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EFFECT OF SOME POSTHARVEST TREATMENTS ON ROSEMARY HERB QUALITY

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ABSTRACT

The present investigation was conducted during the two seasons of 2011-2012 and 2012-2013 at North Sinai Agriculture Research Station – Med. and Aroma. Dept., El-Arish City, North Sinai Governorate, Egypt to study the effect of drying method, package type and storage period on essential oil percentage and their main components and total microbial count on rosemary herbs. Results of this study indicated that Shade drying treatment gave the highest oil (%) followed by oven drying method at 40ºC compared to sun drying. While lowest total microbes count (TMC) occurred with oven drying. The best package type through storage period was carton boxes; increasing storage period decreased the volatile oil percentage and the most of main components but increased total microbial count.

Key words: Postharvest, rosemary, dry, shade, oven, Sun, packaging, TMC.

INTRODUCTION

The family Lamiaceae has many plants which are cultivated for culinary purposes and characterized by their volatile oil widely used by food and pharmaceutical industries as a flavor or in fragrance formulae.

Rosmarinus officinalis, a member of the family Lamiaceae is a flowering plant that grows in Mediterranean countries, southern Europe and in the littoral region through Minor Asia areas wildly. Essential oils are also called volatile oils and are generally aromatic oils obtained by the steam or hydro-distillation of plants. Different parts of plants have been used to obtain essential oils. These include the flowers, leaves, seeds, roots, stems, bark, and wood though secretionary parts. Multiple studies have been reported on the chemical composition of the essential oils of *Rosmarinus officinalis* belonging to different regions in the world (**Khorshidi *et al.*, 2009; Pintore *et al.*, 2002; Bicchi *et al.*, 2000**). The essential oil of *Rosmarinus officinalis* has been the object of several studies antioxidant activity (**Wang *et al.*, 2008; Moreno *et al.*, 2006; Peng *et al.*, 2005; Éva *et al.*, 2003; Lo *et al.*, 2002**), antibacterial (**Ouattara *et al.*, 1997; Delcampo *et al.*, 2000; Oluwatuyi *et al.*, 2004; Rozman and Jersek, 2004; Moghtader and Afzali, 2009**), Toxicity insecticidal (**Papachristos and Stampoulos, 2004; Tunc *et al.*, 2009**), Anti-inflammatory and Antinociceptive (**Takaki *et al.*, 2008**), antifungal (**Ozcan and Chalchat, 2008; Pozzatti *et al.*, 2008**) and only, in recent years have these oils been commercialised as pest control products (**Isman, 2000**). In traditional medicine, Rosemary is used to treat different diseases including: depression, insomniac and arthritic pains (**Zargari, 1995**). Moreover volatile compounds obtained from plants, have known antimicrobial, antifungal and insecticidal activities (**Janssen *et al.*, 1987; Kurita *et al.*, 1981;**

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Oka *et al.*, 2000). Essential oils have many therapeutic and they aid the distribution of drugs and antiseptics **(Palevitch and Yaniv, 1991)**. Volatile aroma compounds are the most sensitive components in the process of herb drying. The effect of drying method on the essential oil content and composition were studied by many investigators like **Guenther (1961)** who stated that the direct exposure of plants to the sun tended to break the stalks and made the leaves brittle. In the same line **Omidbaigi *et al.* (2004)** reported that the volatile oil content of the shade dried flowers of Roman chamomile was the highest compared to sun-dried and oven-dried flowers at 40ºC. On the contrary, **Sefidkon *et al.* (2006)** mentioned that the drying method had no significant effect on oil composition of *Saturia hortensis*. Also, the length of storage affected the essential oil content and composition of many medicinal and aromatic plants. In this way **Singh *et al.* (1994)** reported that storage period length affected the percentage of *Cymbopogon* essential oil and the relative percentages of its constituents. The post-harvesting process of aromatic and medicinal plants has great importance in the production chain, because of its direct influence on the quality and quantity of the active principles in the product sold. Drying has been one of the most important processes in pre-processing of plants. The aim of drying is to reduce the moisture content of the product from actively growing in the field to a level that prevents deterioration of the product and allows storage in a stable condition. Fresh lamiaceae herbs usually contain 75-80% water, and water levels need to be lowered to less than 15% for their preservation. Drying is by far the most widely used treatment.

