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EFFECT OF CALCIUM AND BORON SPRAY ON GROWTH, YIELD AND DRIED GRATED QUALITY OF SOME CARROT CULTIVARS

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Abstract

The field work was carried out at the Experimental Farm of the Desert Research Center at Siwa Oasis, Marsa Matroh Governorate, during the two consecutive seasons of 2015/2016 and 2016/2017. The experiments were conducted to study the effect of calcium and boron as foliar application which were the combination of nine foliar spray application *i.e.,* T1 (Ca 1g/L), T2 (Ca 2g/L), T3 (B 1g/L), T4 (B 2g/L), T5 (Ca 1g/L+ B 1g/L), T6 (Ca 1g/L+ B 2g/L), T7 (Ca 2g/L+ B 1g/L), T8 (Ca 2g/L+ B 2g/L) and T9 control treatment (foliar spry by tap water) on growth, yield and chemical composition of tow carrot cultivars *i.e*., Nantes *cv.* and Fire wedge F1grown in sandy soil conditions. Also, evaluated the effect of oven and microwave drying methods on the quality aspects i.e., color, total carotenoids, vitamin C, vitamin E, total phenol and rehydration ratio. Results revealed that the highest values of plant height; shoot weight; shoot dry matter (%); root length; root dry mater (%); total yield/ fed; total root yield/ fed.; marketable yield/fed; Ca (%) and total carbohydrates (%) were cleared with fire wedge *Cv.* in both growing seasons. But, the highest values of plant weight root diameter; root weight and values of unmarketable yield were obtained with Nantes *Cv.*, in both growing seasons. The highest values of all vegetative growth; root parameters; total root yield Ca (%) and total carbohydrates (%) were recorded with treatment T8 (foliar application by Ca 2g/l and B 2g/l) followed by T5 (foliar application by Ca 1g/l and B 1g/l) and no significant differences between them in both growing seasons. For the drying process, both oven and microwave drying methods improve the quality of the dried grated carrot samples where the total carotenoids, total phenol, vitamin C and vitamin E were enhanced, furthermore, a good color and rehydration ratio were achieved for both T8 and T5 treatment. Consequently, carrot crop could be stored all over the season by using drying process as a dried grated carrot in order to serve our home needs, in the same time, it considered to be a good value added product.

Key words: Carrot - calcium - boron - yield - chemical composition - color - drying methods - rehydration ratio.

Introduction

Siwa Oasis is located in the northern part of the Western Desert of Egypt. The total cultivated area is (20940 fed.). The main activity in Siwa Oasis is agriculture which is depending on palm and olive trees and its industries *i.e.* (Packaging of dates, extract olive oil and pickling olives). Desert Research Center had conducted several projects in the Siwa Oasis. The most important project which was (Studied of the possibilities available to develop and improve plant production in Siwa Oasis). This project had many goals such as achieving sustainable development; create job opportunities, introducing new plant varieties with manufacturing capacity. The carrot was selected as example of new crop in this area. Also, its enter used in many food industries.

Carrot (*Daucus Carota* L.) is the most important crop of Apiaceae family. Worldwide production of carrot is more than 24 million tons, Egypt production of carrot and turnip is more than 239969 and total cultivated area 8209 ha (FAOSTAT 2017). Carrot may be consumed fresh or processed in forms such as pickled carrots, grated carrots, baby food and instant soups. It is highly valued as food mostly because it is a rich source of Vitamin A and antioxidant compounds, such as carotenoids and polyphenols. Furthermore, carrot has abundant nutrients and minerals also the different parts of the crop can be utilized for many medicinal purposes. It is useful in curing kidney diseases (Handelman, 2001; Anjum and Amjad, 2002; Chu, Sun, Wu and Liu, 2002 and Zeb and Mahmood, 2004). Many studies reported that there were significant differences between cultivars with regard to growth parameters such as, leaf volume, leaf base thickness, plant height, fresh and dry weight of shoot, root shape, weight; length, split roots, top greening, internal color, fresh and dry weight of root, yield and market value. (Deotale *et al.*, 1994; Panda *et al.*, 1994; Ali *et al.*, 2006 and Lana, 2012). Also, Heinonen (1990) reported that the content of carotenoid and pro-vitamin A of 19 carrot cultivars were analyzed by HPLC. The result showed high alpha- and beta-carotene contents were found especially in cultivars Nantes Duke Notabene 370 and Nantes Fancy Notabene 405 respectively.

The success of growing this crop for high yields involved the integration of various factors, such as the cultivar choise, climatic conditions, fertilizer by macronutrients, as well as micronutrients which are primary importance in our agriculture system, but due to rapid area expansion under hybrid or high yielding varieties of vegetables, soils are becoming deficient in micronutrients (Malakouti *et al.*, 2009). The micronutrients act as catalyst and enhance the chemical composition of fruits and consider vital for the physiological activities within the plant and play an important role in germination and seedling establishment (Reid, 2001 and Abo Hamad *et al.*, 2014). Boron is one of those micronutrients which are rapidly becoming deficient in soils (Tahir *et al.*, 2009). Boron plays important role in physiological processes like carbohydrates metabolism, translocation and development of cell wall and translocation of sugar and carbohydrates (Siddiky *et al.*, 2007). Moreover, Mishra and Yadav (1989) reported that boron possibly plays a key role in plant metabolism and as essential element for the fast growing meristamatic tissue. It is also required for pollen growth and flower formation. Also, Homutescu et al. (1993) studied the influence of microelement boron on the production of Chantenay variety which was treated with boric acid. It was concluded that boron increased the yields by 5.31-23.47%. Furthermore, an experiment was conducted to study the effects of boron fertilizer on the yield and quality of carrot. Boron fertilizer was significantly influenced on most of the parameters studied. Boron level 3 kg B/ha gave the highest seed yield (1769.11 kg/ha). Also, the application of potassium and boron at higher doses (75 kgK/ha + 15 Bkg/ha) had a significant and positive effect on quality root production of carrot and highest carotene (4.56 mg $100g^{-1}$) ascorbic acid (2.70mg $100g^{-1}$) and total sugar content (7.60%) on root. Malek and Rahim, (2011). Several studies have demonstrated that B application increases the yield of carrots and enhances drought tolerance of carrot cells, whereas its deficiency results in small roots with yellow tops and distinct white core in the middle (Demiray and Dereboylu, 2006 and Satish Kumar Subba *et al.*, 2016).

Calcium (Ca) is an essential macronutrient for plant growth, development and it's an important constituent in the structure of cell walls and cell membranes (Hepler and Winship, 2010). Moreover, the supplement of boron (B) and or calcium (Ca) in the feeding solutions during plant growth influenced the accumulation of other minerals such as P, K, Mg, S and 33–50% increase in the accumulation levels of a- and b-carotenes, beside 45–70% increase of vitamin C in carrot root (Singh et al. 2012).

Indeed, Ca plays an important role in cytosolic signal transduction pathways involved in cell responses to a wide range of biotic and abiotic factors (White and Broadley, 2003). However, calcium is consider as an immobile element, the plants need a constant supply of calcium for vigorous leaf and root development (Del Amor and Marcelis, 2003) which can be accomplished through foliar application. Foliar fertilization is more economical than root fertilization, due to the efficiency and lower cost.Also, the high affinity of Ca for anionic phosphate and carboxylate groups of lipids and proteins at the membrane surface makes Ca an important regulator of membrane structure and function Hirschi, 2004; Batistic and Kudla, 2010). The foliar application of fertilizer is usually preferred because very small amounts of fertilizers are applied per hectare and it also less likely to result in ground water pollution. Moreover, foliar application of nutrients increased the growth and yield of carrot plants (Subrahmanyam and Raju, 2000; El-Tohamy *et al.*, 2011).

