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Effect of Different Drying Methods and Packing Material on Quality of Thyme (*Thymus vulgaris* L.) During Storage

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THIS INVESTIGATION was carried out during successive seasons of (2010/2011) and (2011/2012) at El-Kassassin Hort. Res. Station, Ismailia Governorate, Hort. Res. Institute, A. R. C., Egypt, to evaluate the effect of drying methods; oven at 45°C, shade at 20 ± 2°C, greenhouse at 35 ± 5°C and sun at 30 ± 3°C and packing materials; carton boxes, glass jars, cotton bags and polyethylene bags during the different storage periods of 2, 4, 6, 8, 10 and 12 months on volatile oil, moisture content and herb pigments content, in the thyme (*Thymus vulgaris* L) plant herb.

The highest values of volatile oil percentage was obtained from the oven drying method, while the lowest values was obtained from sun drying method. On the other side, the highest values of dry matter resulted from the shade drying, while the lowest resulted from the sun drying. Oven drying recorded the highest moisture content per 100 g fresh herb, while the lowest values recorded by shade drying in both seasons.

The G.L.C. of the volatile oil revealed that 12 compounds were identified as following Tricyclene, α-Pinene, Camphene, α–Terpinene, Limonene, 1,8-cineol, p- cymene, Camphor, Linalool, Borneol, Thymol and Carvacrol. The major componemts were Limonene and Thymol.

The oven drying combined with both glass jars or carton boxes recorded the highest values of chlorophyll (a), chlorophyll (b) and carotene content in herb, while the sun drying method combined with polyethylene bags recorded the lowest values in this respect during both seasons.

The storage period from 2 to 12 months decrease in the chlorophyll (a), chlorophyll (b) and carotene content of thyme herb in the two seasons.

Keywords: Thyme (*Thymus vulgaris* L.), drying methods, packing materials, storage periods and volatile oil.

Medicinal and aromatic plants are an important source of national income and foreign currency. They are among the most important agricultural export commodities that are in demand in European and other international markets. Moisture content (%) is considered to be one of the most important factors influencing the quality attributes of dried herbs. Drying method of medicinal and

aromatic plants is very important in meeting quality of plants and making them available for foreign and local markets. For this reason, suitable drying methods are needed, characterized in rapid reduction of the water content without affecting the quality of the active ingredients Bohm *et al*. (2006). The duration of drying process can vary from few hours to many weeks. Traditional drying methods, such as air drying in sun or under shade depend largely on the weather conditions, while artificial drying is more rapid and helps plant parts (flowers and leaves) retaining their color and aroma.

Rashed and Younis (2010) found that the highest significant dry matter %, chlorophyll (a) and (b), volatile oil % and oil constituents were recorded for polypropylene and polyvinyl chloride 2 shrink film to keep the quality of oregano herb until four weeks; the best drying system was the solar drying. Increasing storage period decreased the volatile oil percentage and the most of main components of fresh *Origanum syriacum*, L. herb.

Kassem *et al*. (2006) reported that some drying methods decreased essential oil content in lemongrass, oregano, spearmint and peppermint plants and the solar drying method was better than the natural drying (sun drying) and artificial drying (in oven at 45°C). Mohamed, Mona (2010) showed that the shade drying method was the best treatment for producing the highest volatile oil percentage of parsley and dill plants, while oven drying gave the highest percentage of volatile oil components. On the other hand, sun drying method was the lowest one since it caused a decrease in the plant quality.

Thyme (*Thymus vulgaris* L.) belongs to the Lamiaceae (Labiatae) family, which comprises a large number of economically important plants such as mint, sweet basil, salvia, rosemary, marjoram, lavender beside thyme. Most of these plants grow well in Egypt as well in many other countries. It contains volatile oil of aromatic scent Simon *et al*. (1984)

Leaves and flowering tops of the plant are used to extract essential oil by steam distillation Guenther (1961). Volatile oil of Thymus vulgaris consists of different active medical ingredients used for carminative, antimicrobial, antiseptic, expectorant, diaphoretic actions, antigastra intestinal treatments. And some are used as additives in detergents, culinary (in food production) and perfumery industry Boon and Smith, (1999). The aim of this study is to evaluate the effect of the combination between drying methods and packing materials to obtained high pigments quality and volatile oil, content in dried thyme herbs during storage period of 12 months.

