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Utilization of chicory plant for supplementing some products

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ABSTRACT

The purpose of this study is to investigate the possibility to utilize and benefit from the chicory plant (Alseres - Aljedeid,) for supplementing some foods by leaves and roots. This plant containing high nutritional value. Chemical composition and mineral elements were evaluated in both leaves and roots. Sugars, phenolic, flavonoid compounds, vitamins A, D, E, K and B complex group were identified by HPLC and sensory evaluation of supplemented products with chicory. The results of the chemical analysis showed high levels of ash, proteins and fiber in the leaves of the chicory plant if compared to the roots. Both leaves and roots contained high and nearest ratios of the mineral elements. The drying process resulted in a slight decrease in the chemical structure and a significant increase in antioxidant activity. The sugars were identified in both fresh and dry leaves and roots. The percentages of inulin in fresh roots and leaves were 31.01 and 13.84 %, respectively, after drying, they decreased to 29.02 and 9.94 %, respectively. The phenolic compounds and flavonoids revealed that e-vanillic, catechol and salicylic had the highest percentages of phenols in fresh chicory leaves, while p-coumaric acid, caffeic acid, p-oh-benzoic acid, chlorogenic acid, epicatechin and pyrogallol gave the highest percentage in fresh roots, and rosmarinus, acacetin, hispretin, hesperidin and rutin were the highest flavonoids in fresh leaves, while the roots contained high levels of quercetin, hesperidin and rutin, after the process of drying some of those components increased .Concerning vitamins B complex group, data showed that both leaves and roots of chicory plant contain a high proportion of vitamin B12 which decreased after drying. The leaves and roots also contained different percentages of vitamin A, D, E and a high percentage of vitamin K (49.02 and 55.88 mg 100 g) respectively, all vitamins decreased after drying. Sensory evaluation showed that the panelists accepted the processed Tamia supplemented with the powder of the chicory leaves by 1 and 3%. The sample with 5% Chicory powder obtained the lowest palatability rate compared to the other samples. Also supplementing the dough of wheat flour with 1,3 and 5% of chicory leaves powder for producing natural crispy snacks showed a clear palatability among the panelists especially product N3 (natural crispy snacks with 5% chicory leaves powder).

Key words: Chicory plant, Chemical composition, Nutrient value, Antioxidants, Inulin, Phenols, Flavonoids, Sugars, vitamins.

Introduction

Chicory (*Cichorium intybus* L.) is known as “Succory”, “Hendibeh”or “Witloof” is a wild edible plant consumed in Lebanon, Arab countries and other parts of the world. Chicory can grow wild, in its natural habitat, in fields, road sides or home gardens, Chicory is of interest to food industry not only as a source of dietary fibers such as inulin and fructo-oligosaccharides but also as a functional food ingredient that affects in maintaining good health and in preventing disease. Roots and green leaves are the edible parts of the plant. Chicory can be eaten raw in green salads or in cooked dishes mainly mixed with lemon juice, olive oil, salt and fried onions (Bais and Ravishanker, 2001). Chicory is also known to have nutritional and medicinal properties, having micronutrients and macronutrients such as dietary fibers, organic acids and photochemical (Nandagopal and Ranjitha, 2007; Sánchez-Mata *et al.*, 2012).

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Chicory (common name) is known botanically as *cichorium intybus* L. is a bushy perennial herb in the Asteraceae family. Chicory can be consumed in several forms, such as leaves, flowers and roots. Leaves and flowers can be added to salads or vegetables but often have a rather bitter taste (Corey and Whitney, 1987). In Germany, it is usually sold as a constituent of mixtures with roasted barley malt. Baek and Cadwallader, (1998) mentioned that roasted chicory has been widely used in coffee blends, since many coffee drinkers prefer the distinct roasted chicory flavor. In addition, Desprez, *et al*., (1999) stated that industrial root chicory (var. sativum) was used exclusively for producing coffee like-beverage.

