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EFFECT OF CUTS AND DIFFERENT DRYING METHODS ON VOLATILE OIL QUANTITY AND QUALITY OF SWET BASIL (*Ocimum basilicum* L.) PLANT.

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ABSTRACT

The present study was carried out during two successive summer seasons of 2006 / 2007 and 2007 / 2008 at the Experimental Farm of Medicinal and Aromatic Plants, Fac. Agric., Mansoura Univ. The research aimed to study the effect of cuts and different drying methods (room, air and oven at 50 ºC) on volatile oil quality and quantity of sweet basil (*Ocimum basilicum* L.) plant.

Sweet basil is a common herb, used for culinary and medicinal purposes. It is widely cultivated for the production of volatile oil, and is also important for the handling and distribution of raw materials with high moisture content and a limited shelf-life.

The results showed that the oven drying method was the best treatment to produce the highest volatile oil percentage, while the room drying method gave the highest percentage of volatile oil components. Also, the second and third cuts gave the highest volatile oil percentage and yield compared with to the first cut.

The G.L.C. of the volatile oil of the fresh leaves revealed a total of 7 compounds. The total identified compounds constituted 92.62, 91.56 and 87.53 % in the oil of the room, air and oven at 50 ºC drying methods respectively, compared to the fresh plants (91.0 %). The percentage of the main component (Linalool) was 87.77, 81.61 and 79.86% in the oil of the room, air and oven at 50 ºC drying method, respectively compared with the fresh plants (84.55 %) at the second cut in the second season.

INTRODUCTION

Sweet basil (*Ocimum basilicum* L.) is an herbaceous annual plant belongs to Fam. Lamiaceae, used as a spicy in the food industry and for medicinal purposes. It is well known as a plant of folk medicinal for it is accepted officially in a number of countries, and cultivated extensively in France, Egypt, Hungary, Morocco, and the United states (Dostal,1990). The cultivated area of sweet basil in Mediterranean countries has expanded markedly in recent years due to the increasing demand on the European market (Garibaldi *et al*., 1997).

The world market for basil oil is dominated by two main types, the European and Mediterranean. The Egyptian basil oil is considered to be of the highest quality, producing the finest odour. Characteristically, the essential oil from this basil contains high concentration of linalool. Other constituents found in low concentrations include: 1,8- cineole, β-caryophyllene, ocimene, α- terpineol, myrceme, eugenol, limonene, and methyl chavicol (Simon *et al*., 1990).. Traditionally, basil has been used as medicinal plant in the treatment of headaches, antidepressant, coughs, diarrhoea, constipation, carminative, antiseptic, warts and kidney malfunction

(Simon *et al*., 1990). Basil extract has been reported to have antioxidant activity and containing anti-cancer substances (Lee, 2005).

Basil is grown for its dried leaves; it is cut just prior to the appearance of flowers. For volatile oil, it is harvested during full bloom. In the Mediterranean areas, and other countries (Egypt) with similar climates, basil can be grown as a short-lived perennial, with 3-5 cuttings per year. Where two cuts are practiced, the first is generally early in the summer, and the yield is relatively low, and the second just prior to open bloom, (Simon *et al*., 1990).

Time of harvest affected the essential oil percentage and composition in many aromatic plants (Palamino *et al*., 1997, Tansi & Nacar 1999 and Bottcher *et al*., 2000).

Drying of herbs is particularly important for the handling and distribution of raw materials with high moisture content and a limited shelf-life (Sankat *et al*., 1996). Depending on many factors such as chemotype, growth conditions and plant developing stage, basil cannot be kept for long periods after harvesting and the essential oil content and quality can be reduced during postharvest (Bahl *et al*., 2000). The main cause of losses in endogenous, though external factors such as chilling injury many contribute (Lange, 1997).

Volatile aroma compounds are the most sensitive components in the process of herb drying. The change in the concentrations of the volatile compounds during drying process may have an influence on the content of aroma compounds, (Venskutonis, 1997).