Materials and Methods

This investigation was carried out during the two successive seasons of (2010/2011) and (2011/2012) at El-Kassassin, Hort. Res. Station, Ismailia

Governorate, Hort. Res. Institute, Agri. Res. Center, Ministry of Agric., Egypt to evaluate the effect of the combination between drying methods (oven, shade, green-house and sun) and packing materials (carton boxes, glass jars, cotton bags and polyethylene bags) during the different storage periods, *.i.e.* 2, 4, 6, 8, 10 and 12 months on volatile oil, moisture content, pigments content (chlorophyll a, b and carotene) in the fresh and dried herbs of thyme (*Thymus vulgaris* L) plant.

The thyme plants (*Thymus vulgaris* L) seedlings were obtained from the Medicinal and Aromatic Plants Section at El-Kanater El-Khairia, Kalubia Governorate, Hort. Res. Institute, A.R.C. The seedlings were 10 – 15 cm in length, with 10 – 12 leaves and were transplanted on 1st of March in rows (60 cm between rows and 30 cm between plants).

The plants were cut twice in both seasons after three month from the transplanting at 10 cm from the soil surface. Plant samples was 4.8 k.(4 drying methods X 4 packing materials X 3 replicates) fresh herb of two cuttings and divided into four partition (1.2 k. fresh herb) for the each one drying method, each this the weight (1.2 k.) were divided into four partition for the one packing material, each one packing need 300 g. and divided for 3 replicates (100g.for one replicate).

This experiment included 16 treatments, which were the combinations between four drying methods and four packing materials as follows:

- Oven drying + Carton boxes.
- Oven drying + Glass jars.
- Oven drying + Cotton bags.
- Oven drying + Polyethylene.
- Shade drying + Carton boxes.
- Shade drying + Glass jars.
- Shade drying + Cotton bags.
- Shade drying + Polyethylene.
- Greenhouse drying + Carton boxes.
- 10.Greenhouse drying + Glass jars.
- 11.Greenhouse drying + Cotton bags.
- 12.Greenhouse drying + Polyethylene.
- 13.Sun drying + Carton boxes.
- 14.Sun drying + Glass jars.
- 15.Sun drying + Cotton bags.
- 16.Sun drying + Polyethylene.

These treatments were arranged in a randomized complete block design with three replicates.

Drying methods

Samples of thyme plant was divided into four sets, 1.2 kg of the fresh herb was taken to each one way of drying methods and put in the groups each 100g form the following different drying procedures:

Oven drying: The fresh herbs were put on layer paper in oven at 45°C for 6 hours until the complete drying.

Shade drying: The fresh herbs were put in open ventilated area at 20 ±2°C in one layer paper for 15 days until the complete drying.

Green house drying: The fresh herbs were put on layer paper at 35 ± 5°C for 5 days until the complete drying.

Sun drying: The fresh herbs were put on layer paper at 30±3°C for 7-10 days until the complete drying.

Packing materials

After each drying method, the dried samples were separated to different packing materials. The packing materials were carton boxes, glass jars, cotton bags and polyethylene bags. Each containers type contains dry herb came out of 100 g. fresh herb (FW) of thyme (*Thymus vulgaris* L). Four storage container of different material for each method of drying. The storage period is 12 months under room temperature conditions and the data recorded every 2 months in two seasons.

Data recorded

Herb dry matter (g / 100g FW) Plant samples of 100 g were chosen randomly from each treatment and dried at oven, shade, greenhouse and sun drying methods. The dry matter were recorded when its weight remained constant.

Moisture percentage (%) Plants were chosen randomly from each treatment and their moisture % was calculated by drying 50g of the samples at 70 °C in oven with air circulation until a constant weight.

Volatile oil percentage was determined in dry herb according to the method described in the Egyptian Pharmacopoeia(1984), using Clevenger's apparatus for the determination of essential oil according to Guenther (1961).

Gas chromatography; GLC analysis was determined for the volatile oil in 5 samples per plant under this study (1 sample from fresh herb and 4 samples from dry herb). The oil samples were performed using a programmed procedure. The quantitative estimation for each compound was based on the peak area measurement by triangulation Guenther and Joseph (1978).

Chlorophyll a b and carotene were determined in fresh and dry of herb samples (mg/g. D.W.) according to Mazumdar and Majumdar (2003).

Statistical analysis

Data were subjected to the statistical analysis and the differences between the means of the treatments were compared using the least significant differences (L.S.D) at 5 % level as mentioned by Gomez and Gomez (1984).