Jan *et al*., (2011) studied and determined the nutrient levels and chlorophyll contents of roots, leaves, and seeds (market) of *Cichorium intybus*. The nutritional analysis revealed that *Cichorium intybus* is rich in crude proteins, fats and carbohydrates. A significant difference in the crude protein, fats, crude fiber in all parts and seeds both wild and market. Also the elemental analysis for Ca, Mg, Na, K, Cu, Zn and Mn were analyzed in roots, leaves and seeds, the result showed that substantial amount of Ca, Mg, Na, K, Cu, Zn and Mn , were present with slight variation specific to each plant parts. Amount of chlorophyll although statistically insignificant was sensitive to the altitudinal and chronological variation numerically.

Shad *et al., (*2013) revealed that the biochemical, photochemical and antioxidant composition of roots, stems, leaves and seeds of *Cichorium intybus* L. were determined. A statistically significant difference (*p>0.05*) was recorded among different parts of *Cichorium intybus* regarding the biochemical, phytochemical and antioxidant composition. The leaves were found to possess comparatively higher values of total sugars, non-reducing sugars, water soluble proteins, total flavonoids, total phenolic acids and total antioxidants. The phytochemical screening confirmed the presence of tannins, saponins, flavonoids, terpenoids, cardiac glycosides and anthocyanins in each part of the plant. The leaf extract was found to show comparatively low value of IC50 for DPPH inhibition and high reducing power. Due to good biochemical, phytochemical and antioxidant composition, *Cichorium intybus* leaves would be valuable candidate in pharmaceutical formulations and play an important role in improving the human, livestock and poultry health by participating in the antioxidant defense system against endogenous free radicals.

All parts of Chicory (*Cichorium intybus*) possess great medicinal importance due to the presence of a number of medicinally important compounds such as alkaloids, inulin, sesquiterpene, lactones, coumarins, vitamins, chlorophyll pigments, unsaturated sterols, flavonoids,saponins and tannins (Molan *et al.*, 2003; Nandagopal and Ranjitha., 2007; Muthusamy *et al*., 2008; Atta *et al*., 2010)

Harringtoni *et al*. (2006) reported that the mineral content and nutritive value of both desired and less desired pasture components from an organic dairy farm were analyzed and compared. Minerals such as magnesium, manganese, copper, zinc, boron, cobalt and selenium were often significantly higher in species such as chicory, narrow-leaved dock (*Rumex obtusifolius*), Californian thistle (*Cirsium arvense*) and hairy buttercup (*Ranunculus sardous*) than the perennial ryegrass (*Lolium perenne*) and white clover (*Trifolium repens*) components of the sward.

Massoud *et al*., (2009) determined the chemical composition of chicory plant (leaves & roots) and tried to remove the bitter taste in roots, dried and grounded it and utilized of chicory roots in crackers and Nescafe .The obtained results revealed that chicory roots contained high concentration of total carbohydrates (89.41%) and inulin (44.69%), while chicory leaves had lower concentration of both (68.50 and 10.95% respectively). Leaves had higher content of minerals than that of the roots. In addition, It is a good source of minerals especially Fe. The results showed that total phenolic content of chicory leaves and roots, which were 26.4 and 20 mg/g of dry matter expressed as Gallic acid equivalent, respectively. The major phenolic compounds in the methanolic extract of roots and leaves were Caffeic acids coumaric and chlorogenic acids.

Roots of chicory (*Cichorium intybus L.*) were used for production of inulin and as ingredients in certain roasted products (Wilson *et al*., 2004; Geel *et al*., 2005 and Toneli *et al.,* 2007). Inulin (the major compound of chicory root) is a polymer of fructose with β (2 -1) glycosidic linkage. Hui *et al*., (2002) reported that inulin is used as a food ingredient for fat and sugar replacement as a low calorie-bulking agent and as a texturizing agent.

Lactones cause the bitter taste in chicory roots, which have shown to possess anti –inflammatory properties (Cavin *et al*., 2005 and Nandagopal and Ranjitha, 2007), it affects cholesterol uptake and prevent immune toxicity (Kim, 2000). Thus the aim of this study was to determine the biochemical

compositions and bioactive components of chicory plant (leaves and roots) and investigate the possibility of utilization of chicory leaves as functional foods in some products.

