Chemical and Technological Studies on Chicory (Cichorium Intybus L) and Its Applications in Some Functional Food

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ABSTRACT

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. Therefore, the present work aimed to identify the chemical composition of chicory plant (leaves & roots), possibility of removing the bitter taste of roots and utilization of chicory roots in crackers and Nescafe' like product as products added value from this plant. To achieve this goal, chemical compositions as well as minerals of the leaves and roots of chicory plant were determined. Inulin and total soluble sugars were determined also phenols content were extracted and assayed. Phenolic compounds were identified by HPLC. Removing of bitter taste from chicory roots was tried with different treatments ,then the samples dried and grounded to be use in crackers making and Nescafe' .the produced product were tested with some physical factors and evaluated sensorial. The obtained results revealed that chicory roots contain 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 the roots. It is a good source of minerals especially Fe . Total phenolic content of chicory leaves and roots were 26.4 and 20 mg/g of dry matter expressed as Gallic acid equivalent, respectively. Caffeic acids, coumaric and chlorogenic acids were shown to be the major phenolic compounds in the methanolic extract of roots and leaves, respectively. Roasting at 140°C for 20 minutes showed high inulin content and low bitter taste followed by soaking in water (1:4 w/v) at 22 ± 2°C for 24 hrs; in 0.75% citric acid solution (1:10 w/v) for 24 hrs then in hot water (1:4 w/v) at 45°C for 3 hrs. Using of 50% roasted chicory roots as a Nescafe' replacer had no significant effect on organoleptic properties but improved the drink s taste scores. Chicory powdered roots could successfully replace wheat flour (10%) and fat (25%) in producing cracker after debittering by soaking the roots in water or citric acid solution.

INTRODUCTION

Chicory (common name) known botanically as *cichorium intybus l.* is a bushy perennial herb in the Asteraceae family. Chicory can be used in several forms, 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). Barlianto and Marier (1994) reported that roasted chicory (*Cichorium intybus L.*) root is used as a coffee substitute. 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 flavour. Also, Desprez *et al.*, (1999) stated that industrial root chicory (var. sativum) was used exclusively for coffee like-beverage.

Chicons (shoots and leaves) are grown for consumption in salads and vegetable dishes Young and tender roots can also be boiled and eaten. Chicory extracts are added to alcoholic and non – alcoholic beverages (Bais and Raveshanker 2001). Roots of chicory (*cichorium intybus l.*) are used for the production of inulin and as ingredients in certain roasted products (Wilson *et al.*, 2004; Geel *et al.*, 2005 and Toneli *et al.*, 2007). The crop also has potential as a biomass crop for industrial use because it is a plant that's tuberous roots store inulin which can easily be converted to alcohol (De Mastro *et al.*, 2004). 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 texturezing agent. On the other hand, inulin is a dietary fiber with limited calorie value, consequently, suitable for diabetics and is considered to be beneficial to health for its prebiotic properties. Inulin has been identified as an ingredient that substitutes fat or sugar to be suitable for diabetics (Park *et al.*, 2007 and Li *et al.*, 2008). Inulin has been termed as prebiotic because it considers digestible food ingredient that selectively stimulate growth and / or activity of a number of potentially health stimulate intestinal bacteria (Roberfroid and Delzenne, 1998 and Roberfroid *et al.*, 1999), and play a role in the prevention and inhibition of colon and breast cancer (Taper *et al.*, 1995 and 1997). In addition to calorie and fat reduction, it had a fiber effect, lipid modulation and bifibus stimulation. It also increases both the absorption and deposition of calcium in the bones (Labell, 1999).

Sesquiterpine lactones are caused the bitter taste in chicory roots which have been shown anti – inflammatory properties (Cavin *et al.*, 2005 and Nandagopal and Ranjitha 2007), affect cholesterol uptake and prevent immune toxicity (Kim *et al.*, 2000). For this reason, chicory is widely used as a functional food throughout the world for their health promoting and technological properties. Today's consumers hold high standards for the foods they consume. They demand foods that taste great and fat or calorie reduction and they are interested in foods that provide health benefits. Therefore, the aim of this study was to determine and identify the chemical composition, minerals and phenolic compounds of chicory plant, possibility of removing the bitter taste of roots and finally to utilize chicory roots as functional food in crackers and Nescafe' like product.

