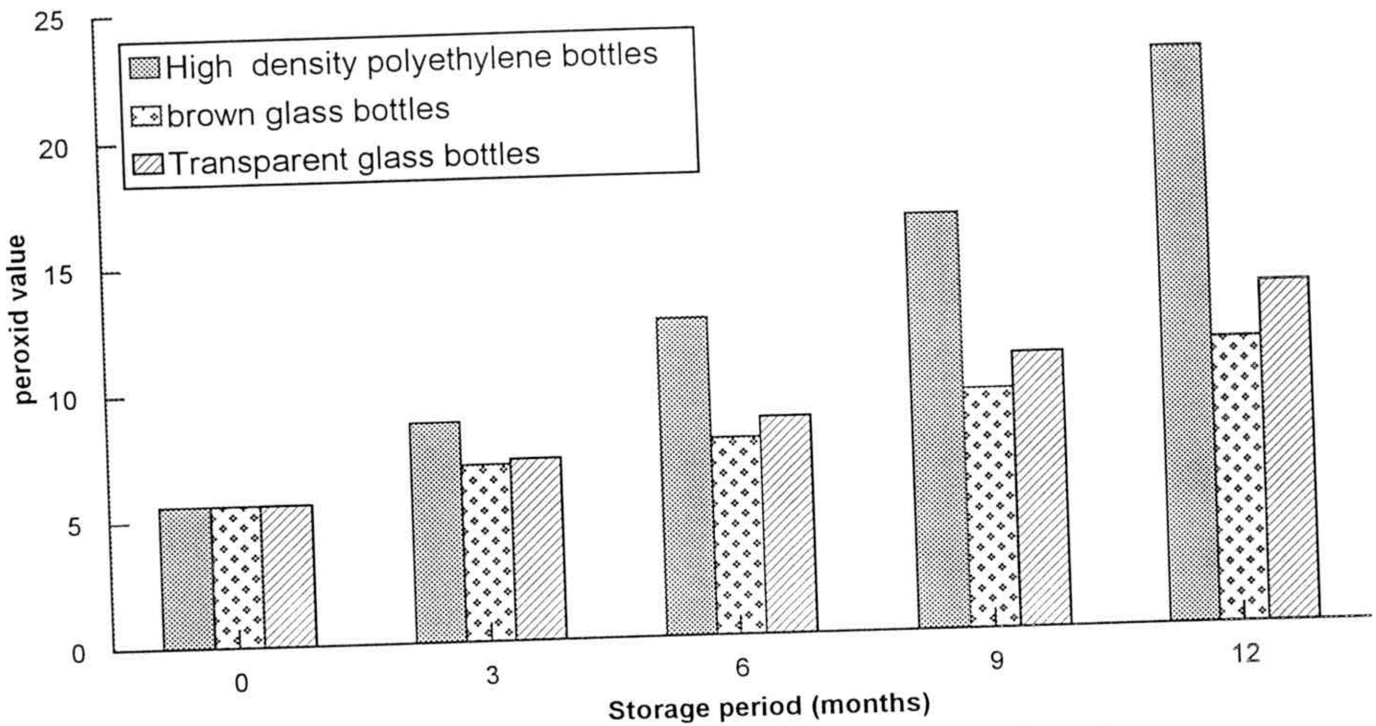

Fig. (27): Peroxid value in olive oil stored for 12 months in different packaging materials.

4.3.2.3. Iodine value:

The iodine value, which reflects the degree of unsaturation of an oil was determined for olive oil stored in brown glass bottles, transparent glass bottles and high density polyethylene bottles and the results are shown in Table (35) and Fig. (28).

It could be noticed that the iodine value was 84.6 at zero time and reached 84.2, 83.9 and 83.5 in oil packed in brown glass bottles, transparent glass bottles and high density polyethylene bottles, respectively after 12 months of storage. This change in iodine value may be due conjugation of unsaturated fatty acids that took place in olive oil packed in high density polyethylene bottles compared with that packed in glass bottles. This results is in accordance with **Egyptian Standard (1993) and IOOC (1996).**

4.3.2.4. Saponification value:

From the results in Table (36) and Fig. (29) it could be noticed that the saponification value in olive oil at zero time was 188.2 while after 12 months reached 195.5, 190.2 and 191.2 packed in high density polyethylene bottles, brown glass bottles and transparent glass bottles respectively.