Materials and Methods

Materials

Chicory (*Cichorium intybus L*) plant used in this study was obtained from the city of Quisna, Minufiya Governorate.
All chemicals and reagents used in the present study were of analytical grade and purchased from El-Gomhouria Co. Chemicals used in HPLC methods were of HPLC grade and purchased from Sigma Co.

Method

Preparation of samples

Fresh Chicory (*Cichorium intybus L*) arrival to the pilot plant in the food technology research institute, Giza. It was immediately washed thoroughly with tap water then divided into fresh leaves and fresh roots as a control.

Dried Chicory samples

Fresh leaves and roots were dried in a hot air oven at 60^{o}C. Then grinded until dust, packed in polyethylene pouches then stored at ambient temperature for analysis.

Application of chicory leaves powder in some foods

A: Preparation of Tamia substituted with different ratio of chicory leaves powder

The powder of chicory leaves was used and substituted Tamia paste (local name) with 1 %, 3 % and 5 %. Tamia paste was prepared from the ingredients (peeled beans, Balls, Onion, Garlic, Coriander, Parsley, salt).

B: Preparation of natural crispy snacks substituted with different ratio of chicory leaves powder

The powder of chicory leaves was used and substituted natural crispy snacks dough (flour- salt- and water) with 1 %, 3 % and 5 %. The dough was prepared as the common way, and then use a rolling pin to roll one ball on a lightly floured surface until it became very thin (flakes). Use a knife to cut the dough into squares or a small cookie cutter to make shaper. Place the snacks close together on a parchment lined baking sheet. Bake at 180C for 10 to 12min.

Analytical Methods

Moisture, total soluble solids (TSS), ash, pH, total acidity, crude protein and crude fiber were determined according to the methods of AOAC (2010). Total free amino acids were determined by formal titration as recommended by Swain and Hills (1959). Chlorophyll A, B and total carotenoids were determined according to Wettestein, (1957). Antioxidant activity was determined by the method of Sheng and Silva, (2006).

Determination of minerals

Minerals (Ca, Mg, Fe and Zn) were measured using Perkin Elmer Atomic Absorption Spectrophotometer (Model 2380, Japan), on the other hand, Mn and K were determined using Flame Photometer (model PE P7, England) as described in the AOAC (2010).

Fractionation and identification of sugars and inulin by HPLC

The sugars of chicory plant (leaves and root) were fractionated and identified by HPLC (Hewllet Packared, series 1050) according to the method of (Chinnici *et al.,* 2005).

Fractionation and identification of phenolic and flavonoid compounds by HPLC

Fractionation and identification of phenolic compounds were carried out by HPLC according to the method described by Pascale *et al.* (1999), while flavonoid compounds fractionation and identification were carried out by HPLC according to the method described by Pirjo *et al*. (2000).

Determination of vitamins B complex group and vitamins A, D, E and K by HPLC

Vitamins B complex group were determined by HPLC according to the method of Papadoyannis *et al*. (1997). Vitamins E and A were determined by HPLC as described by Pyka and Sliwiok. (2001). Vitamin K was determined according to Tomas *et al.* (2007), and Vitamin D according to Gfimiz-Gracia *et al*. (2000).

Sensory evaluation

All the processed products were organoleptically tested for their color, taste, odor, texture and over palatability using a scale from 1 to 10 and the decisions were as Follows: excellent (10) ; Very good (8-9) ; Palatable (6-7) and non-palatable (0-5) according to (Larmond, 1970).

Statistical analysis:

The collected data were recorded as means and analyzed by(SAS) windows (ver.10.1.) using one-way (ANOVA) and Duncan comparisons were tested to signify differences between different samples. AP.Value < 0.05 was considered statistically significant. Data were expressed as means, according to (Snedecor and Cochran 1980).

