Chicory Leave Powder as A Functional Ingredient: Chemical Composition, Bioactive Compounds and Antioxidant Activity

Hamid M. Ziena, Soad T. Kheir and Basma R. Ghazie[1]

ABSTRACT

In this research, the chemical composition, bioactive compounds and antioxidant activity were estimated in chicory leave powder. The results of those analyses were needed to check the functional properties of the powder. The chemical composition result of leave powder was as respectively; moisture content (6.79%), crude protein (15.02%), crude fiber (16.46%), ash (10.80%), fat (3.90%) and nitrogen-free extract (53.82%). Amino acids, fatty acids and mineral content were also evaluated. The bioactive compounds analysis of the leave powder showed that the amount of total flavonoids and total phenols as respectively (8.50mg/g) and (26.4mg/g). The powder was found to contain a high amount of mineral elements such as Ca (the highest), K, Mg, Na and Mn (the lowest). Amino acid analysis showed that glutamic acid is the dominant amino acid and cysteine represents the lowest value. According to the result of amino acids, chicory leave powder is characterized by containing higher levels of some amino acids than the FAO/WHO pattern. Those amino acids were leucine, valine and threonine respectively. As a result of fatty acids analysis, the leaves powder was found to contain a high value of linoleic acid (C18:2) while behenic acid (C22:0) represents the lowest value. The antioxidant activity value of the powder showed 45.5% DPPH inhibition. All this make chicory leave powder a good candidate in functional foods.

Keywords: Chicory, Chemical composition, Total flavonoids content, Total phenolic compounds, Antioxidant activity.

INTRODUCTION

Chicory (*Cichorium intybus* L.), a perennial herb of the Asteraceae family is native to the Mediterranean region, mid-Asia and northern Africa. Historically, chicory was grown by the ancient Egyptians as they believed that chicory is a good medicinal plant and used it in several folk treatments (Centeno,2004). In Egypt, people eat fresh leaves of chicory and sometimes use it in salads and the leaves of several *Cichorium* species have been used for centuries as part of the traditional diet in the Mediterranean countries (as salads or cooked vegetables, and in meat dishes), while the roots are baked, ground, and used as a substitute for coffee and inulin source. The bitter taste of chicory leaves is highly appreciated in some Mediterranean cuisine (in Italy, Spain, Greece and Turkey) Jancic *et al*., (2017). Leaves of chicory are a good source of phenols as well as potassium, calcium, and phosphorus. Chicory has been traditionally used for the treatment of fever, diarrhea, jaundice and gallstones Abbas *et al*., (2014). The studies on rats have shown that chicory possesses anti-hepatotoxic and anti-diabetic activities Saggu *et al*., (2014). It has been also reported that chicory possesses anti-bacterial (Nandagopal and Ranjitha Kumari ,2007), anti-inflammatory (Cavin *et al*.,2005), hyperglycaemic and anti-ulcerogenic activities Uz-Zaman *et al*.,(2006).

Due to good chemical composition, bioactive compounds and antioxidant activity of chicory leaves, it would be a valuable candidate in the functional food industry and can play an important role in improving human health by participating in the antioxidant defense system against endogenous free radicals. The objective of this study was to evaluate the chemical composition, bioactive compounds and antioxidant activity of chicory leave powder as a new source for functional foods production.

MATERIALS AND METHODS

Materials:

Collection and preparation of Chicory samples:

Chicory (*Cichorium Intybus* L.) leave was collected from a field in Kafr el dawar District, El-Beheira Governorate, and Egypt in March 2021. The leave of the plant was washed with tap water to remove the remaining soil and other impurities then dried for 3 days at room temperature until the leave easy converted into powder. The dried leave was milled by an electric mill and then sifted through a 40 mesh sieve. The sifted samples were put in airtight glass jars. The samples were stored in the refrigerator at 4°C until further use.

Chemical composition analysis:

The recommended methods by the Association of Official Analytical Chemists (AOAC.2000) were used for the determination of moisture, ash, fat, protein and crude fiber content. While nitrogen-free extract was calculated by difference.