The effect of drying method on the essential oil content and composition were studied by many investigators. Guenther (1961) stated that the direct exposure of plants to the sun tended to break the stalks and made the leaves brittle. Skrubis (1982) found that air drying of laurel leaves at 40, 50, 60 or 70 °C did not affect the oil composition. Refaat (1988) studied the effect of drying method on sweet marjoram herb, and concluded that the changes in oil constituents were the least when the herb was dried in the shade. Shalaby *et al*. (1988) found that oven drying at 60 °C reduces the essential oil content of the mint plants, whereas air drying at 27- 30 °C had no effect on essential oil content. Diaz- Maroto *et al*. (2002) mentioned that the air drying at ambient temperature resulted in few losses in volatile compounds of parsley (*Petroselinum crispum*) compared with the fresh herb, whereas oven drying at 45°C caused a decrease in the concentrations of the majority of the volatile components. Omidbaigi *et al*. (2004) reported that the oil content of the shade dried flowers of Roman chamomile was the largest compared to sun- drying and oven-drying at 40 °C. Kassem *et al*. (2006) reported that the 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). On the contrary, Sefidkon *et al*., (2006) mentioned that the drying method had no significant effect on oil composition of *Saturja hortensis*.

Only few investigations are known about the effect of drying upon the quality of aromatic herbs. Due to the above mentioned information, this work aimed to attain the best of drying methods on the quality and quantities of volatile oil of sweet basil (*Ocimum basilicum* L.) plants.

MATERIALS AND METHODS

The aim of this research was to study the effect of cuts and different drying methods on the quantity and quality properties of the volatile oil of sweet basil (*Ocimum basilicum* L.) plants. The plants were cultivated in the Experiment Farm of Medicinal and Aromatic Plants, Fac. Agriculture, Mansoure Univ. during the summer seasons of 2006 / 2007 and 2007 / 2008.

Planting:

Sweet basil (*Ocimum basilicum* L.) plants were cultivated using seeds obtained from the Farm of Medicinal and Aromatic Plants, Fac. Agric., Mansoura University. Seeds were sown in the nursery on 15^{th} March in both seasons. The seedlings were transplanted to the experimental field six weeks after sowing on 1^{st} May, when they reached about 8-10 cm height. Field was ploughed to remove the remains of the previous crops, and then divided in to 3 blocks (each block 10 x 4 m) contained 12 rows each 3 m long and rows were 50 cm apart and planting was done at a distance of 30 cm between plants.

Harvesting:

Basil is harvested for its leaves, and the plants cut above the bottom two to four sets of true leaves. To allow for regrowth, cuttings should be at least 15 cm above the ground. The plant samples were harvested at three cuts at the middle of July, August and the end of September. After harvesting, each plant was divided into leaves plus flower tops and stem, each group was dried under different drying methods.

Drying methods:

The plant samples were randomly chosen (12 plants from each block) and using three drying methods:-

1- Room temperature at 30 ± 3º C.
2- Air drying at 27- 30ºC.
3- Oven drying at 50ºC.

The plants dried until weight remained constant after 2 consecutive weights.

Volatile oil determination:

Volatile oil analysis was carried out at the Laboratory of Veget. and Flori. Dept. Fac. Agric., Mansoura Univ. The oil content was determined at harvest (fresh) and after drying in herbs harvested in both seasons.

Volatile oil percentage (%): was determined in the dried samples (50 g) and fresh samples (100 g) in both seasons by subjecting to hydro distillation using modified Clevenger traps in British Pharmacopeia (2000) and the oil samples stored under refrigeration until Gas liquid Chromatography (GLC) analyses.

Oil yield (Liter/fed): was calculated by multiplying the volatile oil (%) per plant by number of plants per feddan (13.333 plants).