Results and Discussion

Effect of drying methods on moisture (%) and volatile oil (%) at storage start

Data presented in Table 1 indicate the effect of drying methods oven, shade, greenhouse and sun on moisture and oil percentage of thyme (*Thymus vulgaris*, L) plant; oven and sun drying decreased moisture of fresh weight (FW) by 62.91 and 65.75% in the first and second seasons respectively, while the shade drying decreased FW by 59.57and 60.51% in the two seasons, respectively. The highest values of oil percentage of 0.757 and 0.827 % resulted from the green house and oven drying at 35 ± 5°C in the first and second seasons respectively, while the lowest values of 0.613 and 0.660% were from sun drying at 30±3°C in both seasons, respectively, which means that sun drying causes more volatile oil loses. The results are in conformity with previous report from Karawya *et al*. (1977) who found that drying mint plants in the sun had decreased the essential oil content by 75 %. Refaat (1992) announced that laurel volatile oil percentage obtained from oven dried leaves at 40 °C was higher than that from shade and sun dried ones by 27.21 and 23.13% respectively, and concluded that more rapid drying produces higher oil percentage. Chang *et al.* (1996) mentioned that the yield and chemical composition of essential oils from Grenadian nutmegs was decreased with increasing drying temperatures to 45°C and this was associated with decreases in monoterpene hydrocarbon content. They announced maximum essential oil yields on a dry weight basis were obtained for nutmegs dried at 21-23 °C. Muller *et al*. (1996) reported that medicinal plants are usually harvested at 80 % moisture content and stored at 11 %. Refaat and Wahba (1998) stated that shade drying of lavender herb showed more conspicuous effect on the volatile oil content, since the decrement in oil percentage of sun and oven dried plants reached 12.07 and 30 % respectively. Abdalla *et al*. (2002) noticed that, the highest percentage of essential oil of lemongrass (*Cymbopogon citratus*) was obtained from drying plant in shade, while the lowest one was obtained from drying in sun. Diaz-Maroto *et al.* (2002) recorded that oven drying at 45°C and air - drying at ambient temperature produced quite similar results and caused hardly any loss in volatile oil of bay leaf (*Laurus nobilis* L.) as compared to the fresh herb. Omidbaigi *et al.* (2004) reported that the flowers of Roman chamomile dried by three different drying methods of sun, shade and oven drying at 45°C and revealed that the oil content of the shade dried flowers was higher compared to sun or oven drying at 45 °C.

It is obvious that rapid artificial drying helps medicinal herbs in retaining quality and in satisfying growing demand of pharmaceutical industry.

TABLE 1. Effect of drying methods on moisture and volatile oil percentage of fresh thyme in two season (2010-2011) and (2011- 2012).

Drying Method	Dry weight (g)		Moisture Content (%)		Volatile oil %	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Oven	37.09	35.37	62.91	64.63	0.743	0.827
Shad	40.43	39.49	59.57	60.51	0.703	0.733
Green house	39.78	38.08	60.22	61.92	0.757	0.800
Sun	38.27	34.25	61.73	65.75	0.613	0.660
L.S.D. at 5%	1.22	0.73	1.22	0.73	0.024	0.009

Effect of drying methods on the volatile oil components (%) at storage start

The results of G.L.C. analysis are shown in Table 2. Data showed the effect of drying methods (oven at 45°C, shade at 20 ± 2°C, greenhouse at 35 ± 5 °C and sun at 30 ± 3 °C) on the volatile oil constituents of fresh thyme herb . The drying method had a significant effect on the proportion of the total main components in volatile oil of thyme plant. The G.L.C. of the volatile oil revealed that 12 compounds were obtained in the oil as follows: Tricyclene, α - Pinene, Camphene, α – Terpinene, Limonene, 1,8-cineol, P-Cymene, Camphor, Linalool, Borneol, Thymol and Carvacrol.

The main components of thyme essential oil were Camphene, Limonene and Thymol. The total identified compounds were constituted 97.950, 97.471, 89.071, 93.191 and 64.377 % in the oil of fresh herb, oven, shade, greenhouse and sun drying methods, respectively. The data presented in Table 2 showed that each drying method had different mode of action on the constellation of the volatile oil compounds; each volatile oil component reacts different under certain drying method and no regular trend can be concluded; a certain (Tricyclene) component can be increased by one method (oven), decreased by another (green house) while posted three fold high by third method (sun drying). Thymol, as other example, remain in similar level by using oven, shade and green house drying method, while decreased by three fold when using sun drying. wever, the highest value of Camphene (7.269%) obtained from sun drying at 30 ± 3 °C while the lowest was (3.517%) from drying at oven at 45 °C. The highest value of Limonene (39.393%) gave from greenhouse drying at 35 ± 5 °C, while the lowest was (14.973%) from sun drying at 30 ± 3 °C. The highest value of P–Cymene (8.603%) from fresh herb, while the lowest was (3.447%) from drying at oven at 45 °C, the highest value of Thymol was (23.693 %) from drying in oven at 45 °C, while the lowest was (5.747%) from drying in sun and the highest value of Carvacrol (8.590%) gave from greenhouse drying at 35 ± 5 °C, while the lowest was (0.009%) from sun drying at 30 ± 3 °C.