Minerals analysis was determined using atomic absorption spectrophotometry according to AOAC (2000).

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[1] Faculty of Agriculture, Food and Dairy Science and Technology Department, Damanhour University, El-Behira Governorate, Egypt

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Amino acid analysis of chicory leave powder was determined and estimated according to the method described by AOAC (2000).

Fatty acid analysis: of chicory leave was determined according to the method described by Radwan, (1978).

Total Flavonoids analysis:

The total flavonoids content were measured by the method described by Shad *et al*., (2013). The total flavonoids content of the extract was expressed as mg catechin equivalents (CE) per gram of sample (mg/g) and calculated from the calibration curve. HPLC was used for the fractionation and determination of the total flavonoids using the method outlined by Goupy *et al*., (1999), and Mattila *et al*., (2000).

Total phenolic analysis:

The content of phenolics was expressed as gallic acid equivalent in mg/g. HPLC was used for the analysis of methanolic extract and to identify the phenolic compounds exactly according to Goupy *et al*., (1999), and Mattila *et al*., (2000).

Antioxidant activity, the DPPH:

The DPPH scavenging activity was measured by the method reported by (Hatano *et al*., 1988) and the absorbance was assayed at 517 nm. Percent inhibition was calculated. Ascorbic acid was used as a standard in the DPPH assay.

RESULTS AND DISCUSSION

Chemical composition:

The chemical composition of chicory leave powder is shown in Table (1). Moisture, crude protein, crude fiber, ash, fat and nitrogen-free extract were 6.79, 15.02, 16.46, 10.80, 3.90 and 53.82 % (on a dry weight basis), respectively. The results presented in this study were found to be in the range of the value reported by Nwafor *et al*., (2017) and Perović *et al*., (2021).

Table1. Chemical composition of chicory leave powder

Chemical composition	%
Moisture	6.79
Crude protein	15.02
Crude fiber	16.46
Ash	10.80
Fat	3.90
Nitrogen-free extract	53.82

Mineral content:

The results of the mineral content of chicory leave powder revealed that the leave was rich in some the important minerals such as Ca, K, Mg, Na, Zn, Fe and Mn. It's known that the content of minerals in plants is affected by some factors such as growing conditions, soil characteristics, pH, and the presence of organic matter and the ability of plants to selectively accumulate some of these elements. Potential causes of variation in the content of mineral elements include agricultural practices, precipitation and temperature Tuncturk *et al*., (2018). Those results agree relatively with the results declared by Schittenhelm, (2001).

Table2. Mineral content mg/100g of chicory leave powder

Minerals content	mg /100 g
Sodium (Na)	70.78
Potassium (K)	185.63
Magnesium (Mg)	125.53
Calcium (Ca)	255.47
Manganese (Mn)	1.05
Iron (Fe)	8.87
Zinc (Zn)	1.93

Amino acid composition:

Amino acids are present in plants, animals and humans and they have an important role in human health maintenance. As in Table (3) results indicated that leucine, valine, phenylalanine and methionine were the major essential amino acids. Concerning the non-essential, the analysis indicated that the glutamic acid (24.00 g/100g) dominated the other detected amino acids. However, arginine and aspartic came in the second order. It could be concluded that chicory leave powder which is rich in lysine can be used to complement cereal protein. Those results are relatively close to the data reported by (GU and Li, 2012). According to the WHO (1973) recommended pattern for an ideal dietary protein, chicory leave powder is a good source of most essential amino acids. It contains an appreciable concentration of leucine, valine and threonine compared to the FAO/WHO Pattern (Table 3).

Fatty acid composition:

As shown in Table (4) the results revealed that the oil of chicory leave powder contains significant quantities of the following fatty acids in descending order; linoleic, linolenic, palmitic, stearic, eicosanoic and behenic acid. However, palmitic acid and stearic acid are the most detected fatty acids among the saturated fatty acids. However, unsaturated fatty acids recorded higher levels 59.48 %. In the chicory plant, palmitic acid was detected at a very high portion (26.30 %).This result is an important detail for the chicory plant compared to other oil seeds and plants. These results agree with the results reported by Kam and Kanberoglu, (2019).

