Chemical Composition, Active Compounds and Functional Properties of Carrot Vegetative or Green Parts

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Abstract

This study was conducted to determine the chemical composition, active compounds, and functional properties of locally planted carrot green parts (leaves, stems and total vegetative parts). Results showed that carrot leaf powder contained more moisture, protein, lipids, fibers and lower ash than stem powder, but carbohydrates were nearly the same. Leaves and stem powders contained high concentrations of (K, Ca, Mg, Zn, Fe, Mn, Cu, and Se). Additionally, the alcoholic and aqueous extract of vegetative parts contained phenolic compounds, flavonoids, proanthocyanidins, alkaloids, and tannins. HPLC analysis found that the aqueous extract of the leaves and stems powders possessed six peaks whose retention time corresponded to the retention time of the peaks belonging to standard compounds (Rutin, Caffeic acid, Chlorogenic A, Catechin, Gallic A. and Kaempferol). Concerning functional properties of all samples under study showed that these powders had good emulsifying ability, water holding capacity, oil binding capacity, and foaming ability. These results consolidate the inclusion of carrot leaves and stem powders as functional ingredients in some food products .

Keywords: carrot green parts, active compounds, functional properties

Introduction

In recent years, the concept of functional foods and therapeutic foods has become a top research topic because of the great importance of these foods in maintaining health, as functional foods are foods that provide natural sources of compounds and elements that have proven from a physiological standpoint their ability to prevent or reduce the risk of some chronic or non-chronic diseases infections. Their benefits go beyond the essential functions of food [1,2.[

Carrots are one of the most prominent crops that have many uses as direct food. They are consumed alone or included with other vegetables in many foods and appetizers[3]. They are also used in many food industries, mostly their leaves are neglected, and the dregs of their roots are waste that is disposed of Important functional preparations characterized dried carrot leaf proprations due to the components they contain, as carbohydrates represent a high percentage of the components of these leaves (61.35%), followed by protein at 20.27% [4.[

Carrot pomace contains about 50% of the beta-carotene found in carrots. Beta-carotene can be used in preparing nutritional supplements from some products such as cakes, bread, and biscuits, and in manufacturing several types of functional

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products due to its beneficial components in this field [5.[

Some studies [6] showed the functional properties of carrot pomace powder and found that the water absorption capacity of carrot pomace powder is higher than its ability to absorb oil, which indicates the presence of hydrophilic compounds in abundance, which is what distinguishes carrots and their products.

Sahni and Shere [7] found that the water holding capacity of dried carrot pomace reached 5.425%, and stated that this low percentage is due to the dried preparation's low content of compounds that encourage water binding, such as starch.

The aim of the recent study was to determine the approximate analysis, the active compounds and the properties of carrot leaves and stems powders in order to utilize them in food fortification

MATERIALS AND METHODS

Collect and prepare study models

The vegetative parts of the local carrot plant growing in Tarmiyah, north of Baghdad, Iraq were obtained during February of the season (2021- 2022). The stems were isolated from the leaves, and the two parts were washed well, dried and crushed using a home coffee grinder, and the powder was passed through a No. 70 sieve (250 microns). The powders were stored in plastic bags at room temperature, in a dry place until use.

Approximate analysis

Chemical analysis of vegetable parts (leaves, stems, and whole parts) powder of the local carrot plant was carried out by determining moisture, ash, protein, fat, fiber, and carbohydrates in the laboratories of the College of Agricultural Engineering Sciences/University of Baghdad according to A.O.A.C [8 .[

Mineral elements

Mineral elements contents of powders of vegetative parts (leaves, stems, and whole parts) of carrot were estimated according to the APHA method [9] using the acid digestion method, or wet digestion. Analysis was done using an atomic absorption device SHEMADZU AA 7000.

Preparation of the aqueous and alcoholic extracts:

Aqueous extract was prepared according to Ahmed et al. [10] by suspending 20 g of each sample (leaves, stems, and vegetative parts) separately in 400 ml of distilled water for an hour on a magnetic stirrer at 40°C, passing the mixture through filter paper (Whatman No.1) under vacuum, and the filtrate was concentrated using a rotary evaporator and dried at 40°C for 24 hours. The powder was stored in tightly sealed bottles in the refrigerator (5±2 mº) until use.