Results and Discussion

Chemical composition of chicory plant (leaves and root) are shown in Table (1), It was found that fresh chicory leaves contain crude protein (15.38%), crude fiber (16.19%), total amino acids (8.33%) and ash content (10.71%). Chlorophyll A, B and total carotenoids of fresh chicory leaves recorded 12.11, 6.57 and 2.54 mg/100g, respectively, while fresh chicory roots contain total soluble solids (12.03%) and smaller amounts of crude protein, crude fiber, ash and total amino acids when compared with fresh leaves. Antioxidant activity was 18.7 and 38.03 for fresh leaves and roots, respectively. These results are similar to those obtained by Massoud *et al*. (2009) who found that crude protein, ash total carbohydrate, total soluble solids and crude fiber for fresh roots and leaves were 4.65-14.70%,4.25-10.91%,89.41-70.71%,11.06-7.80%and5.12-16.78%,respectively. After drying a slight decrease was observed in the chemical composition of leaves and roots except for antioxidant activity which increased to 45.5 and 83.5 respectively, phenolic acids appeared to be mainly responsible for the strong antioxidant activities, also the obtained data of (zarroug *et al*., 2016) supported by conclusions of others who attributed antioxidant activities to the presence of phenolic compounds in chicory roots. Murakami *et al*., (2004) and Buchner *et al*., (2006) reported that decreases in phenol content did not lead systematically to a decrease of the antioxidant activity, as the degradation products of phenolic compounds can also have an antioxidant activity sometimes higher than the initial phenolic compounds.

Mineral contents

Mineral contents of potassium (K) magnesium(Mg), calcium(Ca), manganese(Mn), iron(Fe) and zinc(Zn) of chicory leaves and roots (mg/100g on dry weight basis) are presented in Table (2). It

could be concluded that chicory plant is considered to be a good source of minerals ,the results in Table(2) revealed that potassium, magnesium and calcium are the predominant of minerals in fresh and dried chicory leaves and roots (230.00, 181.90 and 199.60 mg/100g) and (230.00, 180.50 and 199.40 mg/100g), respectively, while iron recorded the main values of minerals in fresh and dried leaves (8.44 and 8.39 mg/100g), respectively. On the other hand, chicory leaves and roots contained a low percentage of manganese and zinc. These results are converged with Massoud *et al*. (2009).

Table 1: Chemical composition in Chicory plant (leaves and roots) (On dry weight basis)

Constituents %	Fresh chicory		Dried chicory	
	Leaves	Roots	Leaves	Roots
Moisture	84.11	68.01	6.47	6.20
Crude protein	15.38	5.09	15.33	5.04
Crude fiber	16.19	4.98	16.13	4.88
Total amino acids	8.33	1.33	8.18	1.29
Ash	10.71	5.25	10.69	5.22
Total soluble solids (T.S.S)	6.52	12.03	6.01	11.96
pH value	6.33	6.50	6.24	6.37
total acidity (as citric acid)	1.53	1.49	1.63	1.68
Chlorophyll A (mg/100g)	12.11	-	4.713	-
Chlorophyll B (mg/100g)	6.57	-	1.276	-
Total carotenoids (mg/100g)	2.54	-	0.384	-
Antioxidant activity	18.7	38.03	45.5	83.5

Table 2: Minerals contents in Chicory plant (leaves and roots) (mg/100g on dry weight basis)

Minerals	Fresh chicory		Dried chicory	
	Leaves	Roots	Leaves	Roots
Potassium (K)	179.49	130.00	179.41	130.00
Magnesium (Mg)	121.10	181.90	120.80	180.50
Calcium (Ca)	139.60	199.60	139.30	199.40
Manganese (Mn)	0.901	0.433	0.901	0.431
Iron (Fe)	8.440	1.920	8.390	1.910
Zinc (Zn)	0.908	0.469	0.905	0.465

Fractionation and identification of sugars contents and inulin in chicory leaves and roots

The fractionation and identification of sugars content in fresh and dried chicory leaves and roots g/100g on dry weight are shown in Table (3). Twelve sugars were identified and quantified in fresh and dried chicory leaves and roots. The fresh leaves and roots contained similar concentration of identified sugars, which decreased after drying. The main carbohydrates of chicory leaves and roots were inulin which recorded 13.84 and 9.94 g/100g for fresh and dried leaves ,respectively ,on the other hand fresh and dried roots were characterized by their high concentrations of inulin (31.01 and 29.02 g/100g), respectively. Adamoli and Rigon (2001) reported that chicory roots contained 15 -20 % inulin, while Massoud *et al*. (2009) found that the inulin content of fresh roots and leaves was 44.69 and 10.95 % respectively. Also Zarroug *et al*. (2016) revealed that inulin content of different ultrasonic extraction treatments varied from 21.5 to 49.80 % for the roots.