In Egypt with the increasing demand for exporting aromatic and medicinal plants such as rosemary, studies on the effect of drying methods, packaging and the storage period on the total microbes count (TMC) and essential oil percentage and composition of rosemary as an important aim of our investigation.

MATERIALS AND METHODS

This investigation was consummated during the two successive seasons of 2011-2012 and 2012-2013; at North Sinai Agric. Res. Station Lab., Med. and Aroma. Dept., El-Arish City, North Sinai Governorate, Egypt to study the effect of drying methods, different packaging and storage periods on essential oil percentage and their main components and total microbes count (TMC) on rosemary.

Rosemary Herb Source

On July 15th of the two tested seasons 2011-2012 and 2012-2013, uniform grown rosemary plants (previously planted on March 30th in the Experimental Farm Station, Agric. Res. Cent., Arish City, North Sinai Governorate, seedlings were transplanted to field in rows 70 cm apart and the distance between plants was 60 cm (one plant/hill) Organic manure and NPK fertilizers were added to the soil one month before cultivation at recommended rate) received the normal agricultural practices. Plants harvested at early morning (6:00 am) at about 5 cm above the soil surface in the second cut. Harvested herbs were immediately transported to the Post-harvest Lab., in the Experimental Farm Station, Agric. Res. Center, El-Arish City, North Sinai Governorate.

Drying Methods

Three drying methods were used as follows:

A. Shade drying involves placing the herb on craft paper in the sun for 24 hours then transfered to shade place until it reached a constant weight (D1).

B. Direct sun drying until it reached a constant weight (D2).

C. Oven drying at 40ºC for 48 hours (D3).

Packaging Process

Three packaging types (plastic cases, Jute cases and carton boxes) were used for each drying method. The samples of dried rosemary herb were packaged and stored for one year in a standard storage room in the same farm where the temperature was 25±1 and the relative humidity ranged from 25 to 40%.

Each treatment included eight replicates and each replicate was 5 kilogram of sage and rosemary dry herb. The stored samples of the dry herb in the different packages were studied for the tested characters in zero time of storage and every four months.

Data Recorded

1. Total microbes count (TMC) per gram sample of all treatments was determined using nutrient agar medium according to the procedure described by **Freitas and Bauab (2012)**.
2. Volatile oil percentage and volatile oil content of dry herb for each sample were determined using the method described in **British Pharmacopoeia (1963)**.
3. GLC analysis as outlined by **Harris (2003)** was used to determine the chemical composition of sage and rosemary essential oil for each treatment. It was carried out at the central herb Lab. of chemical analysis-National Research Center, Cairo.

Statistical Analysis

The experiment was designed in a Complete Randomized Design and was statistically analysis of variances and mean comparison were performed using **SAS (2004)**.

RESULTS AND DISCUSSION

Effect of Drying Method, Packaging Type and Storage Period on Total Microbes Count (TMC) Average Million/g Rosemary

Results presented in Table 1 show significant differences in TMC average in dried rosemary due to the methodology of the drying and storage period and packaging for storage and their interaction, also the results showed significant decrease in TMC average in dried herb using oven drying followed by direct sun and finally shade drying zero time storage (2.80, 3.40 and 5.19 million/g, in the first season and 2.92, 3.69 and 5.25 million/g, in the second season).

On the other hand, the lowest average of TMC (3.79 and 4.18 million/g. for each season respectively) after 4 months storage occurred with using oven drying. However, shade drying method gave the highest TMC average 6.48 and 6.01 million/g, for 1st and 2nd season, respectively.

TMC average in rosemary herb recorded that the lowest values throughout one year storage period in case of drying using oven drying system in comparison with the other drying methods. Also, the TMC values were 2.80, 3.79, 4.42 and 5.46 million/g in the first season while, the values were 2.92, 4.18, 4.88 and 5.95 million/g. in the second season.