Fresh carrot are more perishable and cannot be stored for more than 3-4 days under ordinary conditions due to the moisture content which accelerates degradation, therefore, reducing moisture content to extend shelf-life is imperative. In the same time, carrots being seasonal crop, it is not possible to readily make it available throughout the year, so it's important to develop different products to make it available all over the season (Pittia and Antonello, 2016). Moreover, value-added products have the potential for providing stability to the production of fresh market crops, where it provide income and increase the value of the total production, thereby making carrot production profitable. Besides that, it considered to be an important source of nutritional security product for rural and urban poor (Kulshrestha and Pandey, 2017).

Drying technique considered to be the most suitable storing method for small scale operation and home level. These dehydrated forms may be eaten as such or may be incorporated in traditional food preparations (Krishan *et al.,* 2012 and Kulshrestha and Pandey, 2017). Drying involves the use of heat to vaporize the water present in the food and so reducing the water content and water activity and enhancing microbial safety of biological products (Mathlouthi, 2001). Also, drying process considered to be an excellent post-harvest procedure management where it have the ability to reduce both of space requirement and the need of expensive cooling systems, thus, it recognize to facilitating storage and transportation (Guiné *et al.*, 2008, Guiné, 2010 and Sagar and Suresh, 2010). Dehydration of carrot during the main growing season is one of the important alternatives of preservation.

Drying behavior of different cultivars of the same crop may also vary due to the characteristics of the different varieties, otherwise, the experimental setup impacts on the product quality (Oke and Workneh, 2014 and Aboltins *et al.,* 2016). In the light of this, it was important to investigate the effect of drying process for different carrot varieties to evaluate the quality properties of the dried carrots.

Conventional oven drying method is an economical and controlled ways of drying, but at a higher temperature, it may affect the final product quality. Microwave is unconventional drying method because of the uniform energy distribution, where the heat not only on the surface but also inside the food particles (Contreras *et al.,* 2008 and Ali *et al.,* 2016,). It is favorable for post harvest processing of agricultural products due to drying time reduction, low energy consumption and high product quality (Guiné, 2018). Therefore, the aim of this study was to inspect the effect of oven and microwave drying methods on the quality parameter of the best treatments of carrot varieties under investigation.

Materials and Methods

The field work was carried out at Siwa Research Station of the Desert Research Center, Marsa Matrohe Governorate, during the two consecutive winter seasons of 2015/2016 and 2016/2017. The experiments were conducted to study the effect of calcium and boron as foliar application on growth, yield and chemical composition of two carrot cultivars grown in sandy soil conditions.

Eighteen treatments which were the combination of nine foliar spray application *i.e.*, T1 (Ca 1g/L), T2 (Ca 2g/L), T3 (B 1g/L), T4 (B 2g/L), T5 (Ca 1g/L+ B 1g/L), T6 (Ca 1g/L+ B 2g/L), T7 (Ca 2g/L+B 1g/L), T8 (Ca 2g/L+ B 2g/L) and T9 control treatment (foliar spry by tap water) and two carrot cultivars *i.e*., Nantes *cv.* (from France imported by Vilmorin Co.) and Firewedge F1 (from TAKII SEED Japan imported by SEIF GAARA Co.). Foliar fertilization with calcium as ($CaCl_2$) and boron as boric acid were applied three times after 30, 60 and 90 days from planting date during the growth seasons.

The physical and chemical soil characteristics of the studied site were determined according to Page *et al.*, (1982) and Klute (1986) respectively, as recorded in table 1. The chemical analysis of irrigation water was carried out using the standard method of Page et al. (1982) and presented in table 2.

Organic manure was added at the rate of 30 m³/fed. and calcium super-phosphate (15.5% P2O5) at the rate of 350 kg/fed., were added during land preparation. Nitrogen fertilizer as ammonium sulphate (20.5% N) and potassium sulphate (48% K_2O) at the rate of 300 and 200 kg/fed., respectively. Nitrogen and potassium quantities were divided and applied with drip irrigation every week during growing seasons started after 15 days from planting. Carrot seeds were planted in first week of November through the two growing seasons respectively. Carrot seeds were planted in multiple rows on raised beds that range from (60-65 cm) wide and 25m long with 4 rows for each bed and two rows for each side of drip irrigation line 10 cm apart between rows and plants in rows spaced (7.5 to 10 cm) apart. Carrot seeds are planted and irrigated with drip irrigation system. All

Table 1: Some physical and chemical properties of the experimental soil site.

Soil depth (cm)	Texture class	Soluble anions (me/l)			pH^soil paste	E.C dSm^{-1}	Soluble cations (me/l)			
		HCO_3^-	$SO_4^=$	Cl^-			Ca^{+2}	Mg^{+2}	Na^+	K^+
0 – 25	Sandy loam	0.75	0.85	4.25	6.7	0.58	1.15	0.45	3.92	0.33

pH: Acidity E.C.: Electrical conductivity me/l: milli equivalent per liter

Table 2: Chemical analysis of the irrigation water.

Samples	Ph	E.C. dSm^{-1}	Soluble cations (me/l)				Soluble anions (me/l)		
			Ca^{+2}	Mg^{+2}	Na^+	K^+	HCO_3^-	$SO_4^=$	Cl^-
1st season	7.1	5.54	10.1	13.32	39.4	1.17	9.35	15.1	39.5

pH: Acidity, E.C.: Electrical conductivity, dSm^{-1}: decimenz per meter, agricultural practices were as Egyptian ministry of agriculture recommendation.

Vegetative growth and root parameters

Vegetative growth samples were taken after 120 days from planting, ten plants were selected randomly from each plot and the following characteristics were recorded *i.e.*, plant fresh weight (g.) ; plant height (cm.) ; shoot weight and shoot dry matter percent; average root fresh weight and dry matter percentage and root diameter and length.

Root and yield parameters

At harvest time stage (150 days from planting date), a sample of plants from one m² were randomly taken from each experimental plot for characteristics, *i.e.*, total yield (ton/fed.); root yield (ton/fed); marketable yield and unmarketable yield percentage (included creaked and branched root).

Chemical constituents

Three samples of root from each experimental unit were taken and oven dried at 70ºC until stable weight then grinded to fine particles and used to determine calcium percentage was measured using Flame photometer by method as described by Brown and Lilliland (1964). Total carbohydrates were determined according to A.O.A.C. (1990).

Preparing carrot samples for drying process

Dried grated carrot was prepared according to (Gupta and Shukla, 2017) where carrot samples of recommended treatments were washed, peeled and grated using a kitchen processor, then carrots samples was tied in muslin cloth and dipped in 95°C for 2-3 minutes. After blanching they were cooled to room temperature. Free surface moisture was removed by sieving. Drying using oven and microwave oven using microwave model NN-C988W made in Japan with an 1800 W powerful heater was performed for carrot samples under investigation. The samples of each treatment were dried until it become crispy with attention to overturn the grated carrot samples every 20 minutes for oven treatment and every 2 minutes for microwave treatment to avoid it burned during drying. The dried grated carrot samples were package in polyethylene bags and stored in a refrigerator at °4C until analysis. Also, fresh samples from each treatment were estimated as a control treatment.