Fractionation and identification of phenolic compounds in chicory leaves and roots by HPLC.

Identification of phenolic compound by HPLC in fresh and dried chicory leaves and roots mg/100g on dry weight basis are shown in Table (4). As seen in Table (4) E-vanillic acid was the major phenolic compounds in fresh chicory leaves(60.69 mg/100g)followed by catechol, salicylic acid, pyrogallol, epi-catechin and benzoic acid, respectively, while p-coumaric acid compound represented the major phenolic compound which amounted to78.22 mg/100g in chicory fresh roots followed by caffeic acid, P-OH-benzoic acid, chlorogenic acid, epi-catechin, Catechol, pyrogallol, e-vanillic acid, gallic acid, coumarin and ferulic acid, respectively. The obtained results are in

agreement with Innocenti *et al*. (2005), Massoud *et al*. (2009), and Zarroug *et al*. (2016); they reported the presence of some of the identified phenolic compounds in chicory plant. After drying in the leaves an increase was observed in e-vanillic (64.46 mg/100g),epi-catechin (5.42mg/100g) ,pyrogallol (4.05 mg/100g) and benzoic acid (3.62 mg/100g).On the other hand, a clear decrease was observed in most of phenolic compounds except ellagic acid and benzoic acid which raised to 1.81 and 4.81 mg/100g respectively. The decrease and increase in identified phenolic compounds may be due to the oxidation to quinine and non-enzymatic reactions (khames, 2004), while Capecka *et al.* (2005) explained that the total phenolic content obtained after drying process may be higher or lower based on the type of phenolic compounds present and their location in the cell of fruit.

Table 3: Fractionation and identification of sugars contents by HPLC in fresh and dried chicory leaves and roots (g/100g on dry weight basis)

Sugar compounds	Fresh Chicory		Dried Chicory	
	Leaves	Roots	Leaves	Roots
Glucuronic	0.315	0.032	0.297	0.031
Stackhouse	0.239	0.073	0.208	0.069
Galacturonic	0.164	0.013	0.151	0.011
Sucrose	0.019	0.005	0.015	0.004
Glucose	0.699	0.595	0.622	0.421
Xylose	0.346	0.321	0.322	0.317
Galactose	0.143	0.131	0.136	0.109
Mannose	0.019	0.501	0.016	0.496
Arabinose	0.843	2.102	0.339	2.006
Mannitol	0.006	0.003	0.005	0.003
Sorbitol	0.006	0.013	0.006	0.011
Inulin	13.84	31.01	9.94	29.02

Table 4: Table 4: Fractionation and identification of phenolic compound by HPLC in fresh and dried chicory leaves and roots (mg/100g on dry weight basis)

Phenolic compounds	Fresh chicory		Dried chicory	
	Leaves	Roots	Leaves	Roots
Gallic acid	0.88	6.13	0.32	2.50
Pyrogallol	3.94	16.66	4.05	9.47
4-Amino benzoic acid	0.12	0.28	0.16	0.12
Protocatchuic acid	2.43	5.53	-	4.87
Catechin	0.36	0.09	-	0.20
Chlorogenic acid	0.56	33.91	1.13	23.22
Chatechol	9.89	18.84	0.51	5.48
Epi-catechin	3.59	29.06	5.42	20.08
Caffeine	0.40	6.00	1.14	3.49
P-OH-benzoic acid	0.43	35.13	1.03	3.73
Caffeic acid	0.54	76.13	0.33	14.46
Vanillic acid	2.75	0.12	1.69	0.10
P-Coumaric acid	0.32	78.22	0.31	-
Ferulic acid	1.33	4.94	1.02	3.29
Iso-Ferulic acid	0.54	2.84	0.52	1.84
Ellagic acid	1.01	0.18	1.36	1.81
E-Vanillic acid	60.69	6.16	60.06	5.79
Alpha-Coumaric acid	0.16	0.03	0.11	-
Benzoic acid	2.65	2.97	3.62	4.81
Cinnamic acid	0.44	1.67	0.32	1.06
Coumarin	1.22	6.09	1.02	2.32
Salicylic acid	8.77	3.06	3.57	1.25

Fractionation and identification of flavonoid compounds in chicory leaves and roots by HPLC.