2. MATERIALS AND METHODS

2.1 Materials

Chicory plant (*Cichorium intybus l.* (var.Fredonia) was cultivated in experimental field of sugar crop Res. Inst., Agric. Res. Center at Giza, Cairo Egypt. The chicory was harvested before flowering. All chemicals and reagents used in this study were of analytical grade. Flour, sugar, salt, eggs, baking powder, vanilla, and Nescafe' used in this study were purchased from local market in Alexandria, Egypt.

2.2 Methods

The plant of chicory was washed with tap water to remove remaining soil and other impurities. The leaves and roots were cut into small pieces, homogenized and used for analysis or in food applications. All determinations were carried out in triplicates.

2.2.1 Analytical Methods: Moisture content, total solids, crude fiber, ash, protein and crude ether extract were determined according to AOAC (1995). Total carbohydrates were calculated by difference. Total soluble sugars and inulin were estimated as described by Sadasivam and Manickam (1992). Mineral contents were carried out using atomic absorption spectrophotometry according to AOAC (1995). The methanolic extracts yield of plant for leaves and roots were determined according to the method described by Zeyada *et al.*, (2007). Total phenols content were assayed calorimetrically using the folin – ciocalteau method (Gamez – Meza *et al.*, 1999) in methanolic extract. Soluble dietary fiber was determined as according to Susheelamma and Rao (1978), while insoluble fiber was carried out as mentioned by Ravindran and Palmer (1990). Total dietary fiber was estimated by calculation. The content of phenolics was expressed as gallic acid equivalent in mg/g of extract (GAE g^{-1}). HPLC system was used for analysis of methanolic extracts to identify the phenolic compound exactly according to Torres *et al.* (1987).A C_{18} – Clc – ODS Hypersil reversed phase column 4.6 × 250 mm particle size 5um, Col No 0923002, N was used. A variable wavelength UV detector was used to detect phenolic compounds constituents at 300 nm. Elution was performed at a flow rate at 1.0 ml/min with mobile phase of acetic acid (A) and acetonitrile (B), starting with 100 % A at 30 min, then 90 % A and 10 % B for 10 min, 40 % A and 60 % B over the next 10 min and finally 100 % B over the final 10 min to purge column. Identifications of the phenolic compounds were based on the comparison of the retention times of peaks obtained by Torres *et al.* (1987).

2.2.2 Technological methods

2.2.2.1 Removing of the bitter taste: Different trials were applied to select the best method for decreasing or removing the bitter taste of chicory roots to utilize as functional foods. These trials were illustrated in Fig. (1) as follows:

A- Soaking process: Chicory roots pieces were soaked in: (1) Water at a ratio of 1:4 (roots: water w/v) at room temperature (22 ± 2°C) for 24 hrs. (T_1); (2) hot water at 45°C for 1, 2 or 3 hrs with replace the soaking hot water by fresh one each 30 min. with occasionally shaking (T_2); (3) Citric acid solution (0.75 %) at a ratio of 1 : 10 w/v for 24, 48 hrs and 72 hrs (T_3) and (4) ethanol (80 %) at a ratio of 1:10 w/v for 2, 3 hrs and 24 hrs (T_4). All samples were washed, dried at 40°C, then ground using an electrical mill to pass through 100 mesh sieve and stored at 4^0C in plastic bags until used.

B- Roasting process: Chicory roots were dried at 40°C in an oven for 12 hrs, then ground and roasted at 140°C for 30 or 20 min (T_5). The sample roasted for 20 min was chosen for crackers; therefore it was ground to pass through 100 mesh sieve. The roasted sample at the same temperature for 20 min was mixed with olive oil (10 %) and treacle (10 %) (T_6) cooled and packed in polyethylene bags until use.