Analytical methods

For the fresh and dried grated carrot samples, Total phenol contents were determined according to Singleton and Rossi (1965), total carotenoids were determined according to methods describe Wettestein (1957). Vitamin C were estimated according to the method illustrated by Ullah *et al.,* (2012), where, vitamin E was estimated according to Application Note 251, Dionex Corporation (2010), at the central laboratory, Desert Research Centre, Cairo, Egypt.

Color of dried grated and fresh carrot samples were measured by Chroma meter (Konica Minolta, model CR 410, Japan) calibrated with a white plate and light trap supplied by the manufacturer at Cairo University Research Park (CURP), Faculty of Agriculture, Cairo university. Color was expressed using the CIE L, a and b color parameters (CIE, 1976). A total of three spectral readings were taken for each sample. Lightness (L*) (dark to light), the redness (a*) values (reddish to greenish). The yellowness (b*) value (yellowish to bluish) was estimated.

Rehydration ratio the dried grated carrot samples were determined by soaking 5g of dried sample in 100 mL boiling water for 30 min then cooled. The cooled content was filtered and weighed. Rehydration ratio calculated using the following equation as mentioned by Gokhale and Lele (2011):

$$\text{Rehydration ratio(RR)} = \frac{\text{Weight of the rehydrated material}}{\text{Weight of the dehydrated material}}$$

Experimental design and statistical analysis

The experimental treatments were arranged in split plot design with three replicates, the main plots were assigned for cultivars, whereas, foliar spray treatments were randomly arranged in the sub plots. Statistical analyses of obtained data were done according to Thomas and Hills (1975).

Results and Discussion

Vegetative growth and root parameters

Growth parameters *i.e.*, plant height; plant weight and shoot weight and dry matter percent presented in table 3 and root length; root diameter; root weight and dry matter percent were presented in table 4. Obtained results indicated that there are significant positive effects for both carrot cultivars and foliar spray applications on all investigated growth and root parameters are presented in the tables 3 and 4 showed that:

The highest values of plant height; shoot weight; shoot dry matter (%); root length and root dry mater (%) were cleared with fire wedge *Cv.* But, The highest values of plant weight root diameter and root weight were obtained with Nantes *Cv.*, in both growing seasons. This results in the same line with those reported by Deotale *et al.,* 1994;

Table 3: Effect of calcium and boron foliar spray on plant height; weight and shoot weight and dry matter percentage of carrot cultivars during 2015/2016 and2016/2017growing seasons.

Seasons	**2015/2016**											
Characters	**Plant height (cm)**			**Plant weight (g)**			**Shoot weight (g)**			**Shoot dry matter (%)**		
Cv. Treatments	**N.**	**FW.**	**$(\bar{X})$**	**N.**	**FW.**	**$(\bar{X})$**	**N.**	**FW.**	**$(\bar{X})$**	**N.**	**FW.**	**$(\bar{X})$**
T1 Ca 1g/L	55.1	63.3	59.2	132.7	129.3	131.0	47.4	55.2	51.3	11.0	11.9	11.5
T2 Ca 2g/L	55.8	60.7	58.3	138.3	131.2	134.7	52.1	60.0	56.0	9.7	11.4	10.5
T3 B 1g/L	49.2	52.4	50.8	115.4	118.4	116.9	39.5	53.5	46.5	10.3	10.6	10.4
T4 B 2g/L	50.5	53.5	52.0	129.7	109.4	119.5	43.1	45.7	44.4	10.2	11.4	10.8
T5 Ca1g/B1g/L	59.5	63.2	61.4	161.7	155.7	158.7	58.0	67.1	62.5	12.3	12.5	12.4
T6 Ca1g/B2g/L	55.9	64.2	60.0	152.5	150.1	151.3	54.6	63.7	59.1	12.4	13.0	12.7
T7 Ca2g/B1g/L	54.9	64.6	59.8	150.7	143.2	146.9	62.0	62.6	62.3	12.2	13.6	12.9
T8 Ca2g/B 2g/L	59.1	65.4	62.3	170.7	151.6	161.2	64.5	62.3	63.4	12.9	13.5	13.2
T9 Control	49.7	50.2	49.9	110.9	112.2	111.6	44.4	48.4	46.4	10.4	10.6	10.5
$(\bar{X})$	54.4	59.7		140.3	133.4		51.7	57.6		11.2	12.1	
2016/2017												
T1 Ca 1g/L	59.5	65.4	62.4	136.4	133.6	135.0	48.6	57.5	53.0	10.7	12.0	11.3
T2 Ca 2g/L	57.0	62.3	59.6	141.9	135.6	138.8	53.3	62.1	57.7	9.9	11.6	10.7
T3 B 1g/L	47.3	54.6	50.9	119.5	122.6	121.1	41.1	55.1	48.1	10.9	10.5	10.7
T4 B 2g/L	48.6	53.2	50.9	133.0	113.3	123.2	44.0	47.5	45.8	10.5	12.1	11.3
T5 Ca1g/B1g/L	61.8	65.8	63.8	163.2	163.5	163.4	57.8	68.8	63.3	12.7	12.8	12.8
T6 Ca1g/B2g/L	57.5	66.0	61.7	156.3	152.3	154.3	56.0	65.2	60.6	11.8	12.3	12.1
T7 Ca2g/B1g/L	57.2	67.0	62.1	155.4	144.6	150.0	63.9	62.1	63.0	11.7	13.2	12.5
T8 Ca2g/B 2g/L	58.9	68.8	63.9	171.5	155.7	163.6	61.7	63.8	62.8	12.9	13.9	13.4
T9 Control	48.4	50.9	49.6	114.9	115.5	115.2	45.9	49.4	47.7	10.7	10.8	10.7
$(\bar{X})$	55.1	61.6		143.6	137.4		52.5	59.1		11.3	12.1	
L.S.D at 0.05												
	Sea.1	Sea.2		Sea.1	Sea.2		Sea.1	Sea.2		Sea.1	Sea.2	
Cultivars	1.02	0.55		4.10	4.96		3.92	5.72		0.72	0.74	
Foliar spry	3.97	4.04		8.74	8.96		4.48	4.75		1.25	1.19	
Interaction	NS	NS		NS	NS		6.33	6.72		NS	NS	

*N. = Nantes Cv. *FW. = Fire wedge Cv.

Panda *et al.*, 1994; Ali *et al.*, 2006 and Lana, 2012 which are indicated that there were significant differences between cultivars with regard to growth parameters such as, leaf volume, leaf base thickness, plant height, fresh and dry weight of shoot, root shape, weight; length, split roots, top greening, internal color, fresh and dry weight of root.

The highest values of all vegetative growth and root parameters were recorded with treatment T8 (foliar application by Ca 2g/l and B 2g/l) followed by T5 (foliar application by Ca 1g/l and B 1g/l), there are no significant differences among them in both growing seasons. In general all mixed treatments between Ca and B (T5 to T8) superior significantly when compared with control treatment in all growth and root characters in both growing seasons. This result in the same line with those reported by Hepler and Winship, (2010) and Singh et al. (2012) they indicated that calcium (Ca) is an essential macronutrient for plant growth and development, also it's an important constituent in the structure of cell walls and cell membranes. Moreover, the supplement of boron (B) and or calcium (Ca) in the feeding solutions during plant growth increased the accumulation of other minerals, such as P, K, Mg, S which are reflect on improving plant growth.