Fractionation and identification of flavonoid compounds in chicory leaves and roots by HPLC are presented in Table (5). It could be observed that naringin, routine, hesperidin, rosmarinic, quercitrin, quercetin, hispertin, kaempferol, rhamnetin, apigenin and acacetin were the major identified flavonoid compounds. Data in Table (5) revealed that rosmarinic represented the major flavonoid compound which amounted to 26.44 mg/100g of total flavonoids in fresh chicory leaves followed by acacetin, hispertin, quercetin, hesperidin, quercitrin and routine. The quercetin represented the major flavonoid compound which was 28.44 mg/100g of total flavonoids in fresh chicory roots ,also hesperidin ,routine , rhamnetin, quercitrin, and rosmariminc were detected .Dried fresh chicory leaves caused increase in the concentration of some flavonoids such as hesperidin (5.85 mg/100g), rosmarinic (29.75 mg/100g), quercetin (9.04 mg/100g) while a reduction was observed in the other flavonoids, its for dried roots, hesperidin, rosmarinic and quercitrin increased to 29.11, 6.36 and 3.09 mg/100g, respectively, for dried roots, a clear reduction was also noticed in the other flavonoids .Makris and Rossiter (2000) and Buchner *et al*. (2006) reported that flavonoids in aqueous solution showed different sensitivity to heat treatment due to their structures.

Table 5: Fractionation and identification of flavonoid compounds by HPLC in fresh and dried chicory leaves and roots (mg/100g on dry weight basis)

Flavonoid compounds	Fresh chicory		Dried chicory	
	Leaves	Roots	Leaves	Roots
Naringin	5.89	0.79	5.27	0.67
Ruthin	3.17	22.46	1.87	19.02
Hesperidin	4.49	26.25	5.85	29.11
Rosmarinic	26.44	1.92	29.75	6.36
Quercitrin	3.36	2.89	2.86	3.09
Quercetin	5.06	28.44	9.04	25.84
Hispertin	6.24	-	2.03	-
Kaempferol	0.49	0.31	0.47	0.17
Rhamnetin	1.25	6.28	1.17	-
Acacetin	18.45	0.16	14.69	0.11

Fractionation and identification of vitamins A, D, E, K and B group complex contents in chicory leaves and roots by HPLC

Fractionation and identification of vitamins A, D, E, K and B group complex by HPLC in fresh and dried chicory leaves and roots mg/100g are presented in Table (6).

Table 6: Fractionation and identification of vitamins A, D, E, K and B complex by HPLC in fresh and dried chicory leaves and roots (mg/100g on dry weight basis)

Vitamins		Fresh Chicory		Dried Chicory	
		Leaves	Roots	Leaves	Roots
Vit. B complex group	Thiamine (B1)	6.35	47.02	2.214	41.34
	Riboflavin (B2)	2.91	16.35	1.925	12.84
	Nicotinic acid (B3)	12.72	9.22	5.46	4.15
	Pyridoxine (B6)	4.98	39.03	2.88	5.72
	Folic acid (B9)	2.85	5.14	1.291	3.68
	Cobalamin (B12)	32.16	292.10	22.55	146.10
Vit. A		0.429	0.473	0.030	0.075
Vit. D		0.064	0.059	0.013	0.008
Vit. E		0.012	0.013	0.008	0.009
Vit. k		49.02	55.88	2.042	4.821

The fresh chicory roots had the highest level of vitamin B12 (292.1 mg/100g) followed by vitamin B1,B6,B2,B3 and B9, while in fresh chicory leaves the detected levels were 32.16 ,12.72, 6.35, 4.98, 2.91 and 2.85 mg /100 g for vitamin B12, B3, B1, B6, B2 and B9, respectively. Drying

chicory leaves and roots caused a pronounced reduction in all vitamin B complex. The results in the same Table (6) showed that vitamin K recorded a high level in fresh chicory leaves and roots (49.02 and 55.88 mg /100 g) respectively, and small amounts of vitamin A, D and E. A high reduction in the vitamins (A, D, E and K) content was recorded for dried chicory leaves and roots.