2.2.2.2 Application of powdered and roasted chicory root in some food:

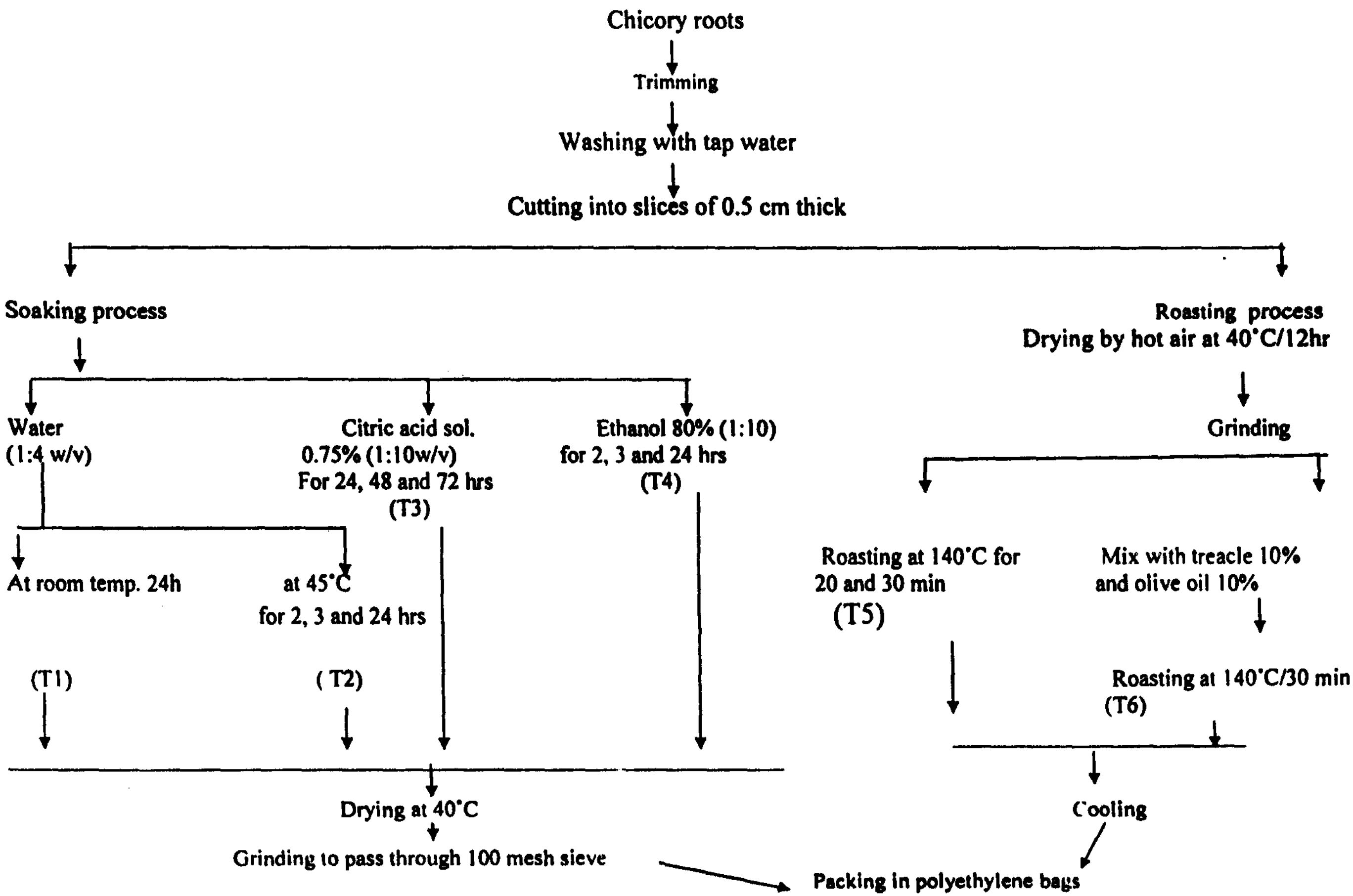
2.2.2.2.1 Nescafe' like beverage (drink):

The powder of roasted chicory was used to replace 50 or 100% pure Nescafe'. The drink was prepared as the common way of preparing Nescafe'.

2.2.2.2.2 Preparation of crackers

Crackers were prepared according the recipe and method of Abd-El-Rahim *et al.*, (2003) using the following ingredients: 90g wheat flour, 7.5g shortening, 10g chicory roots flour (CRF), 2g salt and 2g baking powder. Replacing 10% of wheat flour and 25% of fat by chicory root flour (CRF) were applied according to Elgindy (2003).

Figure (3): Technological treatments of chicory roots for bitter taste removing



2.2.3 Technological tests for crackers

The average volume of 7 crackers was determined with rapeseed displacement method as described by the AACC (1970). Crackers specific lightness and volume were measured according to Elling &Max Millner (1951) as follows: Specific lightness (cc/gm) = (Volume of 7 crackers/Baked weight of 7 crackers) ×20 .Specific volume (cc/gm) = (Volume of 7 crackers/Dough weight of 7 crackers) × 20.The width and thickness of crackers were measured to the nearest mm by accurate ruler and were used to obtain the spread ratio. The spread ratio was calculated according to AACC (1983) as follows:Spread ratio = width (mm) / Thickness (mm).

