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Effect of some Media on Artichoke Sprouts Production and Nutritional Values

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ABSTRACT

Sprouts are excellent source of, amino acids, enzymes, minerals, phytochemicals and vitamins which are the most useful compounds for the human health. This study aimed to investigate the effect of three germination media (soil mixture consisted of soil + vermiculite + 10 % compost, rice straw and kitchen paper towel) on the production and nutritional value of sprouts artichoke comparing with artichoke heads. The highest sprouts yield was produced on soil mixture. On the other hand, based on dry weight, the comparison among sprouts produced on the different media, indicted that sprouts produced on kitchen paper towel showed the highest values of the most nutritional. Meanwhile, sprouts produced on kitchen paper towel exhibited significantly value higher contents of protein, total lipid, inulin, total sugars, calcium, sodium, phosphorus, antioxidants, the essential amino acids (such as leucine, isoleucine, threonine, phenylalanine and valine) than detected in artichoke heads. Reversely, artichoke heads significantly value higher contents of fibers, carbohydrates, phosphorus, vitamin A, vitamin C, total phenols, chlorogenic acid, cynarin, and the essential amino acid aspartic than all sprouts. The essential fatty acids (linoleic acid, linolenic acid) were determined in sprouts produced on soil mixture and rice straw, but they were not found in artichoke heads and produced on kitchen paper towel. According to the current results, it is recommended to collect artichoke seeds, before they are scattered in the soil at the end of the season, to be used in producing sprouts throughout the year as a source of healthy food and a protection from various serious diseases.

Keywords: Germination, sprouts, heads, vitamins and nutritional value, artichoke.

INTRODUCTION

Globe artichoke (*Cynara cardunculus* var. *scolymus* (L.) Fiori) is an ancient herbaceous perennial plant, belongs to the Asteraceae family. It originated from the Mediterranean areas of North Africa and nowadays widely grown around the world, with Italy and Spain being the main producer countries (Lattanzio *et al.,* 2009). It is commercial produced mainly by vegetatively propagation (Sonnante *et al.,* 2007).

The edible portion of the plant is the immature inflorescences (capitula or heads), including the inner bracts and the upper part of the receptacle. In addition, there are some non-food industrial by-products such as leaves, external bracts and stems. (Lattanzio *et al.,* 2009). Under Egyptian conditions, the artichoke heads are produced for 4 months from the end of December to the late of March, El-Sayed (2009).

Globe artichoke heads have high nutritional value due to the low content of lipids and the high levels of minerals (phosphorus, potassium, sodium, calcium, zinc) vitamins (K, C) and bioactive compounds which include polyphenols, flavones, inulin and caffeoylquinic acid derivatives; (Lattanzio *et al*., 2009; Pandino *et al*., 2011, Abdel Magied *et al.,* 2016). Each 100 g fresh weight (FW) of artichoke heads contain 17.75-46.44% carbohydrates, 3.73-18.25% proteins, 0.27-2.06% crude fat , 1.65% ash (Lutz *et al.,* 2011).

Beside Artichoke leaf extract being anti-HIV (human immunodeficiency virus), bile-expelling, hepatoprotective, urinative and choleretic activity (Wang *et al*., 2003), artichoke leaf extract has shown other incredible health benefits, which includes supporting fat digestion and vitamin absorption, helping in stopping cancer growth, lowering cholesterol (Ben Salem *et al.,* 2015), protecting the liver and supports detoxification (Ben Salem *et al.,* 2015, El Morsy and Kamel , 2015) overcoming irritable bowel syndrome (Rahimi and Abdollahi, 2012), balancing the gut flora (Costabile *et al.*, 2010), having antioxidant properties (Negro *et al.,* 2012) , lowering blood pressure (Pandino *et al*., 2011a; Ben Salem *et al*., 2015), protecting from the heart diseases (Bellosta *et al*, 2008), helping in reducing diabetes symptoms and in weight loss (Rondanelli *et al*., 2011), having antimicrobial properties (Zhu *et al.,* 2005) and protecting against lead toxicity (Heidarian *et al*, 2013). Moreover, it was recently proved that artichoke extract improves skin health (Furue *et al*., 2017)

Sprouts are the germinated seeds of various annual plants, including vegetables, herbs, and field crops. Sprouts are about ten days old seedlings. They are termed to be authentic “super” foods, because they are very easy to grow, and do not require an outdoor garden. The entire germinated plant is sold for use mainly in salads and sandwiches. Because sprouts are consumed at the beginning of the growing stage, their nutrient concentration remains very high. In addition, they are excellent source of many useful compounds for the human health, such as amino acids, enzymes, minerals, phytochemicals and vitamins (Webb, 2006). Some sprouts, like Brassica, contain phenolic, like glucosinolates, and selenium-containing components, which are considered health-maintaining important nutrients (Marton *et al*., 2010). These glucosinolates and natural antioxidants can have a considerable role in the prevention of cancer (Sangronis and Machado, 2007). During the germination the polysaccharides degrade into oligo- and monosaccharides, the fats into free fatty acids, while the proteins degrade into oligopeptides and free amino acids, which processes support the biochemical mechanisms in our organism. Thus, sprouts have a positive effect on the health of the human organism (Sangronis and Machado, 2007). Several media have been used for sprouting of seeds, such as a piece of cheesecloth (Soylemez *et al*., 2001), cellulose sponge (Mostafa *et al*., 1987), filter papers (Cevallos-Casals and Cisneros-Zevallos, 2010) and cotton layers (Mugendi *et al*., 2010). On the other hand, Obizoba (1991) spread pigeon pea seeds on wet jute bags and covered with muslin cheese cloth to sprout.