Sensory evaluation of:

A: Tamia fried

Sensory evaluation of Tamia paste substituted with different level of chicory leaves powder are present in Table (7). The organoleptic test is generally the final guide of quality from the consumers point of view (Jimenez *et al*., 1989). It could be clearly observed that the addition of chicory leaves powder by 1 % and 3% gave the best overall palatability of fried Tamia (local name). While it could be noticed that the addition of 5 % of chicory leaves powder to paste of Tamia had the lowest score for all sensory charlatanistic.

Table 7: Sensory evaluation of Tamia paste substituted with different level of chicory leaves powder

Properties / Sample No.	Color (10)	Taste (10)	Odor (10)	Texture (10)	Overall palatability (10)
Control	9.4a	9.3a	9.5a	9.5a	9.5a
NO.1 (1%)	8.4b	8.05b	8.1b	8.15b	8.45b
NO.2 (3%)	6.95c	7.3b	7.25c	7.45c	7.3c
NO.3 (5%)	6.15c	6.0c	6.95c	6.0d	6.3d
LSD at 0.05	0.8006	0.7547	0.8911	0.5903	0.5641

Value with different letters in the same column are significantly different at P< 0.05
Control: Tamia paste
NO.1: 1% Chicory leaves powder, NO.2: 3% Chicory leaves powder, NO.3: 5% Chicory leaves powder

B: **Natural crispy snacks**

Sensory evaluation of natural crispy snacks substituted with different level of chicory leaves powder are illustrated in Table (8), it was found that there were no significant differences was observed between the mean values of all the products substituted with the levels of chicory leaves powder (1, 3 and 5 %) for taste and odor Sensory characteristic, while a significant differences were noticed between T3 (5%) and the previous products (control, T1 and T2) in the mean value of color, crispiness and overall palatability. The description of the overall palatability by the panelists ranged between palatable and much palatable for all the products. It could be clearly noticed that the product of natural crispy snacks, which substituted with 5% chicory leaves powder, had high scores for all sensory characteristic of snacks except color.

Table 8: Sensory evaluation of natural crispy snacks substituted with different level of chicory leaves powder

Properties / Sample No.	Color (10)	Taste (10)	Odor (10)	Crispiness (10)	Overall palatability (10)
Control	8.55a	7.45a	7.7a	6.7b	7.3b
T1 (1%)	8.3a	7.65a	8.05a	7.0b	7.55b
T2 (3%)	8.1a	8.0a	8.05a	7.15b	7.8b
T3 (5%)	7.1b	8.25a	8.1a	9.1a	8.65a
LSD at 0.05	0.815802	0.966452	0.799176	0.800248	0.691900

Value with different letters in the same column are significantly different at P< 0.05
Control: Natural crispy snacks
T1: 1% Chicory leaves powder, T.2: 3% Chicory leaves powder, T.3: 5% Chicory leaves powder

Conclusion

The present study provides data for supporting the utilization of fresh and dried chicory (leaves and roots) as good sources for natural compounds and bioactive components such as phenolic and flavonoid compounds, natural antioxidant and vitamins. It could be reported that fresh and dried chicory leaves are a beneficial plant and they contain high amount of protein, fiber, free amino acid and moderate amounts of antioxidant, while fresh and dried roots contain high values of inulin and antioxidant. Both leaves and roots contained high and nearest ratios of the mineral elements. E-vanilli p- coumaric acid were the main phenolic compounds of fresh leaves and roots, respectively. Rosmarinic and acacetin, quercetin, hesperidin and routine were the main predominant flavonoid compounds. Both leaves and roots of chicory plant contain a high proportion of vitamin B12, which decreased after drying.

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