The interaction between two studied factors showed that the high values of shoot weight were recorded with fire wedge *Cv.* with T5 (foliar application by Ca 1g/l and B 1g/l) followed by nantes *Cv.* with T8 (foliar application by Ca 2g/l and B 2g/l) in the first season and fire wedge *Cv.* with T6 (foliar application by Ca 1g/l and B 2g/l) in the second season respectively. But, the highest values of root diameter were recorded with nantes *Cv.* with T6 in the first season and with T7 in the second season. Significantly when compared with control treatment.

Yield parameters

Yield parameters *i.e.*, total yield/ fed, total root yield/ fed., marketable roots yield/fed. and unmarketable yield

Table 4: Effect of calcium and boron foliar spray on root length; diameter; weight and dry matter percentage of carrot cultivars during 2015/2016 and2016/2017growing seasons.

Seasons	**2015/2016**											
Characters	**Root length (cm)**			**Root diameter(mm)**			**Root weight (g)**			**Root dry matter (%)**		
Cv.Treatments	**N.**	**FW.**	**$(\bar{X})$**	**N.**	**FW.**	**$(\bar{X})$**	**N.**	**FW.**	**$(\bar{X})$**	**N.**	**FW.**	**$(\bar{X})$**
T1 Ca 1g/L	17.4	19.0	18.2	32.3	31.0	31.7	85.3	74.1	79.7	15.5	16.1	15.8
T2 Ca 2g/L	16.1	20.4	18.3	30.3	28.7	29.5	86.2	71.2	78.7	14.9	16.4	15.7
T3 B 1g/L	11.1	14.4	12.8	26.7	26.0	26.3	75.9	64.9	70.4	13.6	16.1	14.9
T4 B 2g/L	12.7	13.5	13.1	24.7	29.0	26.8	86.6	63.7	75.1	14.9	15.7	15.3
T5 Ca1g/B1g/L	17.8	20.8	19.3	39.3	33.0	36.1	103.7	88.6	96.2	17.8	19.3	18.5
T6 Ca1g/B2g/L	17.4	20.3	18.8	39.7	29.7	34.7	98.0	86.4	92.2	17.1	18.3	17.7
T7 Ca2g/B1g/L	16.8	20.1	18.5	38.7	29.3	34.0	88.7	80.5	84.6	17.9	18.2	18.0
T8 Ca2g/B 2g/L	17.5	21.5	19.5	36.7	36.0	36.3	106.2	89.3	97.7	18.5	18.8	18.7
T9 Control	12.1	15.4	13.8	31.7	25.0	28.3	66.6	63.8	65.2	13.4	14.6	14.0
$(\bar{X})$				33.3	29.7		88.6	75.8		15.9	17.1	
2016/2017												
T1 Ca 1g/L	17.8	19.6	18.7	33.1	32.3	32.7	87.8	76.1	81.9	16.0	16.6	16.3
T2 Ca 2g/L	16.8	20.9	18.8	31.0	29.7	30.4	88.7	73.6	81.1	15.4	17.0	16.2
T3 B 1g/L	11.3	15.0	13.2	27.8	26.8	27.3	78.3	67.6	73.0	14.0	16.7	15.3
T4 B 2g/L	13.2	14.4	13.8	25.2	30.2	27.7	89.0	65.7	77.4	15.3	16.1	15.7
T5 Ca1g/B1g/L	19.7	19.8	19.7	40.2	33.2	36.7	103.5	94.7	99.1	17.1	19.9	18.5
T6 Ca1g/B2g/L	16.8	19.4	18.1	40.7	30.4	35.6	100.3	87.1	93.7	17.6	18.8	18.2
T7 Ca2g/B1g/L	17.2	20.6	18.9	42.1	30.4	36.3	91.5	82.6	87.0	18.5	18.7	18.6
T8 Ca2g/B 2g/L	17.6	21.9	19.8	38.9	34.6	36.8	109.8	91.9	100.8	19.1	19.9	19.5
T9 Control	12.4	16.0	14.2	32.8	25.7	29.3	69.0	66.1	67.5	13.2	15.2	14.2
$(\bar{X})$	15.9	18.6		34.7	30.4		90.9	78.4		16.2	17.7	
L.S.D at 0.05												
	Sea.1	Sea.2		Sea.1	Sea.2		Sea.1	Sea.2		Sea.1	Sea.2	
Cultivars	1.11	1.77		1.28	1.10		1.63	1.66		1.05	1.39	
Foliar spry	2.03	1.97		3.32	3.14		6.77	6.77		1.10	1.27	
Interaction	NS	NS		4.70	4.43		NS	NS		NS	NS	

*N. = Nantes Cv. *FW. = Fire wedge Cv.

percent were presented in table 5. Obtained results indicated that there are significant differences between for both carrot cultivars and spray application treatments on all investigated yield parameters. From the data it could remark the following.

The highest values of total yield/ fed, total root yield/ fed. and marketable yield/fed were presented with fire wedge *Cv.* These results could be due to differences between cultivars in the way of adaption on environmental conditions and genetic differences between both cultivars which are decreased growth, productivity and make root take informality shaped. These results agree with those reported by (Pascale *et al.*, 2000). Also, cultivars differential in yield those reported by Ali *et al.*, 2006 and Lana, 2012.

The highest values in total yield/fed. were recorded with T8 followed by T5 but the highest values in total root yield and marketable roots yield were obtained with T5 followed by T8 no significant differences appeared among all mixed foliar spray treatments in both growing seasons. Calcium is considered as an immobile element in plant so foliar application of calcium increased calcium content in plants which enhanced vegetative growth which reflect on yield (Hirschi, 2004; Hepler and Winship, 2010 and Batistic and Kudla, 2010),itcould be due to the role of Boron. Many several studies proved that B application increased yield and enhanced drought tolerance of carrot cells whereas its deficiency results in small roots with yellow tops with a distinct white core in the middle (Demiray and Dereboylu, 2006 and Satish Kumar Subba *et al.*, 2016).

Chemical constituents

Chemical constituents *i.e.* calcium (%) and total carbohydrates (%) were presented in table 6. Obtained results indicated that there are significant differences between both carrot cultivars and spray application treatments on all investigated chemical constituent

Table 5: Effect of calcium and boron foliar spray on total yield, total roots yield, Marketable yield, and Unmarketable (%)of carrot cultivars plants during 2015/2016 and 2016/2017growing seasons.