Under Egyptian conditions, Amin (2008) compared the effect of different media; namely hydroponic medium, sand, cotton cloth and paper towel, on the yield of some vegetable sprouts and found that using hydroponic medium produced the highest yield of broccoli and radish sprouts, while using sand medium produced the highest yield of soybean sprouts. Ibrahim (2010) studied the effect of different media, which were three sole media [clay, sand and vermiculate], three mixtures of clay + vermiculate, sand + vermiculate, peatmoss + vermiculate , and the previous three mixture media with adding 10% compost (by volume) on the yield of sunflower sprouts and found that clay + vermiculate + 10 % compost produced the highest yield of sunflower sprouts. El-Sayed (2012) studied the effect of different growing media (rice straw, kitchen paper and soil, vermiculate and 10% compost) on characters and yield of faba bean, pea and cowpea sprouts. The highest sprout yield was obtained when seeds of cowpea and faba beans were grown on straw medium, and when seeds of pea were grown on kitchen paper.

In spite of the incredible health benefits of artichoke leaves, no one tried to produce sprouts of artichoke and study their nutritional values to be a fresh daily healthy food instead of artichoke heads, that are just available in the market for only 4 months, and fresh medicines instead of oral and injection medicines that are used for curing t of diabetes and virus C. Therefore, the present work was undertaken to study effect of some media on artichoke sprouts production and nutritional values.

MATERIALS AND METHODS

1. Sprout production experiment:

The present work included studying effect of three culture media namely, white kitchen paper towel, rice straw and solid mixture substrate (90 % Clay + vermiculate (1:1) + 10 % compost) on sprouts qualitative and quantitive characters of artichoke seeds (cv. Balady) obtained from a private seed store, Cairo, Egypt. The experiments were conducted in the Improving Competitiveness of Some Vegetables for Export Project, Faculty of Agriculture, Cairo University, Giza, during the period from 2014 to 2016. Seeds (cv. Balady), collected during May 2014 and 2015 from artichoke field at the Agricultural Experimental and Research Station, Faculty of Agriculture, Cairo University, Giza, Egypt. Artichoke offshoots and cutting were planted on 20 and 25 August in 2014 and 2015, respectively, with 100 cm apart between each two plants on the ridge and 100 cm between the ridges, to get artichoke fluorescents (heads). The plants were distributed in 3 plots; each was 15 m^2 area and consisted of 3 rows, each 5 m long and 3 m wide. Each plot contained 15 plants. A primary experiment was conducted on 4^{th} November (using seeds of cv. Balady obtained a privet seed store) to assess the germination percentage of artichoke seeds, before conducting the main experiment. On the other hand seeds of artichoke were sown on 14^{th} and 16^{th} February of 2015 and 2016, respectively. However, the chemical determination contained until the end of 2016.

Artichoke seeds were spread evenly to form a single layer on the different media in plastic trays (23 × 50.5. cm). The seed density for culture and covering the entire medium surface in the tray was 1833 grams dry seeds. The trays with seeds were held, in the Improving Competitiveness of Some Vegetables for Export Project, Faculty of Agriculture, Cairo University, Giza on, tables for germination at room temperature (23 °C and to 85% relative humidity) to sprout. Treatments were distributed in complete randomized design. Green sprouts were harvested after the 1st set of true leaves emergence (10 days after seed sowing). Sprouts were cut from tray with scissors or sharp knife on the substrate surface. Harvested greens were immediately washed and precooked in ice water for 5 minutes and air dried for data collection. Each treatment was repeated four times (4 trays). Meanwhile, 9 artichoke heads were harvested on 24^{th} and 26^{th} February, 2014 and 2015, respectively from 9 different rows in the field for chemical determination.

1. Data recorded for sprout characters:

Ten sprouts were randomly chosen from each tray (replicate) to collect data of sprout weight, seedling length and seedling diameter. Also, sprouts yield per m^2 and per gram of sowing seeds were recorded.

2. Chemical composition

Moisture (mg/100g), chlorophyll (Spad), vitamins C (mg/g)and A(mg/g) and antioxidant (%) were determined in fresh weight, while calcium (mg/100g), potassium (mg/100g), sodium (mg/100g), phosphorus(mg/100g) , total carbohydrates (g/100g), fiber(g/100g), total protein (g/100g), ash(g/100g) inulin (%), total phenols (mg/100 g), Chlorogenic acid (mg/100 g), Cinarin (mg/100 g), amino acids (%) and fatty acids (%) were determined in dry matter. To obtain dry matter for chemical determination, fifty gram fresh weight of each replicate (tray) were oven dried at 70 ^{o} C to a constant weight. There after the nutritional value of artichoke sprouts and heads were determined according to the methods described in A. O. A. C (2000) for fiber, total protein, ash and moisture, by Estefan *et al.* (2013) for P, Ca, K, and Na, by Nielsen (2010) for total carbohydrate and lipid(g/100g), Block *et al.* (1985) for amino acids hydrolysis, Farag *et al.* (1986) using GLC for fatty acids analysis, Pinto *et al.* (2008) by using HPLC for Chlorogenic acid and Cinarin, Meda *et al*. (2005) for total phenol.