2.2.4 Sensory evaluation

Sensory evaluation of Nescafe' and the mixture of Nescafe' and roasted chicory were done according to Einstein (1991), pertaining to appearance of dry granules, colour, aroma, and solubility and cloudy. Sensory properties for crackers samples were evaluated by the method recommended by Ranganna (1994) using a hedonic rating test. Samples were served to the panelists and they were asked to rate the acceptability of the product on 1-9 points scale, ranging from the extreme like (9) to dislike extremely (1) as described by Larmond (1977).

2.2.5 Statistical analysis

The results of the organoleptic properties of the products were statistically analyzed according to Steel and Torrie (1980).

3. RESULTS AND DISCUSSION

3.1 Chemical composition:

Chemical composition of chicory plant (leaves & roots) is shown in Table (1).It was clear that chicory leaves contain high level of protein (14.70%), ash (10.91%), crude ether extract (3.68%) and crude fiber (16.78%) and had low concentration of total carbohydrates (68.50%) compared to with its roots. On the other hand, the roots of chicory were characterized by its high concentration of inulin (44.69%). The obtained results were found to be in the range of the values recorded by Monti *et al.*, (2005) who found that crude protein and ash ranged from 8.56 to 15.73% and 9.58 to 13.75%, respectively. Also these results are agreement with those reported by Femenia *et al.*, (1998).On the other hand, Adamoli and Rigon (2001) reported that chicory root contained 15 – 20 % inulin and 5 – 10 % oligofructose.

Table (1) Chemical composition of chicory plant *

Chemical composition %	Roots	Leaves
Moisture content	75.63 ± 0.39	83.06 ± 1.55
Crude protein	4.65 ± 0.25	14.70 ± 1.03
Crude ether extract	1.69 ± 0.71	3.68 ± 0.19
Ash	4.25 ± 0.11	10.91 ± 1.86
Total carbohydrates	89.41 ± 1.07	68.50 ± 2.08
Total soluble sugars	11.06 ± 1.00	7.80 ± 1.45
Inulin	44.69 ± 0.88	10.95 ± 2.56
Crude fiber	5.12 ± 1.55	16.78 ± 2.20
Dietary fiber (DF) :-		
Insoluble DF	30.73 ± 0.33	ND**
Soluble DF	0.42 ± 0.07	ND**
Total DF	31.15	ND**

*On dry weight basis
Mean ± 5.0 (each value represents the average of three determinations ± standard deviation)
**ND: Not Determined

The mineral content of chicory leaves was found to be relatively higher than that of its roots. Data presented in Table (2) show the mean of the macro-elements content of chicory leaves that can be ranked in the following descending order Ca, K, Na then Mg whereas the micro-elements can be arranged in descending order as follows Fe, Zn, Mn and Cu. Generally it could be concluded that chicory is a good source of minerals especially Fe which was high when compared to the daily requirements for men and women according to National Academy of Science (2001) which have many interesting nutritional aspects. These results are in agreement with those reported by Schittenhelm (2001).

Table (2) Mineral content (mg/100g) of chicory plant (leaves & roots) in comparison with RDA

Chicory plant	Macro-elements				Micro-elements				
	Ca	K	Mg	Na	Fe	Cu	Mn	Zn	Pb
Roots	181.26 ± 4.40	103.7 ± 4.62	20.14 ±1.69	67.42 ± 2.45	1.77 ± 0.21	0.362 ±0.015	0.312 ± 0.10	0.390 ± 0.03	0.038 ± 0.003
Leaves	292.61 ± 13.35	166.57 ± 3.43	6.944 ± 5.86	88.84 ± 2.58	9.178 ± 0.85	0.596 ± 0.06	0.904 ± 0.01	0.91 ± 0.03	0.025 ± 0.01
R.D.A mg/100g	1000-1300	--	240-420	1600	8 - 11	0.8–1.2	1.6-2.3	12-15	

***RDA Recommended daily requirement for men and women according to National Academy of Science (2001).**

3.2 Phenolic compounds content as Methanolic extract :

Yields of methanolic extracts were about 23.16% and 10.75% of chicory leaves and roots, respectively. The HPLC analysis of phenolic constituents presented in Table(3). Data in table (3) revealed that the concentration of coumaric acid compounds represents the major phenolic compound which amounted to 52.93% of total phenolic in chicory roots. Caffeic,chlorogenic and protocatechuic acids were also detected identified in chicory roots. Innocenti *et al.*, (2005) reported that these compounds appeared to be mainly responsible for the strong antioxidant activities. In chicory leaves, caffeic acid was the major phenolic compound presented, followed by chlorogenic, p.hydroxybenzoic, p. coumaric acids, protocatechuic, gallic and iso vanillic acids in descending order. These results are similar to results obtained by Mulinacci *et al.*, (2001), Massoud (2004) and Moussa *et al.*, (2005).