Seasons	**2015/2016**											
Characters	**Total yield (ton/fed.)**			**Total roots yield(ton /fed.)**			**Marketable yield (ton/fed.)**			**Unmarke-table (%)**		
Cv.Treatments	**N.**	**FW.**	**(X̄)**	**N.**	**FW.**	**(X̄)**	**N.**	**FW.**	**(X̄)**	**N.**	**FW.**	**(X̄)**
T1 Ca 1g/L	14.31	15.87	15.09	9.9	12.4	11.1	6.87	9.65	8.26	30.9	22.2	26.5
T2 Ca 2g/L	15.27	16.16	15.72	10.1	12.6	11.3	6.66	9.84	8.25	33.9	22.0	28.0
T3 B 1g/L	12.93	15.09	14.01	8.0	10.7	9.3	4.93	7.54	6.24	38.4	29.3	33.9
T4 B 2g/L	12.61	13.43	13.02	7.6	9.4	8.5	4.63	6.53	5.58	39.5	30.4	34.9
T5 Ca1g/B1g/L	15.67	18.36	17.01	12.2	13.7	12.9	9.48	10.22	9.85	22.3	25.3	23.8
T6 Ca1g/B2g/L	15.65	16.87	16.26	11.0	13.0	12.0	7.75	10.07	8.91	29.7	22.6	26.2
T7 Ca2g/B1g/L	15.68	16.26	15.97	11.2	12.3	11.8	8.09	9.33	8.71	28.3	24.4	26.3
T8 Ca2g/B 2g/L	16.20	17.93	17.07	11.4	13.8	12.6	7.97	10.56	9.27	29.8	23.2	26.5
T9 Control	13.64	14.36	14.00	7.6	10.4	9.0	4.30	7.58	5.94	43.9	27.4	35.6
(X̄)	14.66	16.04		9.9	12.0		6.74	9.04		33.0	25.2	
2016/2017												
T1 Ca 1g/L	14.79	16.41	15.60	11.24	12.77	12.00	8.55	9.93	9.24	24.1	22.3	23.2
T2 Ca 2g/L	15.84	16.54	16.19	11.44	12.97	12.21	8.27	10.18	9.23	27.7	21.5	24.6
T3 B 1g/L	13.43	15.68	14.55	9.26	11.00	10.13	6.39	7.73	7.06	31.2	29.8	30.5
T4 B 2g/L	13.04	13.81	13.42	8.91	9.67	9.29	6.09	6.77	6.43	31.7	30.0	30.9
T5 Ca1g/B1g/L	17.70	18.40	18.05	13.74	13.11	13.42	10.67	10.81	10.74	22.4	23.4	22.9
T6 Ca1g/B2g/L	16.68	17.40	17.04	12.78	12.83	12.81	9.83	10.38	10.11	23.1	22.6	22.8
T7 Ca2g/B1g/L	17.12	16.71	16.91	12.54	12.82	12.68	9.19	9.83	9.51	26.8	23.4	25.1
T8 Ca2g/B 2g/L	17.88	18.59	18.23	12.52	13.31	12.92	9.80	9.62	9.71	25.9	25.5	25.7
T9 Control	13.11	14.72	13.91	9.43	10.75	10.09	6.78	7.85	7.32	28.1	27.0	27.5
(X̄)	15.51	16.47		11.32	12.14		8.40	9.24		26.8	25.0	
L.S.D at 0.05												
	Sea.1	Sea.2		Sea.1	Sea.2		Sea.1	Sea.2		Sea.1	Sea.2	Sea.1
Cultivars	0.73	0.68		0.52	0.81		0.77	0.16		3.63	1.00	
Foliar spry	1.50	1.56		1.23	1.33		1.20	1.18		4.37	2.52	
Interaction	NS	NS		NS	NS		NS	NS		6.18	NS	

*N. = Nantes Cv. *FW. = Fire wedge Cv.

parameters. From the data it could be remark the following.

The highest values of calcium (%) and total carbohydrates (%) were presented with fire wedge *Cv.* These results could be due to genetic differences between cultivars. These results in the same line with those reported by Heinonen (1990) who found that there are differences among content of carotenoid and pro-vitamin A of 19 carrot cultivars.

The highest values in calcium (%) and total carbohydrates (%) were recorded with T8 followed by T5 but the highest values in total root yield and marketable yield were obtained with T5 followed by T8 no significant differences appeared among all mixed foliar spray treatment in both growing seasons. These results in the same line with those reported by Singh *et al.,* (2012). They are found that supplement of boron (B) and or calcium (Ca) in the feeding solutions, during plant growth, influenced the accumulation of other minerals, such as P, K, Mg, S and 33– 50% increase in the accumulated levels of a- and b-carotenes and 45–70% increase of vitamin C in carrot root.

Preparing carrot samples for drying process

Previous results indicated that the best recommended treatments were Fire wedge *Cv.* with foliar application by T5 (Ca 1g/l and B 1g/l) or by T8 (Ca 2g/l and B2g/l) both treatments will be indicated as F1 and F2, respectively.

Abbreviations of treatments

F1F: Fresh control treatment of [Fire wedge Cv+ T5 (Ca 1g/l and B 1g/l)].

F1M: Microwave treatment of [Fire wedge Cv+ T5 (Ca 1g/l and B 1g/l)].

F1O: Oven treatment of [Fire wedge Cv+ T5 (Ca 1g/l and B 1g/l)].

F2F: Fresh control treatment [Fire wedge Cv+ T8 (Ca 2g/l and B2g/l)].

F2M: Microwave treatment of [Fire wedge Cv+ T8 (Ca 2g/l and B2g/l)].

F2O: Oven treatment of [Fire wedge Cv+ T8 (Ca 2g/l and B2g/l)].

Table 6: Effect of calcium and boron foliar spray on calcium and total carbohydrates of carrot cultivars plants during 2015/2016 and2016/2017growing seasons.

Season Characters	2015/2016					
	Calcium (%)			Total carbohydrates (%)		
Cv. Treatments	N.	FW.	(X¯)	N.	FW.	(X¯)
T1 Ca 1g/L	0.287	0.307	0.297	32.45	36.50	34.48
T2 Ca 2g/L	0.303	0.300	0.302	34.47	35.57	35.02
T3 B 1g/L	0.250	0.257	0.253	31.41	32.13	31.77
T4 B 2g/L	0.233	0.257	0.245	30.97	32.20	31.59
T5 Ca1g/B1g/L	0.320	0.337	0.328	35.00	37.48	36.24
T6 Ca1g/B2g/L	0.317	0.320	0.318	33.23	36.27	34.75
T7 Ca2g/B1g/L	0.313	0.340	0.327	33.69	35.40	34.55
T8 Ca2g/B 2g/L	0.331	0.360	0.346	34.93	38.72	36.83
T9 Control	0.237	0.270	0.253	30.66	33.23	31.95
(X¯)	0.288	0.305		32.98	35.28	
2016/2017						
T1 Ca 1g/L	0.290	0.337	0.313	33.07	35.17	34.12
T2 Ca 2g/L	0.303	0.320	0.312	32.17	33.63	32.90
T3 B 1g/L	0.293	0.277	0.285	31.13	32.70	31.92
T4 B 2g/L	0.260	0.280	0.270	31.43	31.71	31.57
T5 Ca1g/B1g/L	0.317	0.367	0.342	34.37	34.70	34.53
T6 Ca1g/B2g/L	0.310	0.353	0.332	34.12	34.87	34.49
T7 Ca2g/B1g/L	0.270	0.387	0.328	34.27	35.30	34.78
T8 Ca2g/B 2g/L	0.313	0.397	0.355	34.67	36.10	35.38
T9 Control	0.277	0.280	0.278	30.60	32.47	31.53
(X¯)	0.293	0.333		32.87	34.07	
L.S.D at 0.05						
	Sea.1	Sea.2		Sea.1	Sea.2	
Cultivars	0.004	0.04		1.50	1.12	
Foliar spry	0.033	0.03		2.44	2.25	
Interaction	NS	0.04		NS	NS	

*N. = Nantes Cv. *FW. = Fire wedge Cv.