The nutritive values of artichoke sprouts and heads that were determined in fresh samples as described by Fung and Luk (1985) for Vitamin C, Rutkowski and Grzegorczyk (2007) for vitamin A, lee *et al*. (2002) for antioxidant and Yadava (1986) for chlorophyll contents using A Minolta SPDAD chlorophyll-Meter (model SPAD 502).

Statistical analysis:

Statistical analysis was employed for each measured trait by analysis of variance (ANOVA) using completely randomized design and the means were differentiated by LSD 0.05 (Snedecor and Cochran, 1980).

RESULTS AND DISCUSSION

1. The effect of different culture media on vegetative characters, chlorophyll content and yield of artichoke green sprouts

Data presented in Table 1 revealed that the highest values of shoot length, average sprout weight, yield per m^2 and yield per one gram of artichoke seeds were obtained by using soil + vermiculite + 10%

compost medium followed by rice straw medium, while the lowest sprout yield was observed when kitchen paper towel was used. The superiority of adding compost to clay + vermiculate medium may be attributed to that compost is rich in organic amendment and provides essential elements for the medium. Similar results were obtained by Anwar (2009), Abdallah *et al.* (2009) and Ibrahim (2010), who recorded the highest values of shoot length, average sprout weight, yield per m^2 and yield per one gram of sunflower seeds on soil + vermiculite + 10% compost medium. Contra resulted were reported by El-Sayed (2012), who recorded a higher sprouts of big seed crops (Faba beans and cow peas) on rice straw medium as compared with soil + vermiculite + 10% compost medium, and attributed this influence due to the role of rice straw in saving aeration and moisture around the sprout roots.

On the other hand there were no significant differences among different media concerning sprout diameter.

Sprouts produced on kitchen paper towel contained the highest chlorophyll reading, followed by those produced on soil + vermiculite + 10% compost medium. On the contrary, the lowest chlorophyll reading was recorded when seeds were sown on rice straw medium in first season. On the other hand there were insignificant among different media concerning chlorophyll reading in second season.

Table 1. The effect of different culture media on vegetative characters, chlorophyll content and yield of artichoke green sprouts

Medium	Sprout length (cm)	Sprout Weight (mg)	Sprout diameter (mm)	Chlorophyll reading (Spad)	Sprout yield g/g of seeds	Sprout yield kg/m^2
			First season			
Soil + vermiculite + 10 % compost	7.90 a	1.11 a	0.70 a	30.04 ab	7.45 a	117.657 a
Rice straw	6.60 b	1.00 b	0.70 a	25.66 b	6.17 b	97.458 b
Kitchen paper towel	3.47 c	0.86 c	0.70 a	33.55 a	2.55 c	40.190 c
			Second season			
Soil + vermiculite + 10 % compost	4.36 a	1.87 a	0.90 a	29 a	6.62 a	104.521 a
Rice straw	3.79 b	1.73 ab	0.90 a	27.32 a	5.23 b	82.558 b
Kitchen paper towel	3.24 c	1.51 b	0.90 a	30.68 a	4.4 c	69.53 c

Values within the column in each crop followed by the same letter (s) are not statistically different; at the 0.05 level (LSD test)

2. The effect of different media on nutritional value of artichoke green sprouts as compared with artichoke heads

Effect of sprouting on proximate analysis on dry weight basis

Fiber content

As shown in Table 2, on dry weight basis, fiber percentage sprouting of artichoke was significantly lower than determined in artichoke heads (Table2). Sprouts produced on rice straw, paper tissue and soil mixture showed 19.6% , 8.9 % and 6.9 % decrease in fiber content as compared with heads, in the first season, and 15.9%, 11.1% and 14.8%, in the second season, respectively. According to the results of Foti *et al.* (1999) found that artichoke seeds contain 18.5% crude fiber (dry weight basis), while the average fiber contents of sprouts in the present study, regardless culture media and year, was 5 % (dry weight basis). These results showed seed sprouting causes a decrease in fiber content. Similarly, Abdallah *et al.* (2009) found that fiber was decreased as result of sprouting of sun flower seeds. On the other hand, the content of total dietary fiber in the artichoke crown in the present study ranged from 5.16 to 6.3 g/100 g. The investigation of Dosi *et al.* (2013) recorded a similar range for the artichoke crown content of total dietary fiber.

Table 2. Effect of growing media on proximate analysis of artichoke sprouts, comparing with artichoke heads