Table (3) Methanolic extract yield, total phenolic content and phenolic compounds (%) in chicory extracts as identified by HPLC.

Chicory	Methanolic extracted yield (%)	Total phenolic content *	Phenolic compound (%)	
Leaves	23.16	26.4 ± 1.05	Gallic acid	1.96
			Protocatechuic acid	2.50
			Chlorogenic acid	17.84
			P. hydroxybenzoic acid	11.04
			Caffeic acid	35.22
			Iso vanillic acid	1.97
			p. coumaric acid	9.65
			Unknown compound	19.46
Roots	10.75	20.0 ± 0.90	Protocatechuic acid	1.77
			Chlorogenic acid	10.85
			Caffeic acid	24.36
			m. coumaric acid	27.90
			p. coumaric acid	25.03
			Unknown compound	10.09

*Values expressed as mg GAE g^{-1} dry extract (mean of three replicates ± standard deviation)

The occurrence of these phenolic compounds in chicory may enable to use these raw materials as an interesting source of natural antioxidants for the food industry as well as an ingredient for nutraceuticals or dietary supplements.

3.3 Debittering of chicory roots.

The bittering agents in chicory are non – toxic and have a range of biological and pharmaceutical activities (Hehner *et al.*, 1998 and Hance *et al.*, 2007). The effect of different treatments of debittering of chicory roots on inulin content and bitter taste are shown in Table (4).

It was clear from Table (4) that all treatments caused a reduction in inulin content. This reduction was based on type of soaking medium, soaking and roasting time as well as temperature. Roasting after mixing with treacle (10%) and olive oil (10%) showed the lowest loss of inulin content with significant reduction in bitter taste.

The reduction percentage of inulin was considerably higher in soaking treatments than roasting treatment. This could be due to the solubility of inulin in water and the low pH value of citric acid and its effect on the inulinase enzyme activity.

The required time for removing the bitter taste of roots was shorter during soaking in hot water at 45°C (T_2) comparing with the other treatments. Soaking in hot water at 45°C (1:4 w/v), reduced the bitter taste compounds of apricot kernel flour by 65% (Attia, 2000), and by 81.38% in loquat kernel (Wafaa, 2002).In addition, no considerable changes were noticed in disappearing bitter taste of roots during soaking in ethanol 80% for 24 hours. Further, the roasting treatment (T_5 and T_6) at 140°C for 20 min. showed high inulin content and decrease of bitter taste followed by T_1 (water at 22 ± 2 for 24 hrs), T_3 (citric acid solution for 24 hrs) then T_2 (hot water at 45°C for 3 hrs).

From the previous results, the treatments of chicory roots (T1, T2 andT3) can be blended with wheat flour for the preparation of crackers as as a functional food ingredient.

Table (4) Effect of soaking in different solutions and roasting on inulin content and removing bitter taste of chicory roots.

Treatments*	Time of soaking or roasting	Inulin %	Bitter taste	Loss of inulin %
Control	___	44.69 ± 0.27	+ + +++	
T_1	24hrs	35.97 ± 0.40	__ slightly	19.47
T_2	1 hrs	37.61 ± 0.54	+++	15.84
	2 hrs	29.88 ± 0.28	++	33.12
	3 hrs	24.19 ± 0.38	+	45.86
T_3	24 hrs	32.34 ± 0.80	++	27.64
	48 hrs	29.55 ± 0.42	+	51.82
	72 hrs	15.02 ± 0.28	__	66.32
T_4	2 hrs	43.57 ± 0.42	+++++	4
	3 hrs	42.82 ± 0.29	+++++	
	24 hrs	38.90 ± 0.12	+++	13.19
T_5	20 min	38.05 ± 0.08	+	14.81
	30 min	37.51 ± 0.38	+	18.75
T_6	20 min	39.13 ± 0.37	+	12.44