Accordingly, Results in Table 1 in general found the use of carton boxes was the best in keeping dry herb for the duration of storage compared to other packages type. Also, the oven dry system gave the lowest average of TMC. Also, it was found that, lowest average of TMC in rosemary dry herb was recorded in case of oven drying method and storing the dried herb in carton boxes or plastic cases during the storage period. Values were found to be statistically the same for plastic cases and carton boxes. These results were in agreement with **Malmsten *et al.* (1991)** who studied two hundred herb samples for microbiological quality, he found that elevated temperature and moisture during storage period lead to increase microbial activity and enzymatic interaction that cause decomposition of active components of stored herb and **Mehasen *et al.* (2009)** who obtained the lowest

Table (1): Effect of drying method, packaging type and storage period on Total Microbial Count (TMC) average of rosemary

Drying method (D)	Package type (T)												
		Plastic	Jute	Carton	Mean	Plastic	Jute	Carton	Mean	Plastic	Jute	Carton	Mean
	Storage period (P)												
	Zero time		4 months			8 months				one year			
						First season							
Shade	5.19	6.21	7.11	6.11	6.48	7.45	9.13	7.03	7.87	8.21	9.99	8.11	8.77
Direct sun	3.40	4.02	6.30	3.68	4.66	5.11	8.11	4.74	5.98	5.37	8.89	5.16	6.47
Oven	2.80	3.91	4.33	3..45	3.79	4.11	5.11	4.05	4.42	5.78	6.14	4.46	5.46
Mean	3.80	4.81	5.91	4.41		5.55	7.45	5.27		6.45	8.34	5.91	
LSD at 0.05	T= 0.097,	D= 0.097,		P = 0.097,		P × T = 0.169,		P × D= 0.169,		T × D = 0.169,		P× D× T= 0.293	
						Second season							
Shade	5.25	6.15	6.35	5.54	6.01	6.97	8.08	6.23	7.09	8.5	11.52	7.32	9.11
Direct sun	3.69	4.86	5.55	4.29	4.90	5.22	6.29	4.93	5.48	7.98	8.32	5.01	7.10
Oven	2.92	3.65	5.32	3.58	4.18	4.80	5.56	4.29	4.88	5.20	7.65	5.00	5.95
Mean	3.95	4.88	5.7٤	4.47		5.66	6.64	5.15		7.23	9.16	5.78	
LSD at 0.05	T= 0.018,	D= 0.018,		P = 0.018,		P× T = 0.032,		P × D= 0.032,		T × D = 0.032,		P× D× T= 0.056	

D: Drying system T: Packaging type P: Storage period

average of TMC stored for four months occurred when using solar drying however, direct sun and shade drying method gave the highest TMC average and the lowest average of TMC in pepper mint dry herb was recorded in case of solar drying method and storing the dried herb in carton boxes or plastic cases during the storage period.

Volatile Oil Percentage

Results presented in Table 2 show significant differences in volatile oil percentage from through the zero time storage, after four, eight months and 12 months storage due to the effect of drying, packaging and their interaction treatments.

Results indicated that, volatile oil percentage of rosemary herb was found to be affected by drying methods. The highest volatile oil content was recorded in case of shade drying method in zero time (1.63 and 1.67% for 1st and 2nd seasons, respectively), while the lowest one was found in direct sun drying in zero time storage (1.47 and 1.41% for 1st and 2nd seasons, respectively). The differences between the values of volatile oil content of the three drying methods were significant so, it could be concluded that, the best drying method was shade drying method in which the evaporation of volatile oil of the rosemary herb was less than the other drying methods. As for the storage period, results also indicated that volatile oil percentage was affected by storage period. It was found that, volatile oil content gradually decreased as the storage period was increased.

Volatile oil percentage was 1.56 and 1.52% for each season respectively in zero time, then this value was decreased after one year storage for 1st and 2nd seasons, respectively, regardless the storage packages.

Concerning the packaging types and its effect on volatile oil percentage of rosemary

Table (2): Effect of drying method, packaging type and storage period and their interaction on volatile oil percentage of rosemary.