Post-harvest decay is the major factor limiting the extension of shelf-life of vegetables (Togrul, 2006). And so it was important to care about minimize the deterioration of best calcium and boron foliar spray treatments for carrot after harvesting. The keeping ability of carrot can be enhanced by drying which considered to be an oldest method of food preservation and represent a very important aspect of food processing. Therefore, grated carrot of both F1 and F2 samples were dried by using oven and microwave drying methods. The color, total carotenoids content, rehydration ratio, vitamin C, Vitamin E and total phenol content were determined in order to study the effect of drying methods on the grated carrot samples.

Effect of drying methods on color of dried grated carrot

Color is one of the most important attributes of the dried food products, where it's negatively influenced by thermal treatments and affected the final visual appearance and so the consumer acceptability (Zielinska *et al.*, 2005). Color of carrots powder samples were estimated by measuring *L*", *a*", *b*" parameters which is widely used as a quality indicator for monitoring of color changes during food processing (Koca *et al.*, 2007). Fig. 1 shows the effect of oven and microwave drying methods on the color of F1 and F2 dried grated carrot treatments in comparison with fresh samples of each treatment as a control treatment. It was found that, the color of dried grated carrot

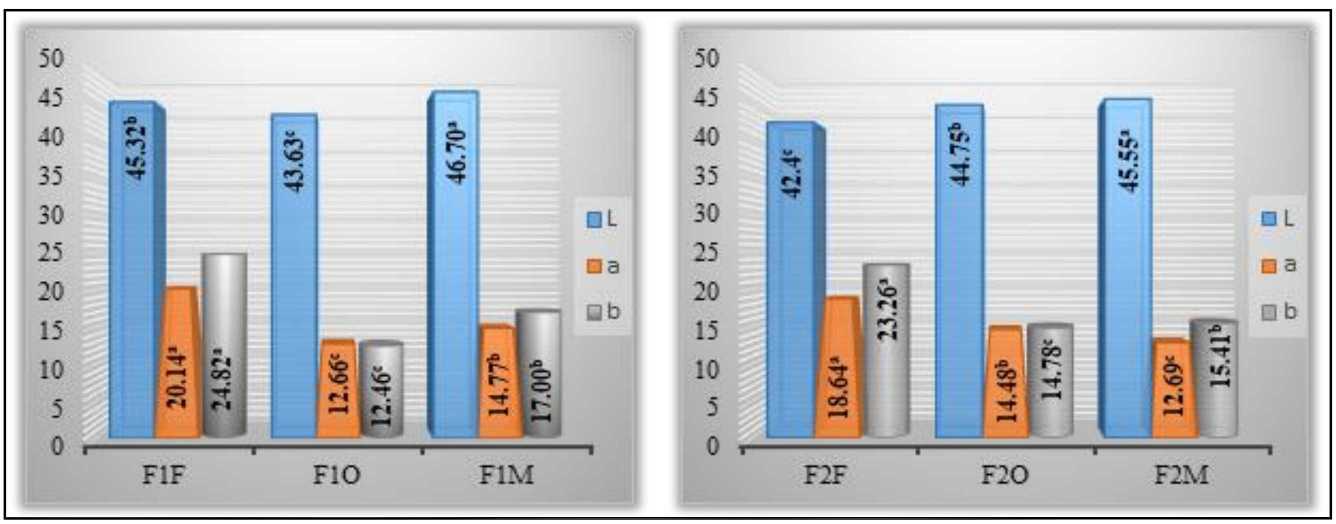

Fig. 1: Effect of drying methods on dried grated carrot color.

samples were seen as much different from that of the fresh one for both F1 and F2. Significant influence of drying methods on the color changes in lightness/darkness (L*), redness (a*) and yellowness (b*) parameters were noticed. The highest mean values of L* parameter was observed with the F1M and F2M samples in comparison with the F1F and F2F, respectively. The mean value of L* parameter for the oven drying samples were found to be higher than the F2 F sample and lower than the F1F sample, where it was 44.75 and 43.63 for F2O and F1O in comparison with 42.4 and 45.32 for F2F and F1F, respectively. The higher L* values meaning the lighter color obtained (Sumnu *et al.,* 2005).

As regard to a* values, it was noticed to be decreased for both oven and microwave drying samples in comparison with the fresh samples for both F1 and F2. The trend of decrement in a* values for F1 was on counter to F2 where the lower a* values occurred with F1O followed by F1M for the F1, while for the F2, the lower a* values were occurred with the F2M followed by F2O. A reduction in b* value has been take place in all dried grated carrot samples where the lower reduction in b* values exist with the microwave drying samples, which mean more yellowish, followed by the oven drying samples for both F1 and F2 treatments. This result in the same line with Lin *et al.,* 1998 who reported that the microwave dried carrot slices were found to be more yellowish.

The a*/b* value is commonly used as an index to report the color quality (brightness of red color) (Al-Juhaim *et al.,* 2015). However, Fig. 2 clarify the a*/b* values for the dried grated carrot treatments where there was a significant increment manifest in the a*/b* values. The lower increment exhibit with the microwave drying samples followed by oven drying samples in comparison with the fresh control samples for both F1 and F2 treatments.

Our results were in agreement with Ali *et al.,* (2016) who illustrated that the more b* values for the dried guava slices the more yellowish color as compared to fresh samples and also, stated that the minimum a*/b* values prevent color damage. Patras *et al.,* (2009) reported a significant reduction in color intensity after thermal treatment for carrot puree. Ibarz *et al.,* 1999 illustrate that, the decrease in redness and yellowness was probably due to the water removal, internal structure alterations and changes in surface texture and concentration of dry matter. The microwave drying method significantly shortened the drying time of carrot with good color quality. This was in accordance with Sumnu *et al.,* (2005), Krokida and Maroulis (1999), Lin *et al.,* (1998) who also reported that drying was performed in a shorter time with less color deterioration when high powers were used and advised using microwave in drying carrot. Where Magdalena and Marek (2011) mention that, the dried carrot cubes lost their redness, yellowness with increasing drying time and temperature.