Alcoholic extract was prepared according to the method described by Zhou et al. [11], by suspending 10 g of each sample in 100 ml of 80% ethanol and leaving for 12 hours with continuous stirring using a magnetic mixer at room temperature. Insoluble parts were excluded by passing the mixture through filter paper (Whatman No.1) under vacuum, and the filtrate was concentrated using a rotary evaporator. The concentrated extract was dried at 40°C for 24 hours using an incubator. The powder was stored in tightly sealed opaque bottles in the refrigerator (5±2 mº) until use.

Qualitative detection of some active compounds in the carrot leaves and stems

The qualitative detection of the active compounds in the powder of dried vegetative parts (leaves and stems) of carrot plants, which are represented by alkaloids, flavonoids, phenols and tannins, was carried

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out according to the methods described by Muhammad [12.[

Quantitative estimation of some active compounds :

Phenolic compounds

The method of Ayoola et al. [13] was followed to estimate the free phenolic compounds in both leaf and stem powder of carrot plants. Absorption was measured at 760 nm using a spectrophotometer, and the concentration of free phenolic compounds was calculated by referring to the standard curve for gallic acid.

Free flavonoids

Free flavonoids were estimated in both leaf and stem powders of carrot plants, according to what was described by Rao et al. [14]. Absorption was measured at 410 nm using a spectrophotometer, based on the rutin standard curve.

Total tannins

The total tannin content was estimated according to the method described by Abdelkader et al. [15]. The absorbance value of the tannin calibration curve was recorded at a wavelength of 540 nm, and the absorbance of the sample was read. Tannic acid in different concentrations was used for preparation of standard curve.

Total alkaloids

Total alkaloids content was estimated using atropine as standard [12.[

Separation and identification of some active compounds in aqueous and alcoholic extracts of leaves and stems

The examination was conducted in the laboratories of Department of Environment and Water, Ministry of Science and Technology using a high performance liquid chromatography device, reversed phase RP. HPLC model Solvent Delivery System 2100, equipped from the German company SYKAM with a multiple pump with a pressure power (5000. 6000 Pa.1) and a multiple optical detector and a C18.ODS separation column (250 × 4.6 mm, 5 µm) to separate phenols using an ultraviolet detector (UV – 278 nm) according to the method demonstrated by the company (2013), and described by Samuchaya [16], the sensors were connected to a computer to display the data in the form of compound (peaks) and recorded the results of the time of appearance of compound and the area occupied by each peak. The carrier phase represented by each of the following was used. Solvent A consists of (95% acetonitrile + 0.01% Triflouroacetic acid) and solvent B consists of (5% acetonitrile + 0.01% Triflouroacetic acid), with a flow speed of 1 ml/min, and the volume of the injected sample was 100 microliters at a temperature of 25 °C, and the transfer speed program was as follows Next: from 0.5 minutes 10%, from 5.7 minutes 25%, from 7.18 minutes 40% and then return to the initial conditions.

Functional Properties

Water Holding Capacity (WHC (

Water holding capacity was measured according to Onsaard et al. [17], which included mixing 1 g of each of the leaves, stems, and vegetative parts powders separately with 20 ml of distilled water in a 50 ml centrifuge tube using a Vortex mixer for 5 minutes. minutes and adjusted the pH to (4, 7, 10, 12) and left for 15 minutes at room temperature (25±2 °C) while ensuring that the pH was stable, then centrifugation was performed at 10000 x g for 30 minutes, and the viability was expressed relating water to the weight of water absorbed by 1 gram of the sample according to the following equation:

WHC (gm Water/ gm Sample) = (W2-W1)/W0

Where:

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W0 = sample weight.
W1 = weight of tube + weight of sample before adding water.
W2 = weight of tube + weight of sediment after removing water.

Oil Holding Capacity (OHC (

The oil holding ability of the was measured according to Onsaard et al [17] by mixing 0.5 g of leaf, stem and vegetative parts powder separately with 7.5 g of sunflower oil in a 10 ml centrifuge tube using Vortex for 5 minutes. It was left for 15 minutes at room temperature (25±2 °C). The tubes were centrifuged at 10,000 x g for 20 minutes, and the oil binding capacity was expressed as the weight of oil absorbed by 0.5 g of the sample, according to the following equation:

OHC (gm Oil/ gm Sample) = (F2-F1)/F0

Where:

F0 = weight of original sample.
F1 = weight of tube + weight of sample before adding oil.
F2 = weight of tube + weight of sediment after removing oil.