Drying method (D)	Package type (T)											
	Plastic	Jute	Carton	Mean	Plastic	Jute	Carton	Mean	Plastic	Jute	Carton	Mean
	Storage period (P)											
	Zero time		4 months			8 months			one year			
	First season											
Shade	1.63	1.29	1.25	1.34	1.29	1.27	1.25	1.29	1.27	1.21	1.20	1.23	1.21
Direct sun	1.47	1.15	1.13	1.17	1.15	1.12	1.09	1.13	1.11	1.03	0.99	1.06	1.03
Oven	1.57	1.26	1.25	1.26	1.26	1.21	1.19	1.23	1.21	1.15	1.13	1.17	1.15
Mean	1.56	1.23	1.21	1.26		1.20	1.18	1.22		1.13	1.11	1.15	
LSD at 0.05	T = 0.016, D = 0.016, P = 0.016, P× T = 0.028, P × D = 0.028, T × D = 0.028, P × T × D = 0.049											
	Second season											
Shade	1.67	1.28	1.25	1.33	1.29	1.26	1.23	1.28	1.26	1.20	1.13	1.21	1.18
Direct sun	1.41	1.13	1.11	1.16	1.13	1.10	1.03	1.11	1.08	0.98	0.95	1.01	0.98
Oven	1.49	1.25	1.24	1.25	1.25	1.20	1.17	1.21	1.19	1.09	1.04	1.11	1.08
Mean	1.52	1.22	1.20	1.25		1.19	1.14	1.20		1.09	1.04	1.11	
LSD at 0.05	T = 0.021, D = 0.021, P = 0.021, P× T = 0.037, P × D = 0.037, T × D = 0.037, P × T × D = 0.064											

D: Drying system T: Packaging type P: Storage period

dried herb, it was pointed out that, the packaging type either preserved the volatile oil percentage of rosemary dried herb, or led to a sharp decrement, this trend was clearly showed throughout the storage period. The highest volatile oil percentage was detected in case of carton boxes, while the lowest one was found in plastic cases.

Results also, emphasized that, an interaction was found between the three factors that used in this study. It was found that, after four months storage period the highest volatile oil percentage was determined in rosemary herb under shade drying method and packaging in carton boxes, the value in this respect were 1.34 and 1.33% in the two seasons. On the contrary, lowest value of rosemary oil percentage was obtained after one year storage with using Jute cases regardless the drying method.

On the light of these findings, it could be concluded that the best quality of rosemary herb (in view of oil percentage) was obtained by using shade drying method for dried herb in carton boxes for a period prolonged to four months. In this case the volatile oil percentage was 1.34% comparing to 1.63% at the zero time (Aug 2011) in the first season. Also, the volatile oil percentage was 1.33% comparing to 1.67% at the zero time (Aug 2012) in the second season.

In addition, the results showed that the best drying system, which gave the highest percentage in rosemary oil, was shade drying system. Also, the storage package, which gave the highest percentage volatile oil, was carton boxes. Similarly, the highest percentage of rosemary volatile oil after one year storage (1.23 and 1.21%) occurred with using shade drying system with carton boxes.

In general, Results reported that the volatile oil percentage of rosemary from the dried herb with the three drying methods was decreased through the storage period from zero time to one year storage. Also, the best storage packaging was the carton which led to the lowest decreasing level in the oil percentage. These results may due to the effect of those post harvest treatments on the chemical composition and biological activity of medicinal plant material. These include the common practices of drying and re-dissolving plant extracts; various filtering methods; the application of heat and; the use of liquid nitrogen to grind plant material. Information, such as storage period and conditions, therefore, should be noted and included in published results. Since accelerated ageing **Omidbaigi *et al*. (2004)** found the oil content of the shade-dried flowers of Roman chamomile was the largest compared to sun-drying and oven-drying at 40°C; **Mohamed (2005)** obtained the highest volatile oil percentage from polyethylene bags followed by cardboard boxes, while the jute sacks had the lowest values of marjoram and rosemary; **Mehasen *et al*. (2009)** obtained the highest volatile oil content of dried herb peppermint in carton boxes compared with plastic and jute and **Ibrahim (2010)** reported that on lemon verbena shade drying gave the highest essential oil percentage followed by oven drying method at 45 ^{0}C. On the other hand **Shala (2007)** found that the highest essential oil percentage in the sage leaves after 6 months resulted from leaves stored in jute packing.

The Active Ingredients

Results in Table 3 indicated that the shade drying method gave the highest percentage of α- Pinene in Rosemary oil followed by the direct sun drying and oven drying (48.9, 43.5 and 38.3%, in the second season while the 1,8 Cineole percentage were 13.9, 11.2 and 11.3%, respectively) at zero time. Shade drying method gave the highest percentage Camphene which valued 9.89, followed by the direct sun drying and oven drying (7.75 and 5.50 in the second seasons, respectively) at zero time.