Effect of drying methods on total carotenoid content of dried grated carrot

Carotenoids are a fat soluble pigments present in red and yellow root vegetables. It is a potent antioxidants present in carrots which help to neutralize the effect of free radicals, thus, decrease risk of some cancers (Dias, 2012). Chemical changes to carotenoid pigments are caused by heat and oxidation during drying, so, it used as a quality index. (Ding *et al.,* 2015, Sabry *et al.,* 2016). Data in Fig. 3 clarify that, total carotenoid content in F2F sample was higher than the F1F sample. Also it was found

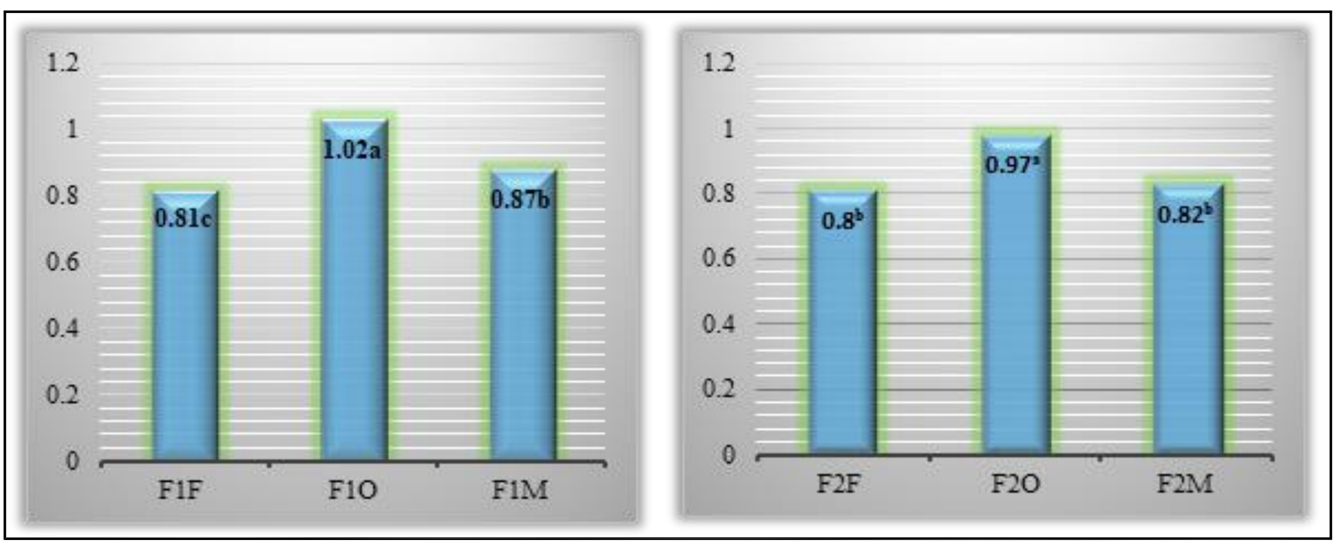

Fig. 2: Effect of drying methods on a*/b* value of dried grated carrot.

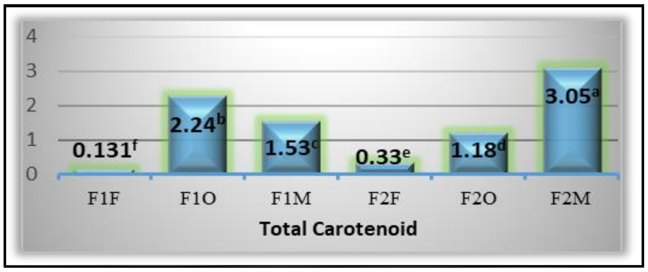

Fig. 3: Effect of drying methods on total carotenoid content (mg/g) of dried grated carrot.

that there was an increment achieved in the total carotenoid content for oven and microwave treatments for both F1 and F2 samples in comparison with the fresh control samples. Our results were in agreement with those obtained by Sabry *et al.,* 2016 who reported that there was an increment achieved in total carotenoid content for microwave treatment of carrot slices when compared with the fresh samples. The trend of our results may be due to the using of calcium and boron spray during plant growth which affected the cell wall structure.

Effect of drying methods on rehydration ratio of dried grated carrot

Rehydration is an important step in the using of dried fruits and vegetables. Rehydration ratio is one of the methods by which the quality of the drying process can be estimated. It is defined as the rehydrated samples ratio of rewet weight sample to the weight of dry sample. The high value of rehydration ratio means the good quality of the dried product where the pores of the dried product have been in a good state that allow water to re-enter the cells (Tadesse *et al.,* 2015, Garcia-Pascual *et al.,* 2006 and Noomhorm 2007). In order to determine the rehydration ratio, the dried grated carrot were boiled for the stage that absorption of water reach to maximum for the final reconstitution. Data in Fig. 4 illustrated that, the highest significant value of rehydration ratio of the dried grated carrot was obtained with the F1 samples as compared with the F2 samples. Also Fig. 4 clarify that the rehydration ratio mean value of the microwave treatment (5.75) was significantly higher than the oven treatment (4.0) for the F1 samples. Where, in opposite, the significant higher mean value of rehydration ratio for the F2 samples was observed with the oven treatments (3.5) followed by the microwave treatment (2.5). This may be due to the using of calcium and boron spray during plant growth which influenced the cell wall structure and have a profound effect on the rehydration ratio of dried grated carrots samples where the treatment of carrot by Ca 1g/l and B 1g/l decreased shrinkage and caused an increment in the rehydration ratio of both microwave and oven treatments. Our results for the rehydration ratio of

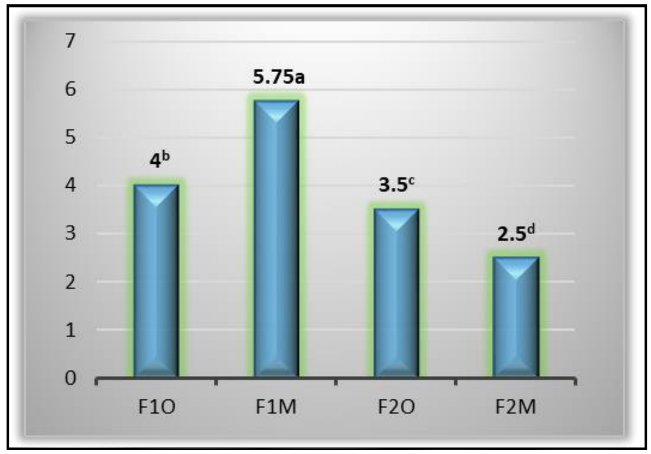

Fig. 4: Effect of drying methods on rehydration ratio of dried grated carrot.

the both F1M and F1O were higher than those resulted by Al-Amin *et al.,* 2015, for solar and mechanical dried carrot, but the rehydration ratio of F2O (3.5) were in closed to rehydration values obtained for solar (3.70) and mechanical (3.65) dried carrot. The rehydration ratio of both F1O and F2O were found to be highly lower than those obtained by Ding *et al.,* 2015, who mentioned that, the rehydration ratio of oven-dried carrot slices was 7.38.

Effect of drying methods on vitamin C and vitamin E concentration in dried grated carrot

Vitamins are organic compounds and vital nutrients that cannot be synthesized in human body, so, it become important to be obtained through the diet (Gerald *et al.,* 2016). Thermal treatments can have a significant impact on the content of vitamins and lead to an inaccurate estimation of nutrient intake. Therefore, it is necessary to determine the effect of drying process on vitamins content of carrot samples after drying (Lee *et al.,* 2018). Vitamin C is an essential water-soluble vitamin where it is a cofactor in numerous physiological reactions like collagen gene expression and peptide hormone activation, it is also an effective antioxidant. Therefore, adequate intake of vitamin C from food is important for normal functioning of the human body (Phillips *et al.,* 2010). Vitamin C is a heat sensitive vitamin, thus, if vitamin C is well maintained during the drying process, other nutrients are probably also preserved and so it could use as an indicator for the preservation of nutrients in dried food items (Lin *et al.,* 1998). Fig. 5 reported the vitamin C concentration of fresh and dried grated carrot. There was an increment in the vitamin C concentration in the dried grated carrot samples for both F1 and F2 samples when compared with the fresh samples for both treatments. The highest vitamin C concentration was observed with the F1O treatments for the F1 sample, where the highest vitamin C concentration was found to