TABLE 2. Effect of drying method on volatile oil components (%) of *Thymus vulgaris* L. plant.

Volatile oil components	Volatile oil components (in %) after drying methods				
	Fresh herb	Oven at 45°C	Shade at 20 ±2 °C	Greenhouse at 35 ± 5°C	Sun at 30±3°C
Tricyclene	2.124	2.160	1.751	0.769	6.730
α – Pinene	3.909	4.017	3.794	5.370	9.627
Camphene	4.162	3.517	4.363	4.060	7.269
α –Terpinene	-	0.892	-	-	-
Limonene	35.78	34.270	33.941	39.393	14.973
1,8 - Cineol	5.530	11.387	6.338	-	-
P - Cymene	8.603	3.447	4.770	3.692	7.388
Camphor	1.804	1.819	-	3.960	-
Linalool	5.736	6.015	7.096	2.467	7.912
Borneol	6.132	4.538	3.145	2.088	4.722
Thymol	22.755	23.693	21.083	22.762	5.747
Carvacrol	1.415	1.716	2.790	8.590	0.009
Total Known	97.950	97.471	89.071	93.151	64.377

Effect of drying methods on chlorophyll (a) content (mg/g D.W.)

Chlorophyll content is considered as quality indicator of freshness. Data in Table (3- a) showed that the chlorophyll (a) content of thyme herb at different drying methods; the oven drying gave the highest values of chlorophyll (a) by 1.83 and 1.26 mg /g DW, while the sun drying gave the lowest values of chlorophyll (a) by 1.69 and 1.13 mg /g DW during the first and second seasons, respectively. These may be due to the degradation effect of light and heat that is more drastic in sun than in oven (heat factor) than in shade (absence of light and heat factor), which is liable for oxidation, polymerization or resinification. Similar results were obtained by Mohamed, Mona (2010) on parsley and dill and showed that aromatic herbs must be dried rapidly to retain their color.

TABLE 3-a. Effect of drying methods on chlorophyll a of thyme herb after different drying methods during the two seasons of 2010-2011 and 2011-2012 .

Chlorophylla	Seasons	Drying methods					
		Fresh herb	Oven	Shad	Green house	Sun	L.S.D. 5%
mg/g D.W	1st season	1.60	1.83	1.71	1.79	1.69	0.00002
	2nd season	1.12	1.26	1.24	1.29	1.13	0.007

Concerning, the effect of the drying methods and packing materials treatments throughout 12 months storage periods in retaining the freshness color after drying with different methods, the chlorophyll (a) content is used as indicator. The data in Table (3-b) showed that, the effect of this interaction treatments resulted significant effect on chlorophyll (a); the glass jars as packing materials retain the highest value of chlorophyll (a) content dried under all different drying methods (oven, shade, greenhouse and sun) throughout storage period of 12 months when compared with the other packing materials. While, the lowest value obtained by using the polyethylene bags as packing materials with different drying methods compared with the others packing materials in both seasons throughout storage period of 12 months. This is mainly due to the structure of transparent polyethylene bags, which gives high penetration level of light more than the carton boxes or the cotton bags which affects the sensitive molecular structure of chlorophyll badly.

These results are in agreement with those obtained by of Rashed (2002) on dill and parsley and Al-Kershi (2003) on spearmint and sweet basil herbs, indicated that stored in polyethylene bags reduced chlorophyll "a+b". Also Mohamed (2005) on marjoram and rosemary leaves, reported that polyethylene bags had the lowest values of chlorophyll content.

Also, it could be noticed that there was a gradual significant decrease in chlorophyll (a) content of thyme herb during the storage periods from 2 to 12 months in the two seasons. These results were parallel to those obtained by Hassan *et al*. (1989) on peppermint and El-Kady (2003) on basil and marjoram, found that during storage up to nine months at room temperature, the chlorophyll content was gradually degraded.

Effect of drying methods, packing materials treatments and different storage periods on chlorophyll (b) content (mg/g D.W.)