From the results, it could be seen that the saponification value of olive oil was increased with increasing storage period and the lowest increased in brown glass bottles. This result is in accordance with **Egyptian Standard (1993) and IOOC (1996).**

4.3.2.5. Unsaponifiable matter:

From the obtained results in Table (37) and Fig. (30) it could be noticed that the unsaponifiable matter of olive oil at

Table (35): Iodine value in olive oil stored for 12 months in different packaging materials.

Time (month)	High density polyethylene bottles	Brown Glass bottles	Transparent glass bottles
0	84.6	84.6	84.6
3	84.3	84.5	84.4
6	84.1	84.5	84.2
9	83.8	84.3	84.1
12	83.5	84.2	83.9

Iodine value was determined by (Hanus) method.

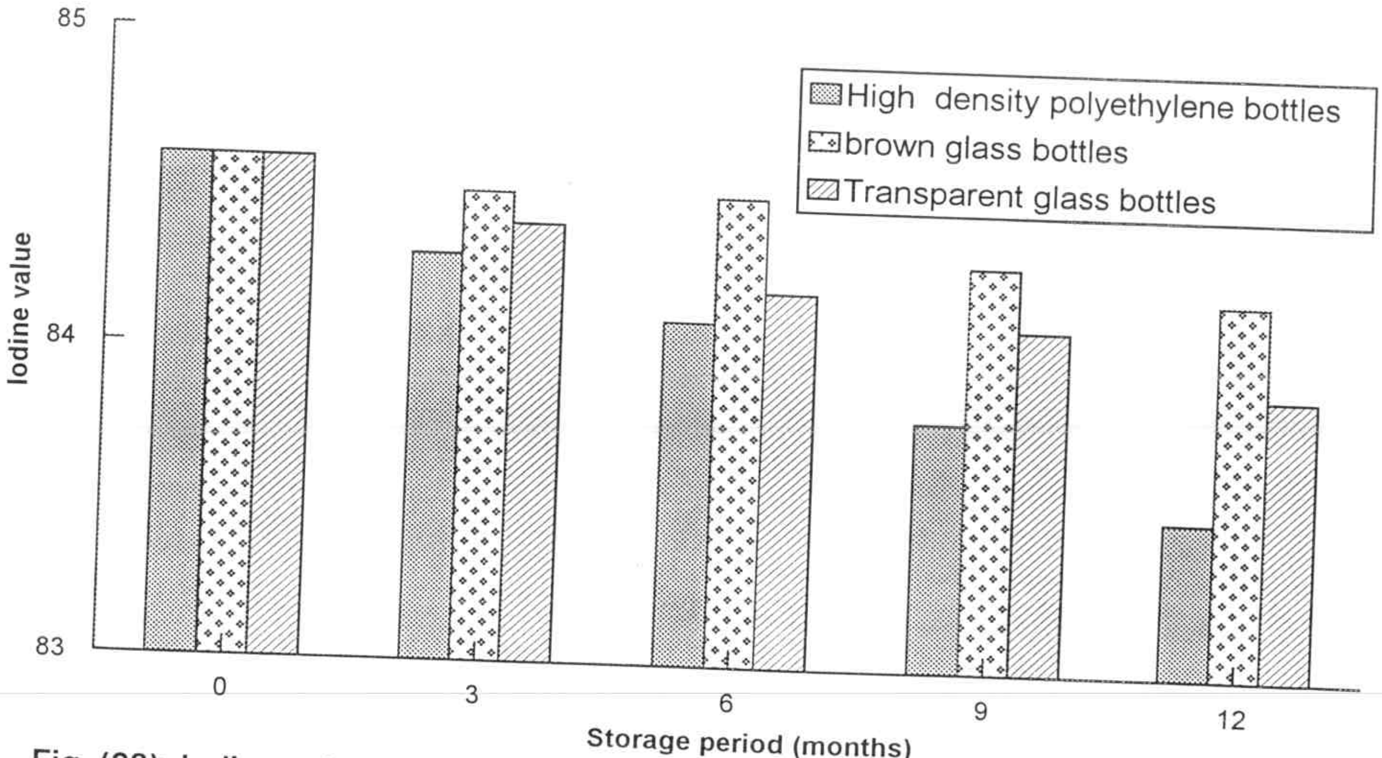

Fig. (28): Iodine value in olive oil stored for 12 months in different packaging materials.