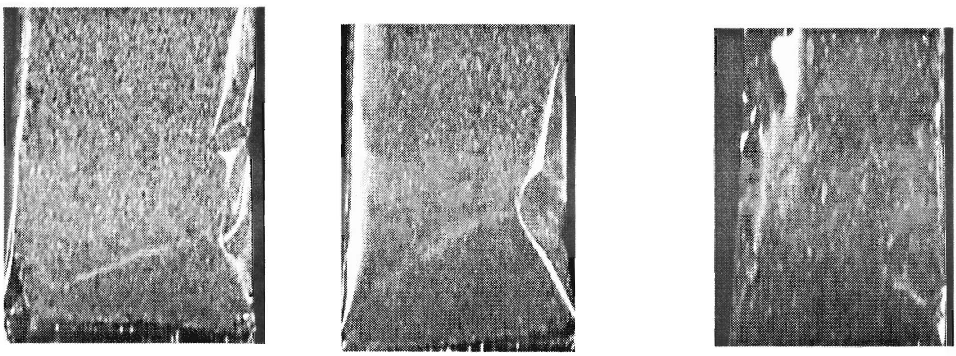
T_1: Soaking in water at a ratio of 1:4 (roots: water w/v) at room temperature (22 ±2°C).

T_2: Soaking in water at a ratio of 1:4 (roots: water w/v) at 45°C.
T_3: Soaking in citric acid solution 0.75% (1:10 w/v).
T_4: Soaking in ethanol 80 % (1:10 w/v).
T_5: Roasting at 140°C.
T_6: Roasting (+ 10% treacle and 10% oil) at 140°C.

3.4 Sensory evaluation.

3.4.1 Sensory evaluation of roasted chicory drink

Approximately 85% of all coffee consumed in South Africa contain between 25% and 75% chicory (Geel *et al.*, 2005). The sensory profiles of 5 Nescafe including pure Nescafe, three Nescafe' blends (1:1 w/w Nescafe' to roasted chicory roots), pure roasted chicory roots were shown in figure (2)and table (5)



A Roasting at 140°C / 20 min | B Roasting at 140°C / 30 min | C Roasting at 140°C / 20 min 10% treacle and 10% olive oil..

Figure (2): Appearance of roasted product produced from chicory roots

The pure Nescafe' had a coarse texture and dark in colour while Nescafe'blend (50% roasted roots) had coarse perforated and light colour granules. The blends and roasted chicory granules also solubilised slower than Nescafe' pure. There was no significant differences in quality attributes, sensory parameters of pure Nescafe' and Nescafe blends (50%) drinks and consumer acceptability was described as very acceptable.

The scores of colour and coarseness of all powder / granules samples were very close to each other, whether pure Nescafe', pure chicory or Nescafe' / chicory blend. The aroma had the same observation except for pure chicory that had relatively lower score. As for drinks, the panelists gave Nescafe' / chicory blends scores very close to pure Nescafe' in colour, taste, aroma and acceptability, while pure chicory can be considered far from them.

Table (5):Mean sensory score attributes of pure Nescafe', Nescafe' blends and pure chicory roots drinks.

Products / Attributes	100 % Nescafe'	Nescafe' /chicory blend (50 /50)			100% chicory
		A*	B**	C***	
Powder / granules					
Colour	8.50 a	8.38 a	8.00 a	7.88 a	8.38 a
Aroma	8.50 a	8.00 a	8.30 a	8.60 a	7.00 b
Coarseness	8.00 a	8.11 a	7.78 a	8.00 a	8.70 a
Drinks					
Colour	8.50 a	8.25 a	8.30 a	8.00 a	7.30 a
Taste	8.50 a	8.00 a	8.11 a	7.80 a	6.50 b
Aroma	8.50 a	8.00 a	8.30 a	8.78 a	6.56 b
Solubility	9.00 a	7.80 a	8.33 a	6.33 b	6.66 b
Overall acceptability	8.50 a	8.12 a	8.40 a	8.40 a	6.30 b

*A: Roasting at 140°C / 20 min
**B: Roasting at 140°C / 30 min.
***C:Roasting at 140°C / 20 min. after adding 10% treacle and 10% olive oil.