Data in Table (4-a) showed the effect of drying methods at storage start on chlorophyll (b) content, as indicater for freshness; the data inducted that the drying methods have significant effect on chlorophyll (b) content, it could be noticed that the oven dying method 45°C gave the highest chlorophyll (b) content with 1.47 and 1.30 mg/g D.W., respectively during the two seasons, compared with the other drying methods. While, the sun drying gave the lowest values of chlorophyll (b) content of 1.22 and 1.17 mg/ g D.W., respectively, during the two seasons. This is in accordance with the findings of Musa *et al*. (2004) found that sun drying method was the lowest one since it caused a decrease in plant quality *i.e.* chlorophyll content. The same results obtained by Mohamed, Mona (2010) on parsley and dill.

TABLE 3-b. Effect of packing materials and different storage periods after drying methods on chlorophyll a of thyme in the 2 seasons of 2010-2011 and 2011- 2012.

Drying methods	Packing material	Chlorophyll a (mg/ g D.W.) Storage periods (months) 2	4	6	8	10	12	Sum of storage Period	Sum of drying Method
		First season							
Oven	Carton boxes	1.797	1.583	1.430	1.440	1.250	1.207	9	34
	Glass jars	1.803	1.747	1.570	1.490	1.417	1.350	9	
	Cotton bags	1.730	1.583	1.510	1.243	1.213	1.193	8	
	Polyethylene bags	1.650	1.357	1.360	1.033	1.033	1.173	8	
Shad	Carton boxes	1.557	1.527	1.423	1.410	1.337	1.380	9	35
	Glass jars	1.667	1.587	1.550	1.527	1.480	1.427	9	
	Cotton bags	1.543	1.507	1.450	1.477	1.353	1.283	9	
	Polyethylene bags	1.527	1.383	1.337	1.250	1.160	1.060	8	
Green house	Carton boxes	1.733	1.440	1.407	1.140	1.080	1.040	8	32
	Glass jars	1.767	1.517	1.490	1.417	1.293	1.183	9	
	Cotton bags	1.643	1.323	1.250	1.217	1.097	1.033	8	
	Polyethylene bags	1.627	1.260	1.177	1.160	1.000	0.910	7	
Sun	Carton boxes	1.600	1.313	1.217	1.180	1.103	1.073	7	28
	Glass jars	1.663	1.297	1.257	1.243	1.177	1.120	8	
	Cotton bags	1.597	1.260	1.150	1.160	1.073	1.033	7	
	Polyethylene bags	1.470	1.057	1.033	1.007	0.973	0.860	6	
	L.S.D. at 5 %	0.027	0.069	0.036	0.041	0.044	0.037		
Sum Drying Period X Storage		26.37	22.74	21.61	20.39	19.04	18.33		
		Second season							
Oven	Carton boxes	1.260	1.223	1.143	1.077	0.976	0.849	7	27
	Glass jars	1.320	1.300	1.233	1.137	1.018	0.976	7	
	Cotton bags	1.203	1.147	1.133	1.063	0.923	0.639	6	
	Polyethylene bags	1.477	1.390	1.297	1.187	1.030	0.909	7	
Shad	Carton boxes	1.347	1.263	1.110	1.067	0.981	0.852	7	27
	Glass jars	1.217	1.307	1.233	1.133	0.993	0.966	7	
	Cotton bags	1.417	1.133	1.150	1.047	0.796	0.652	6	
	Polyethylene bags	1.513	1.383	1.300	1.233	1.002	0.892	7	
Green house	Carton boxes	1.277	1.217	1.173	1.067	1.053	0.820	7	27
	Glass jars	1.330	1.310	1.267	1.100	1.070	0.843	7	
	Cotton bags	1.233	1.160	1.160	0.963	0.863	0.695	6	
	Polyethylene bags	1.307	1.253	1.267	1.187	1.107	0.969	7	
Sun	Carton boxes	1.163	1.140	1.130	1.073	0.856	0.478	6	23
	Glass jars	1.210	1.340	1.257	1.083	0.985	0.591	6	
	Cotton bags	1.083	1.193	1.103	0.985	0.671	0.353	5	
	Polyethylene bags	1.207	1.263	1.253	1.077	1.002	0.673	6	
L.S.D. at 5 %		0.060	0.033	0.035	0.033	0.050	0.040		
Sum Drying Period X Storage		20.50	20.02	19.20	17.47	15.00	12.15		

TABLE 4-a. Effect of drying methods on chlorophyll b of thyme herb during the two seasons of 2010-2011 and 2011-2012.