Table (36): Saponification value in olive oil stored for 12 months in different packaging materials.

Time (month)	High density polyethylene bottles	Brown Glass bottles	Transparent glass bottles
0	188.2	188.2	188.2
3	188.8	188.9	188.6
6	190.9	189.0	189.6
9	192.7	189.5	190.0
12	195.5	190.2	191.3

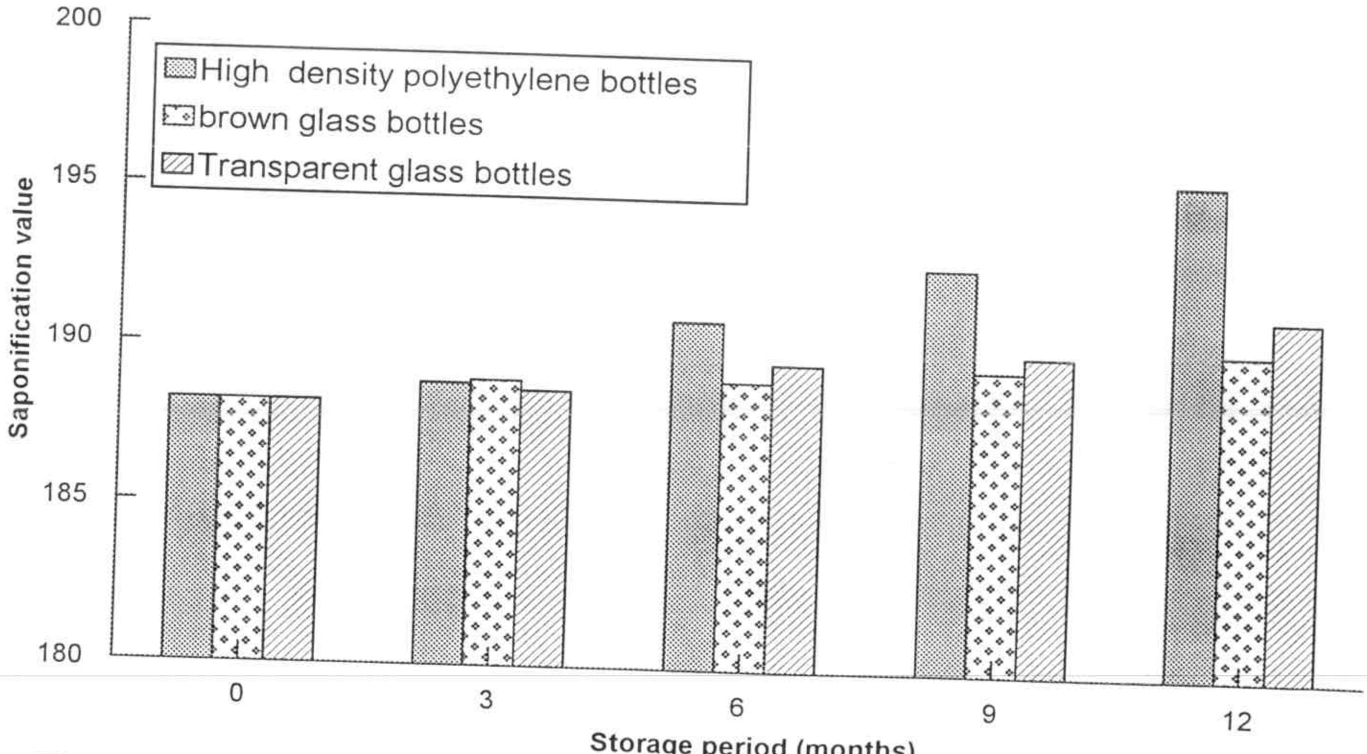

Fig. (29): Saponification value in olive oil stored for 12 months in different packaging materials.

Table (37): Unsaponifiable matter in olive oil stored for 12 months in different packaging materials.