3.4.2 Crackers quality characteristics

Table (6) and Fig. (3) show some characteristics of crackers prepared by replacing 10% of wheat flour and 25% of fat by chicory root flour (CRF). The results indicate that there were insignificant differences in

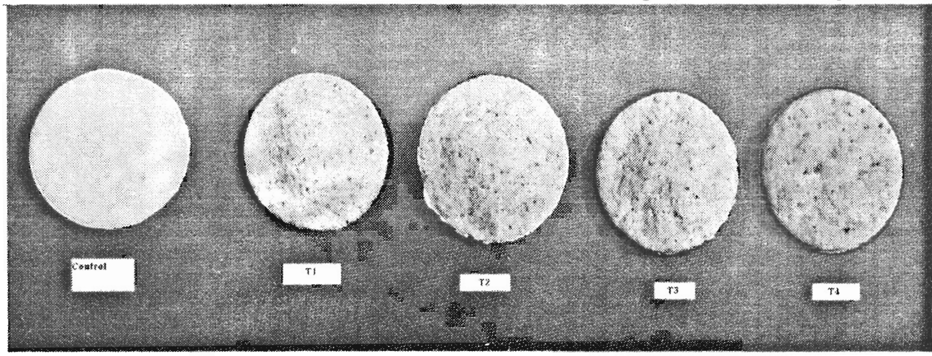


Figure 3. Crackers prepared with replacing 10% wheat flour and 25% fat by chicory root flour (CRF).

Table (6) Quality characteristics of crackers prepared by replacing 10% wheat flour and 25% fat by chicory root flour (CRF).

Products / Property	100% wheat flour and 100% Fat	Replace 10% wheat flour and 25% fat by CRF *				LSD
		T_1	T_2	T_3	T_4	
Thickness (mm)	0.608 ±0.12 a	0.601 ±0.14 a	0.598 ±0.24a	0.500 ±0.72a	0.576 ±0.12 a	0.139
Diameter (mm)	2.48 ±0.07 a	2.44 ±0.09 a	2.44 ±0.06 a	2.37 ±0.09 a	2.42 ±0.09 a	0.073
Volume of 7 crackers	11.03 ±0.09 a	12.11 ±0.03 a	9.87 ±0.08 a	12.00± a	11.41 ±0.03 a	1.970
Weight of 7 crackers before baking (g)	12.77 ±0.12 c	9.58 ±0.16 a	9.74 ±0.19 a	11.05 ±0.12b	13.03 ±0.07 d	0.257
Weight of 7 crackers after baking (g)	9.44 ±0.11 d	6.78 ±0.05 a	6.50 ±0.07 b	7.36 ±0.04 c	9.43 ±0.16 d	0.218
Specific lightness cc/g	23.20	35.72	30.37	32.61	24.20	
Specific volume cc/g	17.27	25.28	20.27	21.72	17.51	
Spread ratio	4.25	4.19	4.08	4.74	4.20	

*T_1 : Soaking in water for 24 hrs at room temperature.

T_2 : Soaking in water for 3 hrs at 45°C

T_3 : Soaking in citric acid solution 0.75% (1:10 w/v) for 24 hrs.

T_4 : Roasting at 140°C for 30 min.

=-thickness, diameter and volume of crackers made from formula containing debittered CRF or roasted CRF or the control containing wheat flour only. Also, spread ratios of all samples were very close to each others.

Nor Aini *et al.*, (1992) reported that the diameter of biscuit is an indicator of its spreadability, the larger the diameter, the more spreadable the biscuit. Crackers with 10% roasted chicory roots were very close to the control (100% wheat flour) than other treatments in weight before and after baking, specific lightness, specific volume and spread ratio. The three treatments of debittering significantly affected the previous characteristics. On the other hand, weight of crackers before and after baking were decreased, while specific lightness and volume were increased.

3.4.3 Sensory evaluation of crackers

Table (7) shows the sensory attributes of crackers containing chicory root. Replacing wheat flour by debittering CRF had little effect on the score of sensory attributes. Roasting chicory roots had the highest effect and clearly lowered score of all attributes. Statistically, there were no significant differences between crackers with 100% wheat flour and that which has been replaced by 10% debittering CRF in all attributes. Contrary, there was significant difference in most attributes between all the cracker samples and the crackers of roasted chicory.

It could be stated that the powdered debittered chicory roots successfully replace wheat flour (10%) in producing crackers with good nutritional value of fiber and their acceptability form the consumer point of view. Vandorpe (1991) stated that dried inulin extracted from chicory roots are used in bakery products, high – fiber drinks and confectionary. It could be conducted that potential utilization of chicory roots in its powder as applied successfully replace wheat flour (10%) in produced crackers or roasting form as substitute Nescafe' (50%) in Nescafe' like beverages with good nutritional value of fiber and their acceptability for consumer.