Chlorophyll b	Season	Drying methods					
		Fresh herb	Oven	Shad	Green house	Sun	L.S.D. 5%
mg/g D.W	1st season	1.19	1.47	1.29	1.23	1.22	0.00005
	2nd	1.07	1.30	1.22	1.41	1.17	0.0003

Concerning, the effect of the drying methods and packing materials treatments throughout 12 months storage periods in retaining the freshness color after drying with different methods, the data in Table (4-b) showed the effect of the drying methods and packing materials treatments on the chlorophyll (b) content; it was significantly affected with the interaction treatments . The interaction effect showed similar trend as in case of chlorophyll (a); oven drying method at 45 °C of thyme herb which stored in glass jars as packing material gave the highest values of chlorophyll (b) content during the two seasons. Also, using the glass jar as packing materials combined with the other drying methods through the 12 months storage period gave the highest values of chlorophyll (b) content. While, the data showed that the sun drying method of thyme which stored in polyethylene bags as packing materials gave the lowest values of chlorophyll (b) content during the tow seasons.

This is mainly due to the structure of transparent polyethylene bags, which gives high penetration level of light more than the carton boxes or the cotton bags which affects the sensitive molecular structure of chlorophyll badly. The longest storage period of 12 months decreased the chlorophyll (b) content of thyme herb in the two seasons the loss increased with increasing period of storage.

These results were parallel with those obtained by Hassan *et al.* (1989), on peppermint, Abd El-Latif *et al*. (2001), on parsley, coriander and peppermint and El-Kady (2003) on basil and marjoram. Mohamed (2005) on marjoram and rosemary.

Effect of drying methods, packing materials treatments and different storage periods on carotene content (mg/g D.W.)

As for the effect of drying methods in zero time, the data in Table (5-a) indicated that the carotene content was significantly affected with the drying methods. The maximum values of carotene content obtained when using the oven drying method at 45 °C resulted (1.15 and 1.02 mg/g D.W.) during the first and second seasons, respectively. While the lowest values when using the sun drying method at 30 ± 5 °C resulted (1.0 and 0.87 mg/ g DW) during the first and second seasons compared to the shade and greenhouse drying methods.

The obtained results are in harmony with Karabulut *et al*. (2007) on apricot (*Prunus armenica* L.) and Mohamed, Mona (2010) on parsley and dill.

TABLE 4-b. Effect of packing materials and different storage periods after drying methods on Chlorophyll b of thyme in the two seasons of 2010/2010 and 2010/2011.

Drying methods	Packing material	Chlorophyll b (mg/ g D.W.) Storage periods (months) 2	4	6	8	10	12	Sum of storage Period	Sum of drying Method
		First season							
Oven	Carton boxes	1.230	1.063	1.023	1.017	0.933	0.830	6	24
	Glass jars	1.190	1.157	1.097	0.993	0.973	0.937	6	
	Cotton bags	1.187	1.033	1.080	1.070	0.897	0.927	6	
	Polyethylene bags	1.220	1.180	1.070	0.910	0.863	0.850	6	
Shad	Carton boxes	1.220	1.140	1.043	0.913	0.880	0.863	6	24
	Glass jars	1.220	1.180	1.083	1.017	1.000	0.973	6	
	Cotton bags	1.230	1.127	1.033	1.053	0.907	0.907	6	
	Polyethylene bags	1.173	0.987	0.877	1.087	0.847	0.813	6	
Green house	Carton boxes	1.247	1.087	1.050	1.050	1.000	1.030	6	26
	Glass jars	1.250	1.067	1.077	1.057	1.040	1.030	7	
	Cotton bags	1.210	1.107	1.040	1.087	1.060	1.070	7	
	Polyethylene bags	1.163	1.093	1.013	0.923	0.910	0.890	6	
Sun	Carton boxes	1.213	1.413	1.030	0.990	0.963	0.943	6	24
	Glass jars	1.183	1.123	1.087	1.333	1.030	0.950	6	
	Cotton bags	1.190	1.077	1.027	1.023	0.987	0.960	6	
	Polyethylene bags	1.203	1.063	0.980	0.893	0.850	0.853	6	
L.S.D. at 5 %		0.015	0.199	0.031	0.192	0.034	0.039		
Sum Drying Period X Storage		19.33	17.90	16.61	16.42	15.00	14.83		
		Second season							
Oven	Carton boxes	1.297	1.270	1.190	1.090	0.025	0.574	5	20
	Glass jars	1.340	1.313	1.120	1.027	0.033	0.620	5	
	Cotton bags	1.247	1.253	1.100	0.976	0.025	0.513	5	
	Polyethylene bags	1.203	1.187	1.067	0.886	0.033	0.292	5	
Shad	Carton boxes	1.247	1.207	1.183	1.057	0.025	0.635	5	20
	Glass jars	1.217	1.210	1.123	1.137	0.033	0.648	5	
	Cotton bags	1.203	1.180	1.153	0.958	0.025	0.419	5	
	Polyethylene bags	1.160	1.157	1.090	0.853	0.033	0.308	5	
Green house	Carton boxes	1.347	1.320	1.227	1.127	0.025	0.514	6	22
	Glass jars	1.413	1.400	1.320	1.163	0.033	0.539	6	
	Cotton bags	1.323	1.293	1.250	0.993	0.025	0.472	5	
	Polyethylene bags	1.197	1.200	1.143	0.849	0.033	0.290	5	
Sun	Carton boxes	1.197	1.180	1.160	0.986	0.025	0.318	5	19
	Glass jars	1.200	1.183	1.130	0.987	0.033	0.338	5	
	Cotton bags	1.147	1.137	1.097	0.884	0.025	0.272	5	
	Polyethylene bags	1.127	1.110	1.080	0.758	0.033	0.171	4	
L.S.D. at 5 %		0.024	0.031	0.033	0.025	0.062	0.033		
Sum Drying Period X Storage		19.87	19.60	18.43	15.73	0.46	6.92		