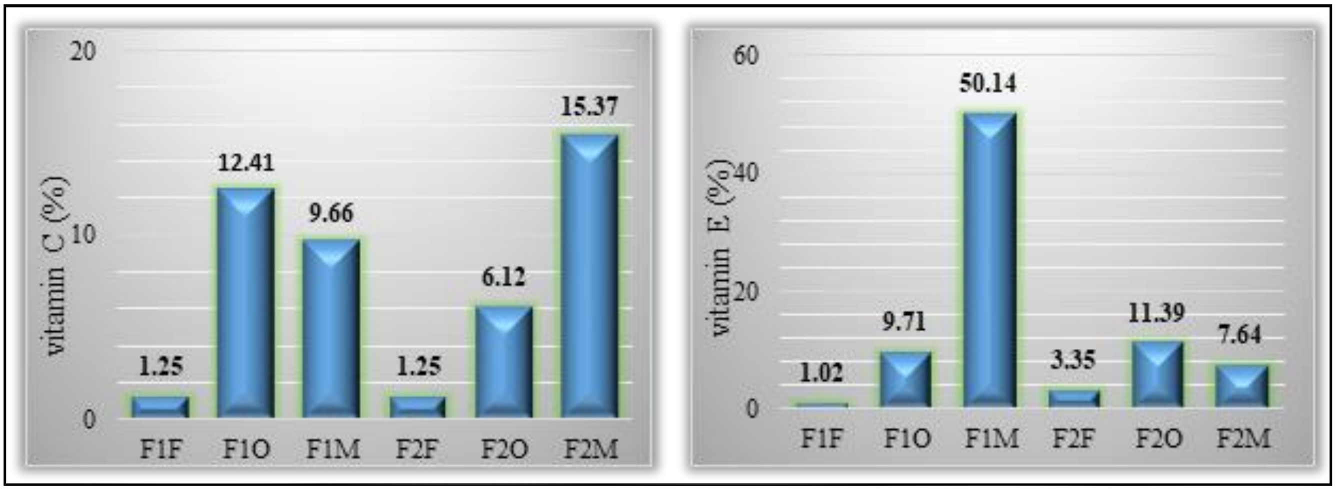

Fig. 5: Effect of drying methods on vitamin C and vitamin E content of dried grated carrot.

be F2M treatments for the F2 sample. Our trend results observed with the F2 sample was in agreement with those reported by Lee *et al*., 2018, who stated that Microwaving had less effect on vitamin C content, with high retention observed for spinach, carrots, sweet potato and broccoli. Also they mentioned that, microwaving retained higher concentrations of vitamin C because of shorter drying time periods result in higher vitamin C retention. Also Ali *et al.*, 2016 indicated that the highest concentration of ascorbic acid was found in microwave followed by oven treatments.

Vitamin E is a natural antioxidant compounds occurs in vegetables, which considered to be the major lipid-soluble component in the cell antioxidant defense system helping in repair damaged cells (Saliha *et al.*, 2014). The data in Fig. 5 presented the vitamin E concentration of fresh and dried grated carrot. There was a significant increment in vitamin E concentration in both dried F1 and F2 samples when compared with the fresh one. The highest significant vitamin E concentration were found to be with the microwave treatment for the F1 sample and with the oven treatments for the F2O sample. There was a higher retention of vitamin E concentration in oven and microwave treatments for both F1 and F2 samples. Our results were in accordance with those observed by Lee *et al.*, 2018, who reminded that there was a trend toward higher retention of vitamin E in thermal treated rather than fresh carrot samples.

Murillo *et al.*, 1976 attributed the high content of vitamin E in cooked vegetables samples could be due to the effect of thermal treatment which may cause softening to the vegetable tissue resulted in the release of vitamin E from the lipids structure or deactivate the activity of tocopherol oxidase, which was found in all parts of plant like roots and so, minimize the loss rate of vitamin E resulted in increment in the retention rate of the vitamin E. Also Choi *et al.,* 2005 mentioned that heat treatment could deactivate endogenous oxidative enzymes. The trend of our results for vitamins contents in F1 and F2 samples may be due to the using of calcium and boron spray during plant growth which affected the cell wall structure.

Effect of drying methods on total phenol content of dried grated carrot

All the thermal treatment methods affected the total phenolic content and antioxidant properties (Chipurura *et al.*, 2010). So it was important to determine the total phenol content. Results presented in Fig. 6 indicated the total phenol content (TPC) in the fresh and dried grated carrot samples. TPC in F1F sample was found to be significantly more than the F2F sample. For the dried grated carrot samples. There was a significant increment in TPC of microwave and oven treatments for both F1 and F2 samples in comparison with the fresh samples. The microwave treatment exhibits a highly TPC than the oven treatment for both F1 and F2 samples but it was highly significant with the F2 samples.

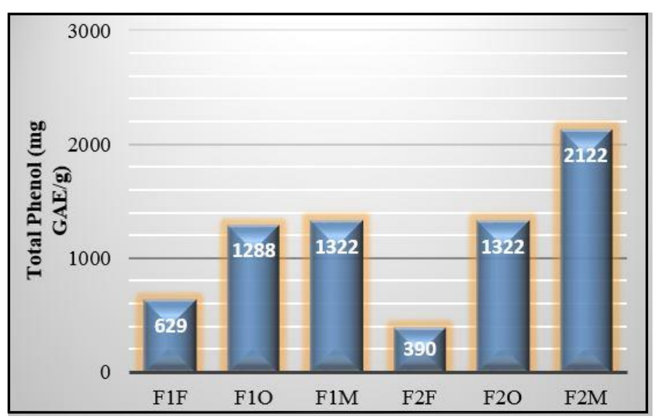

Fig. 6: Effect of drying methods on total phenol content of dried grated carrot.

Our results were in agreement with Lutz *et al.*, (2015) who remind that there was an increment in TPC of carrot samples dehydrated by convective oven and clarified that the obtained dehydrated fruits and vegetables possess a high TPC and thus, it considered to be a good source of natural antioxidants. Nguyen and Le, (2018) reported that the TPC obtained by microwave drying process was significantly higher than those obtained from other drying conditions and also mentioned that the reason for these differences in TPC may be due to different drying temperature and time. Moreover, Sablani *et al.*, (2011) have stated that TPC may be either increase or decrease after drying not only because of the cultivar but also on the production system used during culture. However, this increment in TPC may be attributed to the release of phenolic bonds or hydrolysis of complex phenolic, leading to the production of low Molecular weight compounds (Al-Farsi, *et al.*, 2005, Chang *et al.*, 2006).

Conclusion

Our findings indicated that different drying methods had a good impact on the properties of dried grated carrot. Among the two drying methods used, oven and microwave drying methods, there was an improvement in total phenol, total carotenoids, vitamin C and vitamin E of the dried grated carrot samples, likewise, a progress in color was achieved for both F1 and F2 grated carrot samples when compared with the fresh carrot control samples. Concerning to the rehydration ratio, it was noticed that the best rehydration ratio was observed with the F1 dried grated carrot samples. The difference in our results trend between the two drying methods for the dried grated carrot samples may be due to the using of calcium and boron spray during plant growth which affected the cell wall structure. Therefore, drying process of the best carrot treatments, T8 and T5, led to minimize the postharvest decay and reduce the losing rate of the carrot crop.

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