Emulsion properties

The emulsification ability and emulsion stability were measured according to what was mentioned by Sharma et al. [18], with some modification, as 5 ml of a suspension of leaves, stems, and vegetative parts powders, and each prepared separately, was mixed at a concentration of 0.25% and with a pH of (4, 7, 10, 12) With 5 ml of sunflower seed oil in 50 ml graduated test tubes, the mixture was homogenized using a laboratory homogenizer at a speed of 10,000 rpm for 1 minute, followed by centrifugation at speed 3500xg for 10 minutes, and the size of the emulsion layer was measured, the percentage of emulsification ability was calculated using the following equation

Emulsifying ability = (volume of emulsion layer / total volume) X 100

The stability of the emulsion was estimated after placing the graduated cylinders in a water bath at a temperature of 85°C for 30 minutes, after which the second centrifugation process was performed for 10 minutes at a speed of 3500xg, the stability of the emulsion was calculated using the following equation:

Emulsion stability (%) = (Volume of emulsion layer after heating / Total volume before heating) X 100

Foaming Properties

The foam formation ability of the samples under study was measured according to what was stated by Cano-Medina et al. [19], with some modifications. 50 ml of a suspension of each of the leaves, stems, and vegetative parts of the local carrot plant was prepared at a concentration of 1% and a pH of (4, 7, 10, 12) in 150 ml glass beakers, then whipping using a laboratory homogenizer at a speed of 10,000 rpm for 5 minutes, then transferred to a 50 ml graduated cylinder, and the foam volume was measured before and after mixing with the electric mixer. The ability to form foam was measured using the following equation:

Foam formation ability = [(total volume after whipping –total volume before whipping)/ total volume before whipping] X 100

Foam stability was estimated by measuring the volume of foam formed after 15, 30, 45, and 60 minutes and then applying the following equation:

Foam stability % = (foam volume at certain time / foam volume at zero time) X 100

Statistical analysis

The statistical program Statistical Analysis System (SAS) [20] was used to analyze the data to study the effect of various factors on the studied characteristics, according to a completely randomized design (CRD), and the

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significant differences between the means were compared with the least significant difference test (L.S.D.). At a significant level (P≤0.05.(

Results and Discussion

Chemical Composition

The chemical composition analysis of leaves, stems, and dry vegetative parts of the local carrot plant (Daucus carota L.) is presented in table 1.

The table indicates that the protein content obtained from the dry leaves, stems and total vegetative parts of carrots were 20.93, 10.02 and 16.49%, respectively. These results were higher than with what Jana Ismail [21] reported, showing that carrot leaves contain a somewhat lower protein percentage, ranging from 2.5% to 3.5%. These proteins are composed of a group of essential amino acids, including glutamic acid, which contributes to the flavor of the leaves.

The fat contents in both leaves and stems were 5.506% and 5.314%, respectively; while the overall fat content in the vegetative parts was significantly (p≤ 0.05) lower (2.079%). This percentage is relatively low compared to the other measured components, confirming previous studies that indicated the fat content in carrot leaves and other parts is generally low, typically less than 1% of their total composition. The fats primarily consist of unsaturated fatty acids as stated by Sharma [22.[

Regarding moisture content, the leaves had a moisture level of 11.353%, followed by the stems at about 8.85%, while the vegetative parts had the lowest moisture content at 7.24%. This is lower than what Sharma [22] reported.

The ash content in the leaves was significantly (p≤0.05) lower (13.350%), while it was 19.310% in the stems and 19.40% in the total vegetative parts. The higher ash content in the stems suggests they may serve as a more concentrated mineral source than the leaves.

For carbohydrates, there was no significant difference, with the highest level found in the leaves, followed by the stems and vegetative parts at 36.475%, 36.378%, and 36.145%, respectively. Carrot leaves contain moderate carbohydrates, generally ranging from 5% to 10% of their fresh weight. The carbohydrate composition includes simple sugars such as glucose and fructose, which contribute to the slightly sweet flavor of the leaves and provide a quick source of energy [23.[

The results of Goneim et al. [2] indicated that the protein percentage in dry carrot leaves was comparable to the current study, reaching 20.27%, while carbohydrates and ash were 61% and 15%, respectively. Another study by Okudu et al.

[24] found that the protein content in fresh carrot leaves was 6.72%, while the percentages of fat, ash, and crude fiber were 1.08%, 3.37%, and 3.62%, respectively. Overall, this study indicates that carrot leaves are a good source of proteins and fats, while the stems have higher fiber content. These nutritional components can be utilized in the development of various food products and as a rich energy source.