Nutrient (%)	Value (g) per 100g of dry weight				Value (g) per 100g of edible portion			
	Heads	Sprouts			Heads	Sprouts		
		Soil Mixture	Rice Straw	Paper Tissue		Soil Mixture	Rice Straw	Paper Tissue
				First season				
Moisture	8.46 a	8.86 a	9.85 a	5.25 b	82.07 b	94.4 a	96.36 a	94.58 a
Fibers	5.16 a	4.82 b	4.15 c	4.70 b	1.01a	0.30 b	0.17 b	0.27 b
Protein	11.02 c	19.69 b	22.32 ab	23.82 a	2.13 a	1.19 b	0.88 b	1.39 b
Total lipid	1.3 b	1.2 b	3.0 a	2.75 a	0.25 a	0.07 b	0.12 b	0.16 b
Carbohydrates	66.46 a	58.53 b	54.08 b	58.18 b	12.85 a	3.53 b	2.12 b	3.40 b
Ash	7.6 a	6.9 b	6.6 b	5.3 c	1.47 a	0.42 b	0.26 b	0.31 b
				Second season				
Moisture	8.18 a	8.11a	7.27 ab	6.25 b	74.93 b	93.90 a	94.97 a	92.28 a
Fiber	6.3 a	5.4 c	5.3 c	5.60 b	1.72 a	0.36 b	0.29 b	0.46 b
Protein	10.42 c	21.91 b	21.88 b	25.11 a	2.85 a	1.45 b	1.19b	2.09 ab
Total lipid	1.3 b	1.7 b	2.75 a	1.95 ab	0.35 a	0.11 b	0.15 b	0.16 b
Carbohydrates	67.5 a	57.38 b	57.6 b	56.10 b	18.43 a	3.81b	3.12 b	4.67 b
Ash	6.3 a	5.5 b	5.2 b	5.0 b	1.72 a	0.37 b	0.28 b	0.42 b

Values within the row in each crop followed by the same letter (s) are not statistically different; at the 0.05 level (LSD test).

Crude protein content

Data presented in Table 2 clearly indicated that, protein contents were significantly higher in sprouts (on dry weight basis) as compared with heads. Moreover, sprouting on paper tissues resulted in significant increase in protein as compared to sprouting on soil mixture in both seasons and rice straw in the second season (Table 2). According the results of Foti *et al.* (1999) and Ben

Salem *et al*. (2017), artichoke sprouts contained higher content of protein as compared with that determined in seeds and leaves, respectively. Similar results were recorded by Abdallah *et al.* (2009) who reported that that on dry weight basis, the protein content of sun flower sprouts was higher than that of the seeds.

According to Abdallah (2008), the higher protein content in the sprouts than seeds on a dry weight basis was considered to be related to the differences in the % dry matter content for sprouts compared with hulled seeds .

Lipid content

Table 2 shows that artichoke green sprouts produced on rice straw presented significantly increase in total lipid as compared to heads, on the dry weight basis. Sprouts produced on soil mixture showed the lowest lipids value, while those produced on rice straw showed the highest lipids content with significant differences between them in both seasons. The average head contents of heads is in agreement with that reported by of Petropoulos *et al. (*2017). However, the same authors revealed that artichoke heads content of fats depends on artichoke cultivar. According to the results of Foti *et al.,* (1999), who determined crude oil in artichoke seeds, sprouting cause a sharp decrease in the lipids content. Similar changes in nutrient profile were observed by El-Sayed (2012) when she compared sprouts with seeds of legumes. The reduction in the total lipid in sprouts, comparing with seeds reflects the extent to which these energy reserves are utilized by the developing seedling (Mubarak, 2005).

Carbohydrate content

Concerning carbohydrates, sprouting of artichoke sprouts contaied significantly lower carbohydrates than that detected in artichoke heads. On the other hand, no significant differences in carbohydrates content was detected among sprouts produced on the diffecent media. (Table 2). The analysis of Petropoulos *et al.* (2017) revealed a higher values of carbohdrates in artichoke heads than that deteremined in artichoke heads in the present study, which might be attributed to using different cultivar. Generally the decrement in articoke sprouts than heads may be a result of breakdown of the complex charbohydrates occurs during germination of seeds to simple sugars. This may be due to the utilization of carbohydrates as a source of energy to start germination (Mubarak, 2005). Similar results were reported by El-Sayed (2012) who indicated that green sprouts of cowpea had significantly lower content of carbohydrates than seeds.

Ash content

Ash content in green sprouts of artichoke significantly decreased, as compared with artichoke heads (Table 2) but higher than determined by Foti *et al.* (1999) in artichoke dry seed. Similarly, Ibrahim (2010) and El-Sayed (2012) reported that sprouting caused significantly increase in ash content of green sprout of sunflower and cowpea, respectively, as compared with dry seeds. Artichoke head content of ash was similar to that determined by Petropoulos et *al.* (2017).

Effect of sprouting on proximate analysis on fresh weight basis

Table 2 shows the proximate analysis of artichoke heads and sprouts produced on different media. It was clear that 100 grams of fresh edible artichoke heads had higher contents of fibers, protein, lipids, carbohydrates and ash than artichoke sprouts. These results were attributed to the higher contents of moisture in artichoke sprouts as compared with artichoke heads.

Effect of sprouting on dry matter and sugars content

Data concerning effect of effect of sprouting on dry matter and sugars content are presented in Table 3.

Table 3. Effect of growing media on dry matter and sugars content (%) of artichoke sprouts, comparing with artichoke heads

Sugar (%)	Heads	Sprouts		
		Soil Mixture	Rice Straw	Paper Tissue
First season				
Dry matter	17.93 a	5.60 b	3.64 c	5.42 b
Total sugars	13.65 b	13.92 b	16.07 ab	20.83 a
Inulin	3.42 c	4.79 b	6.56 a	5.64 ab
Second season				
Dry matter	25.07 a	6.10 c	5.03 d	7.72 b
Total sugars	12.7 b	13.38 b	15.78 b	23.67 a
Inulin	3.34 c	4.66 b	6.22 a	6.03 a

Values within the row in each crop followed by the same letter (s) are not statistically different; at the 0.05 level (LSD test).