Essential oil constituents:

Gas liquid chromatography technique (GLC) was used to separate and identified the component of volatilel oil of basil at the Medicinal and Aromatic Plants Section, Agricultural Research Centre, Giza, Egypt. The constituents of the essential oil were identified by matching their retention time (RT) with those of authentic samples under the same conditions, according to Guenther and Joseph (1978).

Statistical analysis:

The experimental design was factorial experiment in a randomized complete block design. Data of the present study were statistically analyzed and the differences between the means of the treatments were considered. The least significant differences (L.S.D) at the levels of 5% according to steel and Torrie (1980**)** were calculated.

RESULTS AND DISCUSSION

Effect of harvesting dates on volatile oil quality:

Table (1) showed the effect of cuts on volatile oil percentage per plant and yield per fed. The second cut of the fresh herb gave the highest volatile oil percentage was (0.37 and 0.36 %) respectively, in the first and second seasons. While, the first cut gave the lowest oil percentage (0.15 and 0.15 %) respectively, in both seasons. The results indicated that the second cut gave the highest volatile oil yield (11.69 and 11.63 liter/fed) respectively in both seasons. While, the first cut gave the lowest oil yield (4.67 and 4.45 liter/fed) respectively, in both seasons.

Table (1): Effect of cuts on volatile oil (%) and yield (l / fed) of *Ocimum basilicum* L. plants during the two seasons of (2006 / 2007) and (2007 / 2008).

Time of harvest	Volatile oil (%)		Oil yield (liter / fed)	
	1st season	2nd season	1st season	2nd season
Cut 1	0.15	0.15	4.67	4.45
Cut 2	0.37	0.36	11.69	11.63
Cut 3	0.35	0.34	10.90	10.50
L.S.D 5%	0.02	0.02	0.02	0.02

There were significant differences in growth, and essential oil content across the collection. These results agreed with those obtained by Tansi and Nacar (1999) mentioned that the highest essential oil percentage (0.98 %) was obtained from the dried leaves at the 3rd harvesting time. Bottcher *et al*. (2000) mentioned that the content of the essential oil of *Melissa officinalis* L. plant changed with cutting date and the second cut was twice high as than that of the first cut. Elamrani *et al*. (2000) worked on Moroccan rosemary, found that the oil yield was dependent on the harvesting time and the period of full flowering gave the best yield.

Effect of different drying methods on volatile oil quality:

Data in Table (2) and Figures (1, 2 and 3) showed that the methods of drying affected the volatile oil percentage in the three cuts. Oven drying at 50 ºC gave the highest oil percentage (2.0, 1.8 and 1.7 %) during the three cuts respectively, followed by air drying (1.8, 1.7 and 1.4 %) and room drying (1.7, 1.6 and 1.4 %) compared to the fresh leaves (Control) (0.15, 0.37, and 0.35 %) during the three cuts respectively.

It is also clear from the Table (2) that the volatile oil (%) was affected by the different drying methods (room, air and oven) compared to the fresh leaves (control).The second season gave the same results. Fresh leaves, accordingly, would have less volatile oil (%) than the dry ones, simply because they possess more water content. Although leaves in shade drying takes longer time to dry than oven drying, the later one have higher drying temperature (50 ºC) than the shade drying under room temperature, and air drying. These results are in agreement with Sefidkon *et al.* (2006) on the aerial parts of *Satureja hortensis,* dried by three different drying methods (sun drying, shade drying and oven drying at 45 ºC) showed no significant difference between oil yield of the oven-dried samples (1.06 %) compared to shade-dried (0.94 %) and sun-dried (0.87 %).

Table (2): Effect of drying methods on the volatile oil (%) of *Ocimum basilicum* L. plants during the two seasons of (2006 / 2007) and (2007 / 2008).