TABLE 5-a. Effect of drying methods on carotene of thyme herb during the two seasons of 2010-2011 and 2011-2012.

Carotene	Seasons	Fresh herb	Drying methods				
			Oven	Shade	Green house	Sun	L.S.D. 5%
mg/g D.W	1st season	0.95	1.15	1.11	1.05	1.00	0.0006
	1st season	0.82	1.02	0.97	0.95	0.87	0.0004

Also, the data in Table 5-b showed that, the drying methods and packing materials treatments had significant effect in carotene content through the 12 months storage periods. The highest values of carotene content of thyme herb resulted by using the oven drying method at 45 °C and stored in glass jars followed by cartoon boxes and cotton bags through 12 months storage periods. While, the polyethylene bags resulted the lowest carotene values under the similar conditions in the two seasons. The ethylene bags hastened the rate of carotene degradation. This is mainly due to the structure of transparent polyethylene bags, which gives high penetration level of light more than the cartoon boxes or the cotton bags which affects the sensitive molecular structure of carotene badly. Concerning the effect of storage periods, it could be noticed that there was a gradual significant decrease in carotene content of thyme herb during the storage periods from 2 to 12 months. The decrement percentages were 51.57 and 37.80 % compared the zero time (after drying methods) in the first and second seasons respectively, when stored for 12 month under the oven drying methods and using the glass jars in the two seasons. Similar results, were obtained by Mohamed (2005) on marjoram and rosemary and Mohamed, Mona (2010) on parsley and dill.

Conclusion

The results showed that using rapid oven drying at 45 °C and jar glasses as packing material were the best drying method and packing material in retaining higher volatile oil content and freshness of stored thyme herb, even though the longer the storage period the lower the quality; a storage period of 12 months may decrease the quality by 50% .

TABLE 5-b. Effect of packing materials and different storage periods after drying methods on carotene of thyme herb in the two seasons of 2010/2011 and 2011/2012.