Effect of sprouting on dry matter percentage

There were significant differences between artichoke heads and artichoke sprouts in dry matter percentage. Artichoke heads contained the highest dry matter percentage, followed by those produced on soil + vermiculite + 10% compost medium. On the contrary, the lowest dry matter percentage was recorded when seeds were sown on rice straw medium. The differences among the three media in this regard were significant. A similar dry matter value in artichoke inflorescences (heads), was revealed by Lutz *et al.* (2011). Dry matter percentage artichoke sprouts was to similar that reported by Abdallah *et al.* (2009) in sunflower sprouts but lower than that define by El-Sayed (2012) in the green sprouts of Faba bean, pea and cowpea.

Effect of sprouting on total sugars

As shown in Table 3 there were significant differences between head and green sprouts of artichoke in the total sugars content, where sprouts contained significantly higher percentage of sugars, as compared with artichoke heart on a dry weight basis. On the other hand, sprouts produced on paper tissues contained the highest percentage of sugars. Sharaf-Eldin (2002) determined total sugars in artichoke heads and found that they depend on harvesting date of the head. The increase of total sugars in sprouts as compared to heads may be attributed to the utilization of carbohydrates to sugars as a source of energy to start germination (Mubarak, 2005).

Effect of sprouting on inulin

As shown in Table 3 there were significant differences between head and green sprouts of artichoke in inulin content, where sprouts contained significantly higher percentage of inulin, as compared with artichoke heads on the dry weight basis. On the other hand, sprouts produced on rice straw contained the highest percentage of Inulin. Sharaf-Eldin (2002) found that inulin concentration in artichoke heads greatly affected by harvesting date of the head. The results of Sharaf-Eldin (2002), who found that inulin content was higher in artichoke leaves than in the edible part (head), are in accordance with the present results which revealed that sprouts contained higher percentage of inulin than artichoke heads. The results revealed the importance of sprouts of a source of inulin, where inulin has beneficial effects on mineral absorption, blood lipid composition and prevention of colon cancer. In addition, inulin is classified as a low calorie food ingredient as it contains less than half amount of calorie content of digestible carbohydrates (Kaur and Gupta, 2002) Therefore, it can be used in the production of fat-reduced foods (Lattanzio *et al*., 2009) and it can be used as a suitable food ingredient substitute to lower the total calorie content of daily diet especially for obese people (Miremadi and Shah, 2012) and recommended for patients suffering from diabetes mellitus (Pandino *et al*., 2011b)

Effect of sprouting on minerals content

Effect of sprouting on mineral content on dry weight basis

The results of mineral content of sprout and inflorescences of artichoke are summarized in Table 4. On dry weight basis, generally artichoke sprouts showed significantly higher value of Ca as compared with inflorescences. Petropoulos *et al.* (2017) determined Ca in artichoke heads and found it strongly affected by artichoke genotype. Furthermore, the highest Ca value was recorded in sprouts produced in rice straw, followed by soil mixture medium and finally paper tissue. Calcium is a constituent of bones and teeth. Besides, it regulates the nerve and muscle function and activates many enzymes (such as succinic dehydrogenase, adenosine triphosphatase, and lipase). Low calcium in extracellular blood increases the irritability of nerve tissue, while calcium deficiency in children causes convulsions, osteomalacia and osteoporosis (Murray *et al*., 2000).

Table 4. Effect of growing media on mineral content (mg /100g) of artichoke sprouts, comparing with artichoke heads

Nutrient (%)	Value (mg) per 100g of dry weight				Value (mg) per 100g of edible portion			
	Heads	Sprouts			Heads	Sprouts		
		Soil Mixture	Rice Straw	Paper Tissue		Soil Mixture	Rice Straw	Paper Tissue
First season								
Calcium (Ca)	740 c	2340 ab	2630 a	1750 b	132.68	131.04	95.73	94.85
Sodium (Na)	130 b	240 a	160 b	220 a	23.31	13.44	5.82	11.92
Potassium (K)	2727 a	1010 b	1017 b	1163 b	488.95	56.56	37.02	63.03
Phosphorus (P)	510 b	780 a	660 ab	610 ab	91.44	43.68	24.02	33.06
Second season								
Calcium (Ca)	710 c	2340 a	2630 a	1650 b	178.00	142.74	132.29	127.38
Sodium (Na)	110 d	240 a	160 c	220 b	27.58	14.64	8.05	16.98
Potassium (K)	2727 a	980 b	1040 b	1293 b	683.66	59.78	52.31	99.82
Phosphorus (P)	550 b	770 a	680 ab	520 b	137.89	46.97	34.20	40.14

Values within the row in each crop followed by the same letter (s) are not statistically different; at the 0.05 level (LSD test).

Similarly, sprouts showed a noticeable increase in sodium and phosphorus over the heads. However, the highest values of these two elements were detected in sprouts produced on soil mixture, followed by those produced on paper tissue for sodium and rice straw for phosphorus. The increase in the phosphorus content due to germination can be explained by increase in phytase activity during germination (Tabekhia and Luh, 1980). Phytase breaks down phytic acid phosphorus and thus increases the phosphorus level (Akinlosotu and Akinyele 1991). On the other hand, this increase of Na could be come from the tap water used for watering seeds during germination (Bau *et al*., 1997).