Drying methods	Volatile oil (%)					
	1st season			2nd Season		
	Cut 1	Cut 2	Cut 3	Cut 1	Cut 2	Cut 3
Fresh	0.15	0.37	0.35	0.15	0.36	0.34
Room drying	1.70	0.60	0.40	1.70	1.60	1.50
Air drying	1.80	1.70	0.40	1.80	1.70	1.50
Oven drying at 50ºC	2.00	1.80	1.70	2.00	1.80	1.70
L.S.D at 5%	0.16	0.16	.0.16	0.16	0.16	0.16

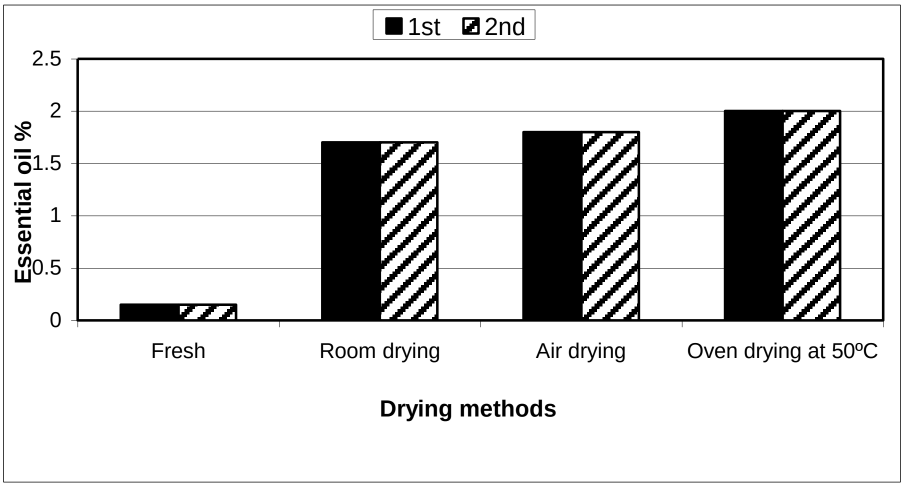


Figure (1): Effect of drying methods on essential oil % of basil for the first cut during two seasons 2006/2007 and 2007/2008

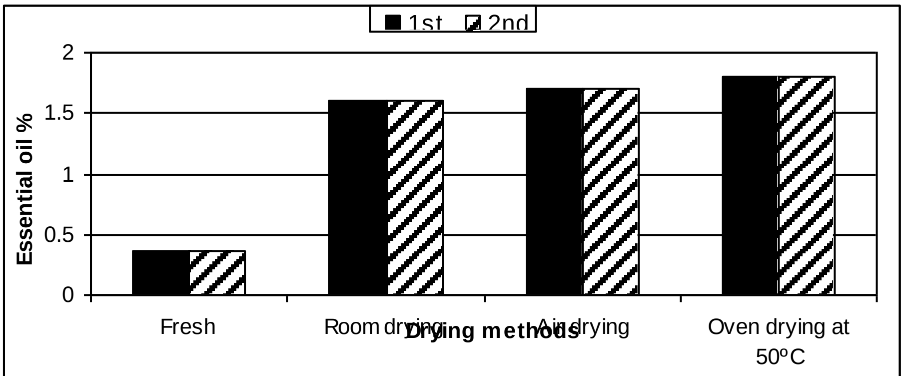


Figure (2): Effect of drying methods on essential oil % of basil for the second cut during two seasons 2006/2007 and 2007/2008