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Table1.Proximate composition of dry leaves, stems, and vegetative parts

Samples	Protein %	Fat%	Moisture %	Ash%	Fibers%	CHO %
Leaves	20.93	5.506	11.353	13.350	12.386	36.475
Stems	10.02	5.314	8.895	19.310	20.083	36.378
Vegetative parts	16.49	2.075	7.24	19.40	18.65	36.145
L.S.D.	3.71 *	1.66 *	1.97 *	2.28 *	3.07 *	2.52 NS

* ($P \leq 0.05$).

Table 2 shows the mineral contents of the powdered leaves, stems, and total vegetative parts of the local carrot. The values for potassium, calcium, iron, magnesium, zinc, manganese, copper, and selenium in the leaves were 188.9, 155.1, 3.5, 58.9, 1.31, 1.25, 0.85, and 0.52 mg/kg, respectively. In the stems, these values were 85.9, 95.8, 2.1, 33.9, 0.98, 0.89, 0.62, and 0.36 mg/kg, respectively. For the total vegetative parts, the values were 174.9, 124.5, 4.0, 66.9, 1.9, 1.58, 1.5, and 0.89 mg/kg, respectively. These values are considered good in comparison to the daily recommended intake of mineral elements according to the Food and Agriculture Organization (FAO) and the World Health Organization (WHO), which are approximately (5160, 5000, 160, 760, 32, 325, and 160) mg/kg for the mentioned minerals, except for selenium, as indicated in Table 2 .

The results indicate that the mineral values in the leaves were higher than those in the stems, which may be attributed to the inherently higher mineral concentrations in carrot leaves compared to the stems. This suggests that the accumulation of minerals in green tissues is greater, as leaves contain a higher amount of chlorophyll and green tissues compared to stems. Consequently, the green tissues are more effective in absorbing and accumulating mineral elements [25 .[

Previous studies have shown that soil pH influences the

absorption of minerals in both leaves and

stems; typically, leaves have a lower pH compared to stems, which increases the absorption capacity for certain minerals [26 .[

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Table 2. Mineral contents (mg/kg) of dry leaves, stems, and vegetative parts of carrot (Daucus carota L.) plant according to the recommendations of FAO.

Samples	K	Ca	Fe	Mg	Zn	Mn	Cu	Se
Leaves	188.9	155.1	3.5	58.9	1.31	1.25	0.85	0.52
Stems	85.9	95.8	2.1	33.9	0.98	0.89	0.62	0.36
Vegetative parts	174.9	124.5	4.0	66.9	1.9	1.58	1.5	0.89
FAO/WHO (mg/kg)	5160	5000	160	760	32	325	160	-

Qualitative detection of active ingredients of carrot leaves and stems powders

Table 3 shows the results of qualitative chemical tests to detect the nature and quality of the active compounds present in the powders of carrot stems and leaves. It indicates the presence of alkaloids, phenols, flavonoids, tannins and proanthocyanidins in the powders of carrot leaves and stems, with the appearance of a positive result for the presence of tannins. These results are qualitatively consistent with what Muhammad et.al. [26] pointed out about the presence of all these compounds, but they proved the absence of tannins in carrot leaf powder. The variations in the absence or presence of tannins can be attributed to the difference in cultivar and their proportions in the different parts of the plant.

Ajanal et al. [27] qualitatively tested the presence of alkaloids using the Dragendorff method. This method relies on the reaction between the alkaloid and the bromocresol green dye. The positive result indicates the formation of a distinct orange color with the presence of a precipitate. It is possible to rely on this reaction in quantitative estimation by reading the absorbance of the reaction solution using spectrometer. In a recent study, there are some results indicated an increase in the percentages of most of the active compounds, including tannins, in different types of carrot plants as a result of fertilizing them with a group of fertilizers consisting of different percentages of NPK and animal manure [28].

Table 3 Qualitative detection of active compounds in carrot stems and leaves powders

npound	t/ Reagent	ms	ves
aloids	yer reagent ic acid gendoff reagent		
nolic npounds	n reagent ic chloride test		-
vonoids	yl alcohol 95% + H% 50		-
abthocyanidibe	hanol-HCl		
nins	d acetate ic chloride	ish en	ckish e

Quantitative estimation of some active components of aqueous and alcoholic extracts of leaves, stems, and green parts.