The highest percentage of camphor was recorded in case of shade drying method (7.87%) followed by direct sun and oven drying (5.10 and 5.21%) in the second seasons respectively. results also indicated that the highest percentage of sabinen and verbenone was found in case of shade drying (5.18 and 3.22%) followed by direct sun (3.56 and 1.79%) and oven drying (3.12 and 1.51%) in the second seasons at zero time. So, it could be reported that, the best drying method was shade drying in which the evaporation of volatile oil of the rosemary herb was less than the other drying methods. Similar results were found by **Abdollah *et al*. (2013)** who stated that on basil the percentage methyl chavicol in the oil decreased significantly when the plant material was dried in the oven at 60°C or microwaved. In addition, linalool, the second major compound in the purple landrace, and geranial and neral, major compounds in the green landrace, decreased significantly when the plant tissue was dried in the oven at 60°C or microwaved and **Vahid and Sharareh (2013)** on sage observed maximum α-Thujone, 1, 8-Cineole and viridiflorol percentage was obtained in shade, sun and oven methods, respectively.

Results in Table 4 for the packaging types and its effect on α-Pinene percentage of rosemary dried herb oil, show that, the packaging type either preserved the α-Pinene percentage of rosemary dried herb, or led to a decrement, this trend was clearly evident throughout the storage period. Accordingly, the highest α-Pinene percentage was detected in case of carton boxes (47.03%) followed by plastic cases (45.93%), while the lowest one was found in jute (45.11%) in the second season after four months. As for the storage period, results also indicated by storage period. It was found that, α-Pinene percentage gradually decreased as the storage period was increased.

Table (3): Effect of drying methods on main components of rosemary essential oil on zero time.

Treatment	Essential oil main components (%)					
	α- Pinene	1,8 Cineole	Camphene	Camphor	Sabinene	Verbenone
Shade	48.90	13.90	9.89	7.87	5.18	3.22
Direct sun	43.50	11.20	7.75	5.10	3.56	1.79
Oven	38.30	11.30	5.50	5.21	3.12	1.51

Table (4): Effect of drying methods, packaging and their interactions on main components of rosemary essential oil after 4 months from storage.

Treatment		Essential oil main components (%)					
		α- Pinene	1,8 Cineole	Camphene	Camphor	Sabinene	Verbenone
Shade	**Carton**	47.03	12.50	8.19	6.33	4.33	2.93
	Jute	45.11	10.90	7.41	5.58	3.60	2.70
	Plastic	45.93	11.80	7.86	5.99	4.10	2.87
Direct sun	**Carton**	42.50	11.20	7.75	5.80	3.96	2.20
	Jute	40.10	8.30	6.79	4.20	3.19	1.57
	Plastic	41.30	10.50	7.00	5.10	3.50	2.00
Oven	**Carton**	38.10	11.10	5.30	5.11	3.01	1.31
	Jute	35.10	9.10	4.30	4.11	2.87	1.12
	Plastic	36.30	10.30	5.10	5.02	2.77	1.21

Results also show that, interaction between the three factors that were used in this investigation; it was found that, after four months storage period the highest α-Pinene percentage was determined in rosemary herb with using shade drying method and packaging in carton boxes.

For 1,8 Cineole percentage in rosemary essential oil, the results in Table 4 indicated that the shade drying method gave the highest percentage of 1,8% Cineole in rosemary oil followed by the direct sun drying and oven drying in case of carton boxes (12.5, 11.2 and 11.1 in the second seasons respectively after Four months.

So, it could be reported that, the best drying method was shade drying system in which the evaporation of volatile oil of the rosemary herb was less than the other drying methods. As for the storage period, results also indicated that, 1,8 Cineole percentage gradually decreased as the storage period was increased.

Also results in the same table indicated that the highest camphene percentage was detected in case of shade drying and packaging in carton boxes 8.19%, while the lowest one found in oven drying and packaging jute cases 4.30% after 4 months storage period. An interaction was found

between drying method and packaging. The highest Camphene percentage was determined in rosemary herb using shade drying method and packaging in carton boxes. As for the storage period, results also indicated that Camphene content gradually decreased as the storage period was increased.