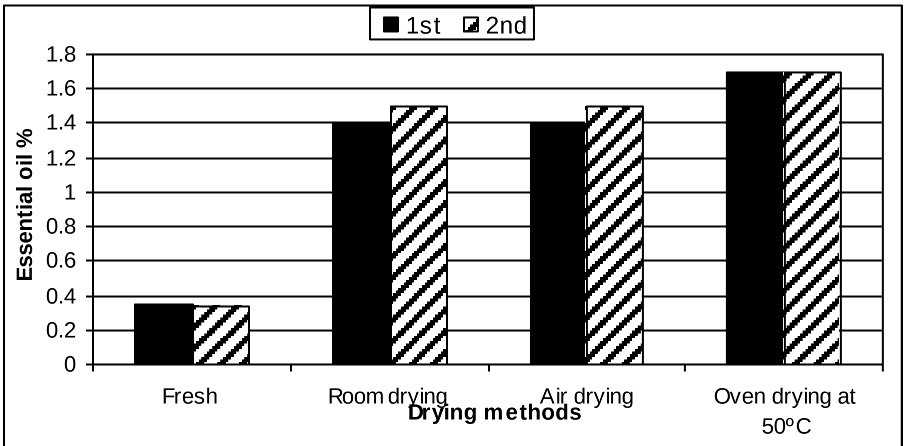


Figure (3): Effect of drying methods on essential oil % of basil for the third cut during two seasons 2006/2007

Data in Table (3) showed that the methods of drying affected the volatile oil yield per feddan in the three cuts. Oven drying at 50 ºC gave the highest oil yield (62.27, 56.67 and 52.91 liter/fed) followed by air drying method (56.04, 53.71 and 43.60 liter/fed) and room drying (52.93, 50.55 and 43.60 liter/fed) compared to the fresh leaves (4.67, 11.69, and 10.90 liter/fed) during the three cuts respectively. The second season gave the same trend of results. These results are in agreement with Svab (1966) who found that artificial drying resulted in higher essential oil content than the natural drying in chamomile plants. Duhan *et al*. (1975) concluded that the maximum oil yield and the highest content of free menthol were obtained when plants of *Mentha piperita* were harvested 163-178 days after planting.

Table (3): Effect of drying methods on thevvolatile oil yield (liter / fed) of *Ocimum basilicum* L. plants during the two seasons of (2006 / 2007) and (2007 / 2008).

Drying methods	Volatile oil yield (liter / fed)					
	1st season			2nd season		
	Cut 1	Cut 2	Cut 3	Cut 1	Cut 2	Cut 3
Fresh	4.67	11.69	10.9	4.45	11.63	10.50
Room drying	52.93	50.55	43.60	50.43	54.69	46.32
Air drying	56.04	53.71	43.6	53.40	54.92	46.32
Oven drying at 50ºC	62.27	56.67	52.91	59.33	58.15	52.5
L.S.D at 5%	0.55	0.02	0.02	0.02	0.02	0.02

Effect of different drying methods on the percentage of volatile oil constituents (%):

The results of G.L.C analysis were shown in Table (4) and Figure (4) which showed the effect of the drying methods on the percentages of the volatile oil constituents at the second cut in the second season. The G.L.C of the fresh leaves oil identified a total of 7 compounds; limonene (0.5 %), 1,8-cineole (0.85 %), linalool (84.55 %), α- terpineol (1.36 %), boreneol (1.40 %), geranyl acetate (1.16 %) and eugenol (1.19 %).

The total components of volatile oil were 91.00, 92.62, 87.53 and 91.56 % from the fresh samples, room drying, air drying and oven drying at 50 ºC, respectively. The room drying method gave the highest (%) of the total oil components compared with the other two drying methods and the control samples. The percentage of the Linalool was 84.55, 87.77, 81.61 and 79.86 % in the oil of fresh leaves, room, air and oven drying methods, respectively. The percentage of the main component (Linalool) was the highest in the dried leaves of room drying compared to the other different drying methods.

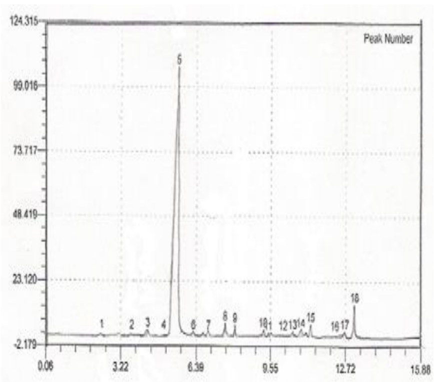
Table (4): Effect of different drying methods on volatile oil constituents (%) of *Ocimum basilicum* L. plants at the second cut in the second season (2007 / 2008).