Table3.Amino acid composition in chicory leave powder

Amino acids composition	Chicory leaves powder g/100g protein	FAO/WHO Pattern *
Essential amino acids		
Leucine	6.64	4.8
Valine	4.49	4.2
Phenylalanine	4.70	5.6
Methionine	3.82	4.2
Lysine	3.75	4.2
Isoleucine	3.35	4.2
Threonine	3.23	2.8
Non-essential amino acids		
Glumatic acid	24.00	
Arginine	10.30	
Aspartic acid	10.30	
Glycine	6.64	
Alanine	4.35	
Serine	3.88	
Proline	3.50	
Tyrosine	3.50	
Histidine	2.35	
Cysteine	1.20	
Total essential amino acids %	**32.33**	
Total non-essential amino acids %	**67.67**	
E/N %	**47.8**	

***** FAO Pattern 1957: (g/100 g protein), World Health Organization, 1973. Energy and protein requirements. FAO Nutrition Meetings Report Series No.52**.**

Table4. Fatty acid composition in chicory leave powder

Fatty acids composition	Symbol	%
Palmitic acid	C16:0	26.30
Stearic acid	C18:0	6.50
Eicosanoic acid	C20:0	4.00
Linolenic acid	C18:3	28.50
Behenic acid	C22:0	2.50
Linoleic acid	C18:2	30.98
Total saturated fatty acids %		**39.3**
Total unsaturated fatty acids %		**59.48**
Sat/Unsaturated %		**66**

Bioactive compounds of chicory leave powder:

a) Total phenolic compounds:

Phenolic or polyphenols are secondary plant metabolites that are ubiquitously present in plants and their products. Many of them are reported to have high levels of antioxidant activities. Dzharov *et al*.,(2016). Table (5) displays that the total phenolic content was 26.4 mg/g. The main phenolic compound found in chicory leave powder was E-vanillic acid (59.89 mg/g) (Table 6). The result of the total phenolic content of chicory leave powder agree with the result reported by Massoud *et al*.,(2009) and hence the result of total phenolic compounds (Table 6) is in agreement with the result reported by Dallar *et al*., (2014) and Perović *et al*., (2021).

Table 5. Total phenols, total flavonoids and antioxidant activity of chicory leave powder

Component	Value
Total phenols mg/g	26.4
Total flavonoids mg/g	8.50
Antioxidant activity (DPPH inhibition %)	45.5

Table6. Phenolic compounds of chicory leave powder

Phenolic compounds	mg/g dry matter
Gallic acid	0.36
Catechol	0.54
Pyrogallol	4.23
Epicatechin	5.48
P-OH-benzoic acid	1.13
Chlorogenic acid	1.34
Caffeic acid	0.37
P-Coumaric acid	0.35
Vanillic acid	1.71
Ferulic acid	1.13
Ellagic acid	1.41
Iso-Ferulic acid	0.53
Caffeine	1.13
E-vanillic acid	59.89
Cinnamic acid	0.35
Benzoic acid	3.59
Coumarin	1.02
Salicylic acid	3.61
Total phenolic compounds	**85.1**

b) Total flavonoids content:

The flavonoids play an important role in the biological system; they have antioxidant, antimalarial, anti-inflammatory, antiproliferative, cytotoxic, analgesic, sedative, anti-hepatotoxic and hypoglycaemic bioactive properties (Costa *et al*., 2017). The total aqueous ethanolic flavonoids content of chicory leave powder was 8.50 mg/g as shown in Table (5). Results in Table (7) showed that rosmarinic and acacetin recorded the highest levels (20.15 and 14.72 mg/g respectively). Those results are relatively in agreement with the results reported by Abbas *et al*., (2014) and Ishfaq *et al*., (2018).