Table 4 shows the concentration of phenolic compounds in the extracts of stems, leaves, and vegetative powders of carrot plants, both by alcoholic and aqueous extraction methods, and based on the standard curve for gallic acid in figure 1. It is clear from the table that there were significant differences in the concentrations of phenolic compounds among different parts of the carrot plant. The concentration of phenolic compounds reached (0.535, 1.050 and 1.159 mg/g) for stems, leaves, and vegetative parts, respectively, and (0.365, 0.344 and 1.049 mg/g), in the aqueous extract. The results obtained indicate whether by the aqueous or alcoholic method or even with regard to the type of part extracted from it (stem or leaves) the differences in concentrations of phenolic compounds in the two extracts. This may be attributed to many factors, including the type and method of extraction that depends on the extraction solvents, the time and temperature of extraction, the extent of polarity of the extracted phenolic compound, in addition to the degree of oxidation of the extracted active substance as confirmed by both Dao et al. [29-31] who pointed out the influence of the aforementioned factors on the quantity and quality of the active compounds extracted.

AL-Mudhafr et al. [32] found that the carrot plant contained phenolic compounds in the alcoholic and aqueous extracts, but their concentration in the alcoholic extract (58.29 mg/g) was higher than their concentration in the aqueous extract (42.63 mg/g).

They showed that the difference in the amount of phenolic compounds extracted between water and alcohol is due to the nature of the separated compounds in terms of their solubility in the solvents used in the extraction. Aqueous extracts usually contain small amounts of phenolic compounds compared to their high levels in alcoholic extracts due to the efficiency of ethanol in

extracting polyphenols from plant samples [33].

Carrots contain different types of phenolic compounds, and mainly contain hydroxycinnamic acids and their derivatives. Among them, chlorogenic acid is a major type of hydroxycinnamic acid, accounting for 42.2% to 61.8% of the total phenolic compounds detected in various carrot tissues [34].

Table 4. Quantitative estimation of some active compounds in the aqueous and alcoholic extracts of leaves, stems, and whole vegetative parts of the carrot plant.

Compounds	Vegetative parts (mg/g)		Leaves (mg/g)		Stems (mg/g)		
	Alcoholic	Aqueous	Alcoholic	Aqueous	Alcoholic	Aqueous	L.S.D.
Phenolic compounds	1.159	1.049	1.050	0.344	0.535	0.365	0.329 *
Flavonoides	0.746	0.625	0.664	0.110	0.141	0.241	0.252 *
Alkaloids	0.043	0.034	0.031	0.019	0.013	0.011	0.024 *
Tannins	0.019	0.011	0.014	0.008	0.005	0.003	0.012 *
* (P≤0.05).							

The flavonoid compounds in the stem and leaf extracts of the carrot plant were estimated on the basis of the standard rutin compound. Table 4 shows that the percentage of flavonoids in the alcoholic extract of the stems was higher than that in the aqueous extract, and the percentage reached 0.241 mg/g for alcoholic extract and 0.141 mg/g for aqueous extract of carrot stems when examined at wavelength of 415 nm. Concerning flavonoid compounds in the leaves, their concentrations in the alcoholic and aqueous extracts were 0.664 and 0.110mg/g, respectively. The differences in the concentrations of flavonoids in the two extracts could be attributed to the differences in the nature and polarity of the solvent used. Although water is considered as a solvent, It transports molecules of the active compounds well compared to other polar solvents by increasing the permeability of the plant tissue [31]. However, organic compounds are also characterized with their ability to extract phenols and flavonoids in higher proportions due to the effect of forming hydrogen bonds between the active compounds and proteins, thus weakening them

and extracting higher proportions from them [36,37].

The results in the previously mentioned table show that the alcoholic extracts contain tannins at concentrations reaching (0.005, 0.014 and 0.019 mg/g) in the stems, leaves and vegetative parts. For the aqueous extracts, the concentrations of tannins reached (0.003, 0.008 and 0.011 mg/g) for the three parts, respectively. These discrepancies may be due to the nature of tannins extraction and the effect of different extraction solutions on them [38].

The results in Table 4 indicate that the concentrations of alkaloids in the stems, leaves and vegetative parts reached (0.013, 0.031 and 0.047 mg/g), respectively in the alcoholic extracts, while they reached (0.011, 0.019 and 0.034 mg/g), respectively in the aqueous extracts. These results indicate that alkaloids are distributed between the aqueous and organic phases, and this is due to the properties that characterize these compounds.

These concentrations are low compared to other plants. Ajanal et al. [27] found that the roots of the medicinal herb (Plumbago zeylanica Linn.) contained alkaloids at a concentration of 26.95 mg/g, and the Indian pipali herb (Pipper longum Linn.) contained 14.07 mg/g.