Drying methods	Packing material	Carotene (mg/ gm D.W.)						Sum of storage Period	Sum of drying Method
		Storage periods (months)							
		2	4	6	8	10	12		
		First season							
Oven	Carton boxes	1.100	0.913	0.827	0.733	0.580	0.557	5	19
	Glass jars	1.130	0.867	0.853	0.777	0.600	0.563	5	
	Cotton bags	1.033	0.820	0.807	0.697	0.643	0.587	5	
	Polyethylene bags	0.970	0.787	0.733	0.630	0.540	0.477	4	
Shad	Carton boxes	0.967	0.860	0.820	0.720	0.747	0.630	5	19
	Glass jars	1.000	0.930	0.907	0.827	0.783	0.700	5	
	Cotton bags	0.923	0.837	0.793	0.700	0.690	0.633	5	
	Polyethylene bags	0.893	0.827	0.757	0.610	0.523	0.467	4	
Green house	Carton boxes	0.927	0.820	0.807	0.707	0.690	0.597	5	18
	Glass jars	0.970	0.860	0.857	0.773	0.713	0.617	5	
	Cotton bags	0.917	0.803	0.793	0.600	0.587	0.500	4	
	Polyethylene bags	0.857	0.777	0.737	0.553	0.517	0.503	4	
Sun	Carton boxes	0.857	0.740	0.760	0.593	0.690	0.600	4	17
	Glass jars	0.890	0.777	0.760	0.697	0.763	0.693	5	
	Cotton bags	0.830	0.690	0.693	0.577	0.593	0.560	4	
	Polyethylene bags	0.787	0.673	0.643	0.550	0.527	0.467	4	
L.S.D. at 5 %		0.014	0.030	0.030	0.023	0.020	0.030		
Sum Drying Period X Storage		15.05	12.98	12.55	10.74	10.19	9.15		
		Second season							
Oven	Carton boxes	0.907	0.867	0.857	0.730	0.540	0.510	4	17
	Glass jars	0.920	0.840	0.897	0.803	0.650	0.580	5	
	Cotton bags	0.810	0.833	0.683	0.697	0.593	0.477	4	
	Polyethylene bags	0.783	0.803	0.760	0.683	0.517	0.383	4	
Shad	Carton boxes	0.867	0.807	0.753	0.787	0.693	0.627	5	18
	Glass jars	0.887	0.903	0.823	0.763	0.743	0.650	5	
	Cotton bags	0.823	0.813	0.730	0.680	0.590	0.510	4	
	Polyethylene bags	0.740	0.740	0.727	0.597	0.513	0.417	4	
Green house	Carton boxes	0.930	0.893	0.810	0.647	0.610	0.560	4	17
	Glass jars	0.947	0.927	0.857	0.757	0.697	0.667	5	
	Cotton bags	0.827	0.760	0.777	0.680	0.507	0.430	4	
	Polyethylene bags	0.743	0.713	0.703	0.583	0.473	0.330	4	
Sun	Carton boxes	0.867	0.803	0.727	0.640	0.553	0.463	4	16
	Glass jars	0.907	0.900	0.840	0.747	0.663	0.630	5	
	Cotton bags	0.800	0.653	0.717	0.623	0.440	0.383	4	
	Polyethylene bags	0.697	0.613	0.630	0.587	0.433	0.293	3	
L.S.D. at 5 %		0.029	0.036	0.038	0.035	0.037	0.041		
Sum Drying Period X Storage		13.46	12.87	12.29	11.00	9.22	7.91		

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تأثير طرق التجفيف و مواد التعبئة على نوعية نبات الزعتر اثناء فترة التخزين

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تم إجراء هذا البحث خلال موسمين متتاليين (2010-2011) و(2011-2012) بمحطة البساتين بالقصاصين محافظة الاسماعيلية التابعة لمعهد بحوث البساتين - مركز البحوث الزراعية – مصر وذلك لتقييم تأثير طرق التجفيف وهى (فرن على درجة 45 م^0 والظل 20± 2 م^0 والصوبة 35± 5 م^0 والشمس 30± 3 م^0) وكذلك إستخدام عبوات التعبئة من (صناديق كارتون - برطمانات زجاجية - أكياس قطنية - أكياس من البلاستيك) خلال فترات تخزين مختلفة من (2- 4 – 6 – 8 – 10 – 12 شهر) وذلك على المحتوى من الزيت الطيار وصبغات الكلوروفيل والكاروتين لعشب نبات الزعتر .

أظهرت النتائج أن أعلى قيم من النسبة المئوية للزيت الطيار تأتى من إستخدام طريقة التجفيف بواسطة الفرن وأقل قيمة تأتى من طريقة التجفيف الشمسى.وبالنسبة لتحليل مكونات الزيت الطيار وجد أن زيت الزعتر يحتوى على 12 مركب هما: Tricyclene, α - Pinene, Camphene, α – Terpinene, Limonene,1,8-cineol, p- Cymene, Camphor, Linalool, Borneol, & Limonene : وأن المركبين الاساسيين هما Thymol and Carvacrol Thymol

كما ان إستخدام طريقة التجفيف بواسطة الفرن وتعبئة العشب الجاف فى عبوات من البرطمنات الزجاجية او صناديق الكرتون أعطت أعلى محتوى من الكلورفيل ا، ب والكاروتين كمعايير للنوعية، خلال الموسمين. اما إطالة فترة تخزين العشب من 2 الى12 شهر تظهر نقص تدريجى فى المحتوى من الكاورفيل ا، ب والكاروتين لعشب نبات الزعتر خلال الموسمين وان الضرر على النوعية يزداد مع زيادة فترة التخزين.