Components	Essential oil components (%)			
	Fresh (Control)	Drying Methods		
		Room	Air	Oven
Limonene	0.50	-	0.14	-
1-8 Cineole	0.85	0.63	0.81	3.34
Linalool	84.55	87.77	81.61	79.86
α -Terpineol	1.36	1.12	1.44	4.78
Boreneol	1.40	1.0	1.21	0.4
Geranyl acetate	1.16	1.31	1.07	1.25
Eugenol	1.19	0.79	1.25	1.93
Known	**91.00**	**92.62**	**87.53**	**91.56**

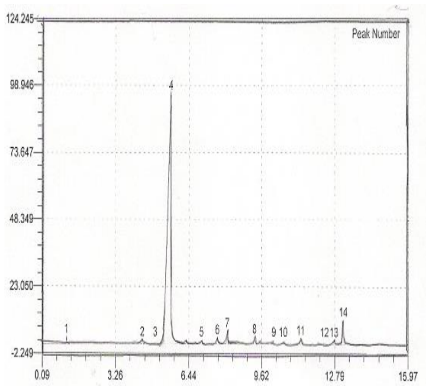
While, the other components such as limonene, 1,8- cineol, α-terpineol, borenol, eugenol and geranyl acetate made up only small percentages of the volatile oil. Generally, the results are very similar to those of Lemberkovies *et al*. (1996) indicated that the main constituents of basil oil were linalool (40-60

%), methyl chavicol (1-1.5 %). Bottcher *et al*. (2000) mentioned that the content and composition of the essential oil ingredients of *Melissa officinalis* L. changed with cutting date and Nurzynska (2001) found thirty- three compounds were identified of basil, which linalool was isolated at the highest percentage (71%). These results are in agreement with those of Omidbaigi *et al*. (2004) reported that the oil content of the shade dried flowers of Roman chamomile was the highest compared to sun-dried and oven-dried at 45 ºC. Asekun *et al*. (2007) mentioned that method of drying affected the oil composition of *Menthe longifolia*.

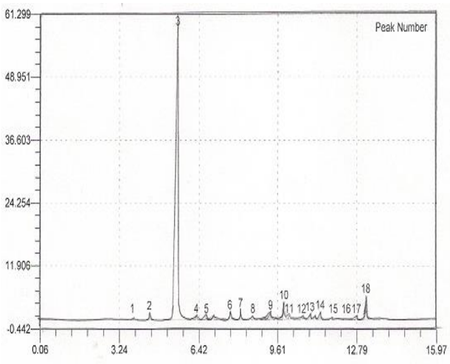
It could be concluded that in the second and third cuts the essential oil was higher than in the first one because they contained more leaves plus flower tops, drying leaves of sweet basil in the room temperature is recommended for obtaining higher essential oil quantity and quality.



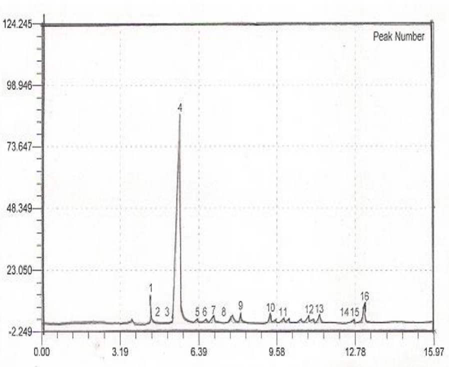
Fresh (control)



Room-drying method



Air- drying method



Oven drying method at 50 ºC

Figure (4): G.L.C. of sweet basil volatile oil fresh and dried leaves at room, air and oven drying at 50 ºC in second cut and second season (2007 / 2008).