It was reported that phosphorus is a constituent of bones, teeth. In addition it the main component of adenosine triphosphate (ATP), phosphorylated metabolic intermediates and nucleic acids. Therefore, it is vitally concerned with many metabolic processes and synthesis of phospholipids and phosphoproteins (Murray *et al*., 2000). On the other hand, sodium is the principal cation in extracellular fluids; therefore, it regulates osmotic pressure of the body fluids, plasma volume and acid-base balance, and involves in absorption of monosaccharides, amino acids and bile salts. In addition, it preserves normal irritability of cell permeability and controls muscle and transmission of nerve impulses (Murray *et al*., 2000).

On the contrary, artichoke sprouts revealed significant decrease in potassium content as compared with artichoke heads. The decrease observed in potassium may be due to utilization by the growing shoot or leaching into water during germination (Akinlosotu and Akinyele 1991).

Potassium is the principal cation in intracellular fluid. Potassium deficiency causes structural abnormalities (including in skeleton and cardiac muscle) in addition to the paralysis and the mental confusion (Murray *et al.,* 2000)

Effect of sprouting on minerals content on fresh weight basis

Table 4 shows that 100 grams of fresh edible artichoke heads had higher contents of minerals than artichoke sprouts. These results were attributed to the higher contents of moisture in artichoke sprouts as compared with artichoke heads.

Effect of sprouting on vitamins and medical compounds

The Effect of sprouting on vitamins and medical compounds is shown in Table 5.

Effect of sprouting on vitamins

Vitamin C concentration in artichoke head was extremely higher than that noted in green sprouts of artichoke. Although Vitamin C was extremely low in artichoke sprouts, as compared with artichoke heads, it was in the range of that found in different sprouts, such as sunflower sprouts (Abdallah *et al.,* 2009). On the other hand, vitamin C concentration in artichoke heads was higher than the determination of Gil-Izquierdo *et al.* (2001), Similarly, Vitamin A concentration in artichoke heads was significantly higher than recorded in artichoke sprouts. According to the previous studies, it was generally found that sprouting process increased vitamin A and C. These results agree with those reported by Anwar (2009) and Abdalla *et al.* (2009) who recorded increase in the conents of sun flower sprouts of ascorbic acid content (vit. C) and vitamin A as compared with seeds.

Vitamin C has been associated in human health with reduction of incidence of cancer, blood pressure, immunity, and drug metabolism and urinary hydroxyproline excretion, tissue regeneration (Walingo, 2005).

Effect of sprouting on anti-oxidant and total phenols:

Sprouts on paper tissue showed marked increases in anti-oxidant as compared with artichoke heads, whereas soil mixture showed a reverse trend. In this respect, sprouts produced on soil mixture contained significantly a lower anti-oxidant as compared with artichoke heads (Table 5). On the other hand, there were no significant differences in the anti-oxidant contents between sprouts produced on rice straw and artichoke heads. Cevallos-Casals and Cisneros-Zevallos (2009) and El-Sayed (2012) found that antioxidant activity was increased as a result of germination of brassica and legume crops, respectively. Antioxidants may be effective in the prevention and/or treatment of diseases when the right antioxidant is given to the right subject at the right time for the right duration (Kurutas, 2016).

Table 5. Effect of growing media on vitamins and medical compounds in of artichoke sprouts, comparing with artichoke heads

Treatments	Vitamin A (mg/g FW)	Vitamin C (mg/g FW)	Anti-Oxidants (% FW)	Total Phenols (mg/100 g DW	Chlorogenic acid (mg/100 g DW)	Cynarin (mg/100 g DW)
			First season			
Heads	3.24 a	18.10 a	26.67 b	4209 a	1046 a	292 a
Soil Mixture Sprouts	2.68 ab	1.23 b	22.33 c	2535 b	355 b	136 a
Rice Straw Sprouts	1.97 b	0.53 b	25.67 b	2565 b	377 b	95 a
Paper Tissue Sprouts	2.50 ab	2.47 b	30.00 a	2510 b	356 b	123 a
			Second season			
Heads	3.17 a	16.85 a	25.67 b	3600 a	1029 a	240 a
Soil Mixture Sprouts	2.60 b	0.89 b	19.5 c	1502 b	246 b	86 b
Rice Straw Sprouts	2.20 b	0.53 b	23.33 b	1592 b	235 b	75 b
Paper Tissue Sprouts	2.48 b	2.98 b	29.63 a	1510 b	225 b	85 b

Values within the row in each crop followed by the same letter (s) are not statistically different; at the 0.05 level (LSD test).

There was a noticeable increase in total phenols in artichoke heads, as compared to sprouts. On the other hand, no significant differences were registered in total phenols in sprouts among the different production media. The concentration of total phenols in artichoke heads was more4 times than in sprouts. When Abdel Magied *et al.* (2016) determined total phenols in two artichoke cultivars (Green Globe and Violet) and found their concentrations in the artichoke leaves markedly greater than those determined in heads. However, the concentration of total phenols in the study of Abdel Magied *et al.* (2016) was higher than found in the present study, which was conducted on the local (Balady) cultivar. Such differences in the concentrations between the two studies revealed the importance of cultivars effect. According to Lombardo *et al.* (2010), the qualitative and quantitative variability of the phenolic complement in artichoke flower heads of different varieties depends on their genetic diversity, as well as on their physiological stage of development (harvest time) and on climatic conditions during plant growth .