Time (month)	High density polyethylene bottles	Brown Glass bottles	Transparent glass bottles
0	0.99	0.99	0.99
3	0.93	0.95	0.94
6	0.86	0.90	0.90
9	0.80	0.88	0.95
12	0.75	0.85	0.82

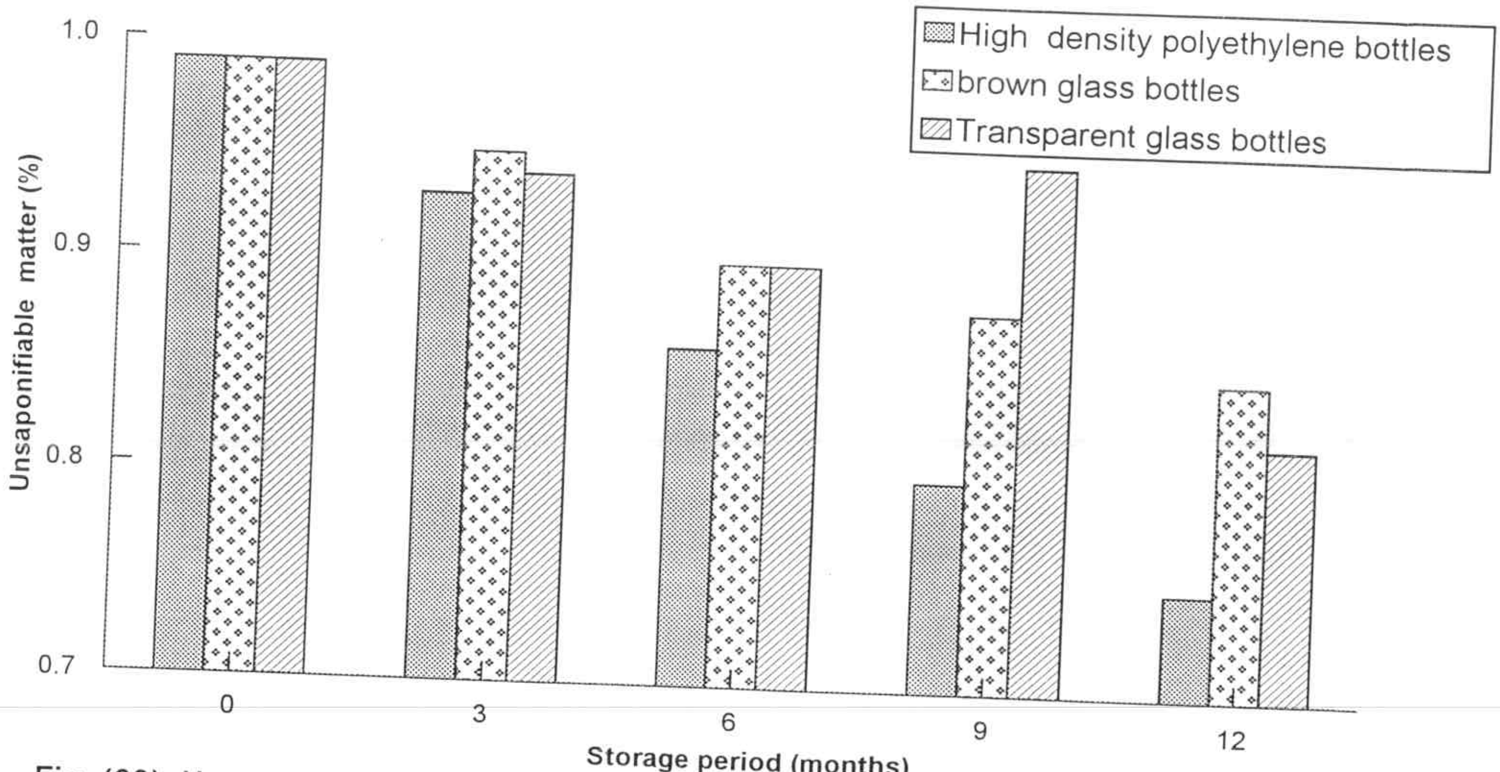

Fig. (30): Unsaponifiable matter in olive oil stored for 12 months in different packaging materials.

zero time was 0.99% while, after 12 months reached 0.75, 0.85 and 0.82 packed in high density polyethylene bottles, brown glass bottles and transparent glass bottles, respectively.

From the results in the same Table (37) it could be seen that the unsaponifiable matter was changed with increasing storage period and highest change in unsaponifiable matter in high density polyethylene bottles. This change unsaponifiable matter may be due to increase of acidity. This results in agreement with those reported by **Abd- El-Baky et al. (1991).**

Finally it can be concluded that the packaging of olive oil in brown glass containers gave better results than packaging in transparent glass and in plastic containers.