Moreover, the interaction between the drying method and packaging types resulted in a significant decrease in Camphor, the results indicated that the highest Camphor percentage was detected in case of shade drying and packaging in carton boxes (6.33%), while the lowest one was found in oven drying and packaging jute cases (4.11%) after 4 months storage period. As for the storage period, it was found that, Camphor content gradually decreased as the storage period was increased.

Interaction between the drying method and packages types resulted in a significant decrease in percentage of Sabinen and Verbenone in dry rosemary herb. It was found that, the highest value of Sabinen (4.33%) and Verbenone (2.93%) occurred with shade drying and packaging in carton boxes after 4 months in the second season.

In general, results also showed that the packaging type either preserved the α-Pinene, 1,8 Cineole, Camphene, Camphor, sabinen and verbenone percentage of rosemary dried herb, or led to a decrement. Accordingly, the highest α-Pinene, 1,8 Cineole and Camphene, Camphor, Sabinen and Verbenone contents were detected in case of carton boxes, while the lowest one was found in Jute cases.

Results also, revealed that, an interaction was found between the three factors that used in this investigation. It was found that, after four months storage period the highest value for each of α-Pinene, 1,8 Cineole, Camphene, Camphor, sabinen and verbenone content was determined in rosemary herb with using shade drying method and packaging in carton boxes. These results are in harmony with those reported by **Mehasen *et al*. (2009)** who noted the highest menthol, menthone and iso-menthone content was solar drying system then packed the dried herb peppermint in carton boxes compared with plastic and jute and **Khater *et al.* (2002)** on damsissa reported that the content of ambrosin and damsin was affected due to storing period**.** On the other hand, **Khalid *et al*. (2008)** found that drying of *Melissa officinalis* L. under sun is the most suitable for a high percentage of monoterpene hydrocarbons (during the first harvesting) or oven-dried herb at 40°C (during the second harvesting), but keeping it in fresh state are recommended for the highest oxygenated monoterpene during the first and second harvesting.

Results in Table 5 indicate that after 8 months the shade drying method gave the highest percentage of α-Pinene, 1,8 Cineole, Camphene, Camphor, Sabinen and Verbenone in rosemary oil followed by the direct sun drying and oven drying. Results showed that the packaging type affected the percentage of α-Pinene, 1,8 Cineole, Camphene, Camphor, Sabinen and Verbenone in rosemary dry herb. The highest α-Pinene, 1,8 Cineole and Camphene, Camphor, Sabinen and Verbenone contents were detected in case of carton boxes followed by plastic cases, while the lowest one was found in Jute cases.

Also, the interaction between the three factors that were used in this investigation was observed. It was found that, after eight months storage period the highest α-Pinene, 1,8 Cineole, Camphene, Camphor, Sabinen and Verbenone content was determined in rosemary herb under shade drying method and packaging in carton boxes.

Moreover, α-Pinene, 1,8 Cineole, Camphene, Camphor, Sabinen and Verbenone value of rosemary oil was found to be affected by drying methods and packaging type. The highest value for each of α- Pinene, 1,8 Cineole, Camphene, Camphor, Sabinen and Verbenone percentage

Table (5): Effect of drying methods, packaging and their interactions on main components of rosemary essential oil after 8 months from storage.

Treatment		Essential oil main components (%)					
		α- Pinene	1,8 Cineole	Camphene	Camphor	Sabinene	Verbenone
Shade	Carton	46.03	12.00	8.01	6.13	4.13	2.73
	Jute	42.11	10.00	6.40	5.00	3.00	2.55
	Plastic	45.50	11.60	7.66	5.75	4.00	2.35
Direct sun	Carton	42.00	11.01	7.55	5.54	3.81	2.12
	Jute	39.11	7.34	6.50	3.89	3.00	1.21
	Plastic	41.10	9.88	6.70	4.25	3.10	1.89
Oven	Carton	37.11	10.88	4.38	4.19	2.91	1.22
	Jute	33.11	8.22	3.60	3.91	2.38	1.00
	Plastic	35.3	10.12	3.71	4.92	2.25	1.15

was recorded in case of shade drying method with carton boxes (46.03, 12.00, 8.01, 6.13, 4.13 and 2.73%, respectively in the second season after 8 months), followed by plastic cases (45.50, 11.60, 7.66, 5.75, 4.00 and 2.35%, respectively in the second season after 8 months).