REFERENCES

Asekun, O. T.; D. S. Grierson and A. J. Afolayan (2007). Effect of drying methods on the quality and quantity of essential oil of *Mentha longigolia* L. subsp. Capensis. Food Chemistry., 101 (3): 995-998.

Bahl, J. R.; S. N. Garc; R. P. Bansal; A. A. Naqvj; V. Singh and S. Kumar (2000). Yield and quality of shoot essential oil from the vegetative, flowering and fruiting stage crops of *Ocimum basilicum* cv. Kusumohak. J. Medicinal and Aromatic Plants, 22: 743-746.

Bottcher, H.; I. Gunther and R. Franke (2000). Physiological post harvest response of lemon balm (*Melissa officinalis*). Zeitschrift fur Arznei und Gewurzpflanzen, 5(314): 145-153.

British Pharmacopoea (2000). Determination of Volatile Oil in Drugs. The Pharmaceutical press. London.

Diaz-Maroto, M. C.; M. Perez-Coello and M. Cabezudo (2002). Effect of different drying methods on the volatile components of parsley (*Petroselinum crispum*). European Food Research and Technology, 215(3): 227-230.

Dostal, D. L. (1990). Post harvest storage of sweet basil. M. Sc. Thesis. Michigan State University.

Duhan, S. P.; S. N. Garg and S. K. Roy (1975). Effect of age of plant on the quality of essential oil of peppermint (*Mentha piperita* L.). Indian J. pharmacopy, 37(2): 41-42. [C. F. Hort. Abst., 46(4): 3]

Elamrani, A.; S. Zrirae; B. Benjilai and M. Berrada (2000). A study of Moroccon rosemary oils. J. Essential Oil Res.12 (4): 487- 495.

Garibaldi, A.; M. L. Gullino and G. Minuto (1997). Diseases of basil and their management. Plant Diseases. 81:124-132.

Guenther, E. (1961). The Essential Oils. Vol. IV. Individual Essential Oils of The Plant Family Umbelliferae. 4th Ed. Dr. Van Nostrand Company, Inc. 618-663.

Guenther, Z. and S. Joseph (1978). Handbook Series in Chromatography. GRC press Inc.

Kassem, A. M.; I. E. EL-Batawi and M. M. A. Sidky (2006). Effect of solar energy and other drying methods on quality of some medicinal plants. The 14th Annual Conference of Society of Agric. Eng., Nov., 22: 766-782.

Lange, D. L. and A. C. Cameron (1997). Pre and post harvest temperature conditioning of greenhouse grown sweet basil. Horti. Sci., 32: 114-116.

Lee, S.; K. Umano; T. Shibamoto and K. Lee (2005). Identification of volatile components in basil (*Ocimum basilicum* L.) and thyme (*Thymus vulgaris* L.) leaves and their antioxidant properties. Food Chem., 9: 137-141.

Lemberkovics, E.; V. Petri.; H. Nguyen and I. Mathe (1996). Relationships between essential oil and flavonoid biosynthesis in sweet basil. Acta Horticulturae, (426): 647-655.

Nurzynska, Wierdak, R. (2001). Analysis of content and chemical composition of essential oil from two forms of sweet basil (*Ocimum basilicum* L.). Acta Horticulturae, 9:189-193

Omidbaigi, R.; F. Sefidkon and F. Kazemi (2004). Influence of drying methods on essential oil content and composition of Roman chamomile. Flavour and Fragrance J., l9: 196-198.

Refaat, A. M. (1988). Effect of Fertilization levels, method of drying and periods of storage on the sweet marjoram herb yield and its active ingredients. Ph.D., Thesis, Fac. Agric. Ain Shams Univ.

Sankatc. K.; F. Castaigne and R. Maharaj (1996). The air drying behavior of fresh and osmotic ally dehydrated banana slices. International J.Food Science and Technology, 31: 123-135.