Table7. Total flavonoids content in chicory leave powder

Flavonoid compounds of dried chicory	mg\ g dry matter
Naringin	5.31
Acacetin	14.72
Rutin	1.89
Rhamnetin	1.27
Hesperidin	6.05
Kaempferol	0.52
Rosmarinic	20.15
Hispertin	2.13
Quercitrin	3.16
Quercetin	9.34
Total flavonoid compounds	**64.54**

DPPH radical scavenging activity:

The antioxidant activity of chicory plants was the subject of investigation in numerous scientific studies. The analysis revealed that flavonoids and phenols are present in chicory leave powder. It is well known in general that flavonoids and phenols act as highly effective free radical scavenging and as antioxidants. The result of DPPH scavenging activity was 45.5 % inhibition of DPPH as shown in Table (5). This result is lower than the result reported by Khalaf *et al*., (2018) (80.95 ± 0.39%). Abbas *et al*., (2014) reported that the IC50 value of chicory leave extract was found to be 67.2 ± 2.6 µg/ml. The result of DPPH radical inhibition (45.5%) is close to the results reported by Ishfaq *et al*., (2018). This value makes chicory a good raw material for healthy food.

CONCLUSIONS

In a conclusion, the results of the chemical composition and antioxidant activity of chicory leave powder showed that it could be a good source of bioactive compounds like flavonoids and phenolic compounds as well as some important minerals. This makes the plant an important ingredient to add to the functional food industry, where attention is now drawn to it.

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الملخص العربي

مسحوق ورق الشيكوريا كمكون وظيفى : التقييم الكيميائي ،المركبات النشطة حيويا والنشاط المضاد للاكسدة

حامد مرسي زينة وسعاد توفيق خير وبسمة ربيع غازى

فى هذا البحث، تم تقدير التركيب الكيماوى، المركبات النشطة حيويا والنشاط المضاد للأكسدة لمسحوق ورق الشيكوريا وكانت نتائج هذه التحليلات مهمة للتحقق من الخصائص الوظيفية لأوراق النبات. كانت نتيجة تحليل التركيب الكيماوى لمسحوق أوراق الشيكوريا كالتالى: المحتوى الرطوبة (6.79%)، البروتين الخام (15.02%)، الألياف الخام (16.46%)، الرماد(10.80%) ، الدهن (3.90%) والمستخلص الخالى من النيتروجين (53.82%). وتم تقدير أيضا كل من الأحماض الأمينية والدهنية ومحتوى المعادن. أظهر تحليل المركبات النشطة حيويا لمسحوق ورق الشيكوريا أن كمية الفلافونويدات والفينولات الكلية على التوالى كانت كالتالى (8.50mg/g) و (26.4mg/g). ووجد أن الورق احتوى على كميات عالية من العناصر المعدنية مثل الكالسيوم (الأعلى تركيزا) ، البوتاسيوم ، الماغنسيوم، الصوديوم والمنجنيز (الأقل تركيزا). كما أوضح تحليل الأحماض الأمينية أن حمض الجلوتاميك هو الحمض السائد مقارنة بباقى الأحماض وكان حمض السيستين يمثل أقل الأحماض تركيزا. وطبقا لنتيجة الأحماض الأمينية، فإن مسحوق أورق الشيكوريا يتميز باحتوائه على بعض الأحماض الأمينية أعلى من نموذج FAO/WHO. وهذه الأحماض تتمثل في الليوسين ،الفالين و الثريونين على التوالى . وجد أن مسحوق أوراق الشيكوريا يحتوى على تركيز عالى من حمض اللينوليك بينما كان حمض البيهنيك الأقل تركيزا. كما عادل النشاط المضاد للأكسدة للمسحوق 45.5% تثبيط لمركب DPPH. مما يجعل النبات مرشحا جيدا كمكون يمكن استخدامه فى الأغذية الوظيفية.

الكلمات المفتاحية: الشيكوريا، التركيب الكيماوي، المحتوى الكلى للفلافونويدات، المركبات الفينولية الكليه، النشاط المضاد للأكسدة.