The previous studies revealed that total phenols were increased as a result of sprouting process in fenugreek and mustard (Anwar, 2009) and faba bean (El-Sayed, 2012).

Similarly, the concentrations of chlorogenic acid and cynarin were in heads significantly higher than in sprouts. Meanwhile, no significant differences were detected in the concentrations of chlorogenic acid and cynarin among the different media that used for sprouts production. Shen *et al.* (2010) reported that, the three compounds; Chlorogenic acid, Cynarin and 1,5-di-o-Caffeoylquinic acid are the major active compounds in artichoke, they are considered to be responsible for their antiatherogenic action. The concentration of cynarin and chlorogenic acid in heads was more 2 and 3 times, respectively, than that located (Table 5). Sharaf-Eldin (2002) determined chlorogenic acid and cynarin in artichoke heads and found that their concentration depended on harvesting date of the head. Recently, Abdel Magied *et al.* (2016) reported that chlorogenic acid and cynarin in artichoke heads depended on cultivar.

The higher concentration of total phenols in leaves, as compared to artichoke heads may be due to subjecting artichoke plants the environmental stress, which lead the plants to increase the concentrations of phenols in the leaves. Colla *et al*. (2013) came to similar results who reported that increased salinity in the nutrient solution increased the leaf content of total polyphenols, chlorogenic acid, cynarin and luteolin. The decrease of total phenols, chlorogenic acid and cynarin in the sprouts may be due to the ideal conditions prevailing during seed germination of artichoke. As was reported by Fukumoto and Mazza (2000) caffeoylquinic acids have potential health benefits in the context of inhibiting the development of cancers, exacerbated by the presence of reactive oxygen specie

Effect of sprouting on amino acids:

Data in Table 6 showed that arginine was not detected in heads, while proline amino acid was not found in sprouts. The absence of proline in sprouts may be attributed to synthesis of proline under stress, and sprouts are produced under the optimum conditions. Sprouting on paper tissue led to significant increases, over the artichoke heads, in all amino acids, except lysine. Also, as compared with heads, sprouts produced on rice straw contained higher concentrations of all amino acids, except aspartic, valine, tyrosine and lysine. On the other hand, sprouting on soil mixture resulted in an increase only in threonine, glutamic, glycine, phenylalanine and histidine, over heads. The present results are in agreement with these reported by Sibian *et al.* (2017) who found the essential amino acids such as lysine, methionine, leucine, isoleucine, threonine, Isoleucine, phenylalanine and valine and the non-essential ones, which include serine, proline, aspartic acid, alanine and glycine had shown a significant increase during germination; however, the increments in the studied grains were different. Aragao *et al.* (2015) recorded significant differences in the concentrations of each amino acid throughout the days of seed imbibition of *Cedrela fissilis* . The changes in amino acids pattern might be provided these amino acids by the mobilization of stored proteins in mature seeds.

Table 6. Effect of growing media on amino acids (%) of artichoke sprouts, comparing with artichoke heads

Amino acids	Sprout			
	Heads	Soil mixture	Rice Straw	Paper Tissue
Aspartic	3.21 ab	1.72 b	2.53 b	5.06 a
Threonine	0.24 c	0.30 c	0.66 b	1.12 a
Serine	0.62 b	0.52 b	0.86 ab	1.37 a
Glutamic	1.12 b	1.47 b	2.20 A	5.01 a
Proline	0.09	-	-	-
Glycine	0.96 b	1.71 b	2.46 b	4.19 a
Alanine	0.99 b	0.95 b	1.72 ab	3.20 a
Valine	0.69 b	0.40 b	0.67 b	1.30 a
Isoleucine	0.36 bc	0.13 c	0.51 b	0.76 a
Leucine	0.84 b	0.76 b	1.46 ab	2.17 a
Tyrosine	0.60 ab	0.20 b	0.48 b	1.19 a
Phenylalanine	0.48 c	1.44 bc	1.84 ab	2.76 a
Histidine	0.49 b	0.55 b	0.81 b	1.28 a
Lysine	89.33 a	88.12 a	82.15 a	68.35 b
Arginine		1.75 b	1.65 b	2.27a

Values within the row in each crop followed by the same letter (s) are not statistically different; at the 0.05 level (LSD test).

Isoleucine, leucine and valine are often referred to as the "stress" amino acids because they play important roles in energy metabolism and the body's response to stress. In certain conditions, such as severe infection or liver disease, the ability of the liver to convert the essential amino acid phenylalanine to tyrosine is impaired and both amino acids play important roles in the metabolism of hormones and neurotransmitters. (Zimmermann, 2001). During some cases, such as rapid growth (in pregnancy, infancy, and childhood), stress, strenuous physical exercise, surgery and chronic illness arginine requirements became very high (Zimmermann, 2001). According to the present study, it is recommended to consume sprouts produced on paper tissue instead of heads, because those sprouts contained more amounts of all amino acids, and especially the essential amino acids, than artichoke heads.