Table (7)Mean sensory scores attributes of crackers containing chicory root

Treatments / Property	100% wheat flour, 100% fat	Replace 10% wheat flour and 25% fat by CRF *				LSD
		T_1	T_2	T_3	T_5	
Shape	7.9±1.10 b	7.1±1.14 ab	7.4±1.35 ab	6.9±1.51 ab	6.1±1.23 a	1.135
Colour	8.17±1.04 b	6.55±1.03 b	7.00±1.21 b	7.17±0.98 b	6.17±0.98 ab	0.889
Taste	7.83±0.93 b	7.00±1.54 b	7.29±1.10 b	7.00±1.13 b	4.42±0.74 a	0.922
Flavour	7.32±1.27 b	7.09±1.70 b	7.27±0.9. b	6.36±1.29 ab	5.36±1.03 a	1.099
Texture	7.92±1.27 b	7.23±1.53 b	7.54±1.08 b	7.08±1.44 b	6.15±1.60 a	1.144
Overall acceptabiliy	8.05±1.01 b	7.23±1.25 b	7.41±0.66 b	7.00±0.97 b	5.18±1.54 a	0.96

*T_1 : **Soaking in water for 24 hrs at room temperature.**

T_2 : Soaking in water for 3 hrs at 45°C.

T_3 : Soaking in citric acid solution 0.75% (1:10 w/v) for 24 hrs.

T_5 : Roasting at 140°C for 30 min.

***CRF**: Chicory roots flour

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الملخص العربى

دراسات كيميائيه وتكنولوجيه علي نبات الشيكوريا واستخدامها في بعض الاغذيه الوظيفيه

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يعتبرنبات الشيكوريا من النباتات الهامة فى الصناعات الغذائية حيث انها مصدر للالياف التغذوية مثل الأنيوليين والسكريات العديدة وأيضا كمكون غذائى وظيفى له تاثير أيجابى للحفاظ على الصحة العامة و مقاومة الأمراض لذلك تهدف الدراسة الى التعرف على التركيب الكيماوى لاوراق وجذور نبات الشيكوريا(*Cichorium intybus* L.) و إمكانية التخلص من المذاق المر من الجذور والأستفادة منها كمكون غذائى في اعداد المقرمشات أو كبديل للنسكافيه لرفع القيمة الغذائية لتلك المنتجات. ولتحقيق الهدف تم تقدير التركيب الكيماوى و المعادن فى كل من الأوراق وجذور الشيكوريا وتقدير الأنيولين والسكريات الذائبة الكلية كما تم أستخلاص المواد الفينولية وتقديرها والتعرف عليها بطريقة HPLC و التخلص من المرارة من الجذور باستخدام بعض المعاملات المختلفة ثم طحن تلك الجذور وأستخدامها فى تصنيع المقرمشات و مشروب النسكافية وأختبرت الخواص الطبيعية والحسية للمنتج الناتج وأوضحت نتائج التحليل الكيماوى أن جذور الشيكوريا تحتوى نسبة أعلى من الكربوهيدرات (89,41 %) والأنيولين (44,69 %) عن الأوراق (68,5 و 10,95 % على التوالى). بينما تعتبر الأوراق مصدر جيد للعناصر المعدنية و خاصة الحديد . وكذلك فى نسبة المركبات الفينولية الكليه التى تمثل 26.4و20 مجم/جم فى الاوراق و الجذور على الترتيب. وأظهرت نتائج التعرف على المركبات الفينولية في المستخلصات باستخدام HPLC أن كلا من أحماض caffeic coumaricو و chlorogenic acid يمثلا أعلى نسبة فى المركبات الفينولية.كما أوضحت النتائج أن التحميص على 140م° لمدة 20 ق أدى الى أنخفاض فى ا لمرارة وأرتفاع فى محتوى الأنيولين مقارنة بالنقع في ماء على 22 ± 2 م° لمدة 24 ساعة أو 45 م° لمدة 3 ساعات (1:4)، و في 0,75 % محلول حامض الستريك (10:1) لمدة 24 ساعة . كما أوضحت نتائج الخواص الحسية عدم وجود أى فرق معنوي في الخواص الحسية للنسكافيه المستبدله بنسبة 50 % من جذور الشيكوريا المحمصة ونسبة 100 % نسكافيه كما أنها حسنت من درجات طعم المشروب. وقد نالت المقرمشات قبول المحكمين عند استبدال 10 % من دقيق القمح و 25 % من الدهن بمسحوق جذور الشيكوريا بعد ازالة المرارة بالنقع في الماء أو محلول حامض الستريك.