Sefidkon, F.; K. Abbasi and Gh. B. Khaniki (2006). Influence of drying and extraction methods on yields and chemical composition of the essential oil of *Saturia hortensis*. Food Chemistry, 99: 19-23.

Shalaby, A. S.; A.M. El-Gamasy; S. El-Gengaihi and M. Khattab (1988). Post harvest studies on herb and oil of *Mentha arvensis* L. Egyptian J. Horticulture, 15(2): 213-224.

Simon, J. E.; J. Quinn and R. G. Murray (1990). Basil; A sourse of essential oils. J. Janick and J. E. Simon (eds.). Advances in new crops. Timber press, OR. p. 484-489.

Skrubis, B.G. (1982). The drying of laurel leaves. Perfumer and Flavours J., 7(50): 37- 40.

Steel, R. G. and J. H. Torrie (1980). Principles and Procedures of Statistics. M. C. Grow Hill Book company Inc. New York (N. H. S. D.), London.

Svab, J.; E. Tyihak and J. Rapoti (1966). Drying experiments with Hungarian commercial chamomile. Herbahyng, 5(1): 31-36

Tansi, S. and S. Nacarar (1999). The herb yield and essential oil composition of bush basil (*Ocimum minimum* L.) grown in Turcky. Turkish Journal of field crops., 4(2):71-74.

Venskutonis, P. (1997). Effect of drying on the volatile constituents of thyme (*Thymus vulgaris* L.) and sage (*Salvia officinalis* L.). Food Chemistry., 59(2): 219-227.

تأثير الحشات وطرق التجفيف المختلفة على كمية وجودة الزيت الطيار فى نبات الريحان.

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أجريت هذه الدراسة في مزرعة النباتات الطبية والعطرية بكلية الزراعة جامعة المنصورة ، خلال موسمين زراعيين متتاليين ٢٠٠٦/٢٠٠٧ و ٢٠٠٧/٢٠٠٨ لدراسة تأثير ميعاد الحصاد وطرق التجفيف المختلفة (الغرفة – هوائي – فرن على درجة ٥٠ ºم) على كمية وجودة الزيت الطيار في نبات الريحان.

وقد أظهرت النتائج ما يلي : -

اولا :- أعطت الحشة الثانية والثالثة أعلى نسبة مئوية وأعلى محصول للزيت الطيار للفدان مقارنة بالحشة الأولى.

ثانيا :- أعطى التجفيف فى الفرن أعلى نسبة مئوية للزيت الطيار بينما أعطى التجفيف فى الغرفة أعلى نسبة مئوية لمكونات الزيت الطيار الفعالة.

ثالثا :- أظهرالتحليل الكروماتوجرافى للزيت الطيار الناتج من الأوراق الطازجة ٧ مركبات هى (ليمونين – سينيول – لينالول – الفا تربينول – بورنيول – جيرانيل اسيتات – يوجينول) وكانت النسبة المئوية لمجموع هذه المركبات هى (٩١,٠٠ و ٩٢,٦٢ و ٨٧,٥٣ و ٩١,٥٦%) لكلا من نباتات الكنترول وطرق التجفيف المختلفة فى الغرفه والهوائى والفرن على التوالى.

رابعا:- كان مجموع النسب المئوية للمكون الاساسى (لينالول) هى ٨٤,٥٥ و ٨٧,٧٧ و ٨١,٦١ و ٧٩,٨٦ % على الترتيب لكلا من نباتات الكنترول وطرق التجفيف فى الغرفة والهوائى والفرن وأعطى التجفيف فى الفرن أعلى نسبة مئوية لللينالول.

التوصية :- يوصى بجمع نباتات الريحان الحلو عند التزهير (الحشة الثانية والثالثة) واستخدام طريقة التجفيف فى الغرفة كانت افضل معاملة لانتاج العشب المجفف لنبات الريحان مقارنة بباقي طرق التجفيف حيث أعطى أعلى جودة للزيت الطيار.

قام بتحكيم البحث

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