Effect of sprouting on Fatty acids:

Fatty acids in heads and green sprouts of artichoke are presented in (Table 10). Sprouting changed the composition of fatty acids. In this respect, some fatty acids, such as oleic (ω9), linoleic (ω6), linolenic (ω3), paullinic, eicosadienoic acid, methyl ester and behenic were found in sprouts, while they were not detected in heads. Conversely, Artichoke heads had pentadecylic acid, while sprouts did not contain this fatty acid. On the other hand, the unsaturated fatty acids: Linoleic (ω6), Linolenic (ω3), were found in the sprouts produced on soil mixture and rice straw, but they were not found in sprouts produced on paper tissue. The unsaturated fatty acids, linoleic (ω6) and linolenic (ω3) acids are the two essential fatty acids for humans, because mammalian cells lack the enzymes necessary for their synthesis. Therefore, these two polyunsaturated fats (18:2 and 18:3, respectively) must be obtained from dietary sources. Omega-3 fatty acid (linolenic) is beneficial in the prevention and treatment of atherosclerosis, lower levels of triglycrides, while increasing HDL cholesterol and can lower blood pressure in case of hypertension (Zimmermann, 2001). Therefore, consumption of artichoke sprouts, produced on soil mixture and rice straw, is more beneficial than artichoke heads.

Table 7. Effect of growing media on fatty acid (%) of artichoke sprouts, comparing with artichoke heads

Fatty acid	Heads	Sprouts		
		Soil mixture	Rice straw	Paper Tissue
Pentadecylic (C15:0)	46.56			
Palmitic (C16:0)	19.22	38.5	14.87	10.71
Stearic (C18:0)	34.23	20.09	21.34	8.4
Oleic (c18:1 ω9)		11.72	17.77	17.3
Linoleic (c18:2 ω6)		15.93	24.71	
Linolenic (c18:3 ω3)		4.07	11.43	
Arachideic (c 20:0)				
Paullinic (C20:1)		3.36	2.88	16.97
Eicosadienoic acid, methyl ester (C20:2)			0.7	26.53
Behenic (C22:0)	-	-	3.81	

The fatty acid: eicosadienoic acid, methyl ester is found in the sprouts produced on rice straw and paper tissue but not found in the sprouts produced on soil mixture. Furthermore, behenic acid was detected only in sprouts produced on rice straw. Heads, sprouts of soil mixture, rice straw and paper tissue contained the highest concentration of pentadecylic, palmitic, linoleic (ω6) and eicosadienoic acid, methyl ester, respectively. Petropoulos *et al.(*2017) detected twenty fatty acids in the heads of 8 artichoke genotypes being the most abundant palmitic acid and linolenic acid (on average 42.9 and 29.63%, respectively), followed by other saturated and unsaturated acids such as oleic, stearic, a-linolenic, arachidic, caproic, capric, myristic, behenic and lignoceric acids. According to Simopoulos (2004) the consumption of vegetables that contain low n-6/n-3 fatty acids (ratio of omega 6/omega 3 fatty acids) is highly associated with the reduction of risk of development of various chronic diseases, such coronary heart disease in men and vitamin E deficiency.

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تأثير بعض البيئات على الانتاج والقيم الغذائية لنبت الخرشوف

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لأن نبوت البذور تعتبر مصدرا ممتازا للأحماض الأمينية والإنزيمات والمعادن والفيتو كيمكال والفيتامينات التي تعتبر أكثر المركبات فائدة لصحة الإنسان ، هدفت هذه الدراسة إلى دراسة تأثير ثلاث بيئات للإنبات [(خليط تربة يتكون من التربة + الفيرميكوليت + 10٪ كمبوست) ، قش الأرز ، ومناديل المطبخ الورقية] على الإنتاج والقيمة الغذائية لنبوت بذور الخرشوف مقارنة مع رؤوس الخرشوف. اظهرت النتائج انه تم إنتاج أعلى إنتاجية للنبوت على خليط التربة. من ناحية أخرى ، استنادا إلى الوزن الجاف ، فإن المقارنة بين النبوت المنتجة على البيئات المختلفة، اظهرت أن النبوت المنتجة على ومناديل المطبخ الورقية قد اعطت أعلى قيم غذائية. وفي الوقت نفسه ، أظهرت النبوت المنتجة على مناديل المطبخ الورقية قيم أعلى من البروتين ، الدهون الكلية ، الأنولين ، السكريات الكلية ، الكالسيوم ، الصوديوم ، الفوسفور ، مضادات الأكسدة ، الأحماض الأمينية الأساسية (مثل الليوسين ، الأيسولوسين ، الثريونين ، فينيل ألانين ، فالين) عن تلك المقدرة في رؤوس الخرشوف. على العكس فلقد وجد ان رؤوس الخرشوف بها محتويات أعلى من الألياف ، والكربوهيدرات ، والفوسفور ، وفيتامين أ ، وفيتامين ج ، والفينولات الكلية ، وحامض الكلوروجينيك ، والسينارين ، والحمض الأميني الأساسي الأسبارتين من جميع النبوت المنتجة. ولقد احتوت النبوت المنتجة على خليط التربة وقش الأرزعلى الأحماض الدهنية الأساسية (حمض اللينوليك وحمض اللينولينيك) ، بينما لم توجد هذه الاحماض الدهنية في رؤوس الخرشوف والنبوت المنتج على مناديل المطبخ الورقية. ووفقا للنتائج الحالية ، فانه يوصى بجمع بذور الخرشوف ، قبل انتشاراها في التربة في نهاية الموسم ، للأستفادة منها في إنتاج نبوت طوال العام كمصدر للغذاء الصحي وللحماية من الأمراض الخطيرة المختلفة .