In general, the value of each of α-Pinene, 1,8 Cineole, Camphene, Camphor, Sabinen and Verbenone was decreased through storage period and the lowest decrement was with shad drying treatment in the carton package. However, the highest decrement was with oven and direct sun dried rosemary in Jute cases. Similar results were obtained by **Al-Kershi (2003)** who reported that storage sweet basil and peppermint after natural and artificial drying resulted in a significant reduction in principal components of essential oil in the two drying methods during storage period.

Results in Table 6 indicate that after storage for one year, the shade drying method gave the highest percentage of each of α-Pinene, 1,8 Cineole, Camphene, Camphor, Sabinen and Verbenone in rosemary oil followed by the direct sun drying and oven drying.

Also, α- Pinene, 1,8 Cineole, Camphene, Camphor, Sabinen and Verbenone value of rosemary oil was found to be affected by drying methods and packaging type . The highest value of each of α- Pinene, 1,8 Cineole, Camphene, Camphor, Sabinen and Verbenone percentage were recorded in case of shade drying method with carton boxes (45.96, 11.55, 7.11, 5.73, 4.00 and 2.33%, respectively in the second season after one year), followed by plastic cases (42.50, 10.36, 5.96, 4.25, 3.20 and 2.15%, respectively in the second season after one year).

As for the storage period, results also indicated that, α-Pinene, 1,8 Cineole, Camphene, Camphor, Sabinen and Verbenone percentage gradually decreased as the storage period increased. On contrast **Badawy (2010)** noticed that the highest sweet basil oil constituents were from jute sacks (storage materials), while the least were from carton boxes during 6 months (storage period) by using all drying methods of room, air and oven at 50^{o}C, respectively.

Table (6): Effect of drying methods, packaging and their interactions on main components of rosemary essential oil after one year from storage.

Treatment		Essential oil main components (%)					
		α- Pinene	1,8 Cineole	Camphene	Camphor	Sabinene	Verbenone
Shade	Carton	45.96	11.55	7.11	5.73	4.00	2.33
	Jute	40.14	8.70	6.10	4.80	2.90	2.05
	Plastic	42.50	10.36	5.96	4.25	3.20	2.15
Direct sun	Carton	42.00	10.01	7.00	5.12	3.10	2.00
	Jute	36.12	5.34	6.13	2.91	2.33	1.01
	Plastic	40.10	8.88	6.60	3.35	3.00	1.60
Oven	Carton	36.11	9.88	4.12	3.89	2.61	1.02
	Jute	31.11	6.21	3.30	3.11	2.11	0.95
	Plastic	33.31	9.74	3.21	3.22	2.21	1.05

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الملخص العربى

تـــأثـيـــر بعـــض معامـــلات مـــا بعـــد الحصـــاد على جـــودة عشـــب حصـالبـــان

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أجريت هذه الدراسة خلال الموسمين المتتاليين ٢٠١١-٢٠١٢ و٢٠١٢-٢٠١٣ في محطة البحوث الزراعية بالعريش، بقسم النباتات الطبية والعطرية، محافظة شمال سيناء وذلك لدراسة تاثير طريقة التجفيف ونوع العبوة وفترة التخزين علي نسبة ومكونات الزيت الطيار الرئيسية والحمل الميكروبي لعشب الحصالبان وقد أشارت نتائج هذه الدراسة إلى أن معاملة التجفيف فى الظل أعطت أعلى نسبة من الزيت تليها طريقة التجفيف فى الفرن عند درجة حرارة ٤٠ درجة مئوية مقارنة مع التجفيف المباشر فى الشمس بينما اقل حمل ميكروبى وجد فى حالة التجفيف بالفرن، وكان أفضل نوع عبوه خلال فترة التخزين كانت صناديق الكرتون؛ كما وجد أنه بزيادة فترة التخزين انخفضت نسبة الزيت الطيار ومعظم المكونات الرئيسية ولكن زاد الحمل الميكروبي في عشب حصالبان.

الكلمات الإسترشادية: معاملات ما بعد الحصاد، حصالبان، تجفيف، ظل، فرن، شمس، تعبئة، الحمل الميكروبى.

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