Identification of phenolic compounds of aqueous and alcoholic extracts by HPLC

The results obtained in tables (5 and 6) and Figures (1 and 2) showed that the results are somewhat similar for the stem extract based on HPLC technology, for the aqueous and alcoholic extracts (comparing with the results of the standard compounds Rutin, Caffeic acid, Chlorogenic A, Catechin, Gallic A. and Kaempferol), as it was found that the aqueous extract of the stems possessed six peaks whose retention time corresponded to the retention time of the peaks belonging to each standard compound, which reached a concentration of (2.58, 2.5, 5.8, 5.9, 3.9, 2.3 mg/gm), respectively.

The results also showed that the leaf extract had six peaks, and the retention time matched the peaks of the aforementioned standard compounds, whose concentrations in the extract reached (2, 1.9, 5.07, 4.9, 2.7, 1.8 mg/gm), respectively, despite the superiority of the aqueous extract. However, the active compound Catechin had the highest concentration in the two extracts. By studying the peaks of the leaf extract in its aqueous and alcoholic forms, it was noted that it contained five peaks whose appearance time differed with the compounds obtained from the stem. Their retention time coincided with the retention time of the peaks of the following standard compounds (Rutin, Chlorogenic A, Hydrobenzin A, Gallic A. and Apigenin), and their concentrations in the aqueous extract reached (6.7, 7.7, 6.5, 6.3, 2.4 mg/gm), respectively. The concentrations of the compounds in the alcoholic extract reached the range of (4.7, 4.6, 4.4, 4.8, 1.8 mg/gm), respectively. It was found that the highest percentage of the active compounds extracted by the two methods in the leaves was due to the compound Chlorogenic A.

The data obtained through high-performance liquid chromatography are consistent with what was obtained by Algarra et al. [34] who showed that the carrot extract possesses more than one peak and that each of these peaks represents a certain type of active compounds.

In the study of Malo and Mansour [39], phenolic compounds were extracted from olive leaf varieties after eliminating plant dyes and oil compounds, and the total phenols were separated with a solvent consisting of methanol and water. The results of HPLC

technology showed that the phenolic extract consisted of Gallic acid, Caffeic acid, p-hydroxy benzoic acid, Vanillic acid and Syringic acid [40].

It can be inferred from the results shown in our study that the aqueous extract proved superior in terms of concentrations of active compounds in the stem and leaves. Therefore, this method is environmentally friendly and provides economic value that can be used at the commercial manufacturing level. These results are consistent with sustainable development data presented by Oliveira et al. [41].

Table 5. Retention time and concentrations of the active compounds obtained from the aqueous and alcoholi7c extracts of the stem of the local carrot plant.

Stem								
Compound	Standard 10ppm) (		Aqueous extract			Alcoholic extract		
	Retention time (min)	Area	Retention time (min)	Area	Concentration (mg/gm)	Retention time (min)	Area	Concentration (mg/gm)
Rutin	11.72	65.08	.1185	44.1987	2.58	.1187	.154129	2
Caffic acid	9.58	962.15	58.9	69.1985	2.5	52.9	.152014	1.9
Chlorogenic A	8.00	1204.89	00.8	18.5894	5.8	08.8	.489508	5.07
Catechin	5.29	759.08	28.5	48.3621	5.9	25.5	.301598	4.9
Hydrobenzin A	4.68	1204.58	-	-	-	-	-	-
Gallic A.	3.10	910.55	20.3	19.2652	3.9	28.3	.201200	2.7
Kaem pferil	2.19	1045.98	15.2	49.1985	2.3	17.2	.152249	1.8
Apigenin	6.25	950.14	-	-	-	-	-	-
Leaves								
Rutin	11.72	65.08	.1180	49.5210	6.7	.1178	.362209	4.7

Caffic acid	**9.58**	**962.15**	**-**	**-**	**-**	**-**	**-**	**-**
Chlorogenic A	**8.00**	**1204.89**	**95.7**	**18.7452**	**7.7**	**90.7**	**.542189**	**4.6**
Catechin	**5.29**	**759.08**	**-**	**-**	**-**	**-**	**-**	**-**
Hydrobenzin A	**4.68**	**1204.58**	**70.4**	**15.6320**	**6.5**	**69.4**	**.425698**	**4.4**
Gallic A.	**3.10**	**910.55**	**12.3**	**58.4589**	**6.3**	**02.3**	**.356228**	**4.8**
Kaem pferil	**2.19**	**1045.98**	**-**	**-**	**-**	**-**	**-**	**-**
Apigenin	**6.25**	**950.14**	**28.6**	**08.1854**	**2.4**	**25.6**	**.142599**	**1.8**

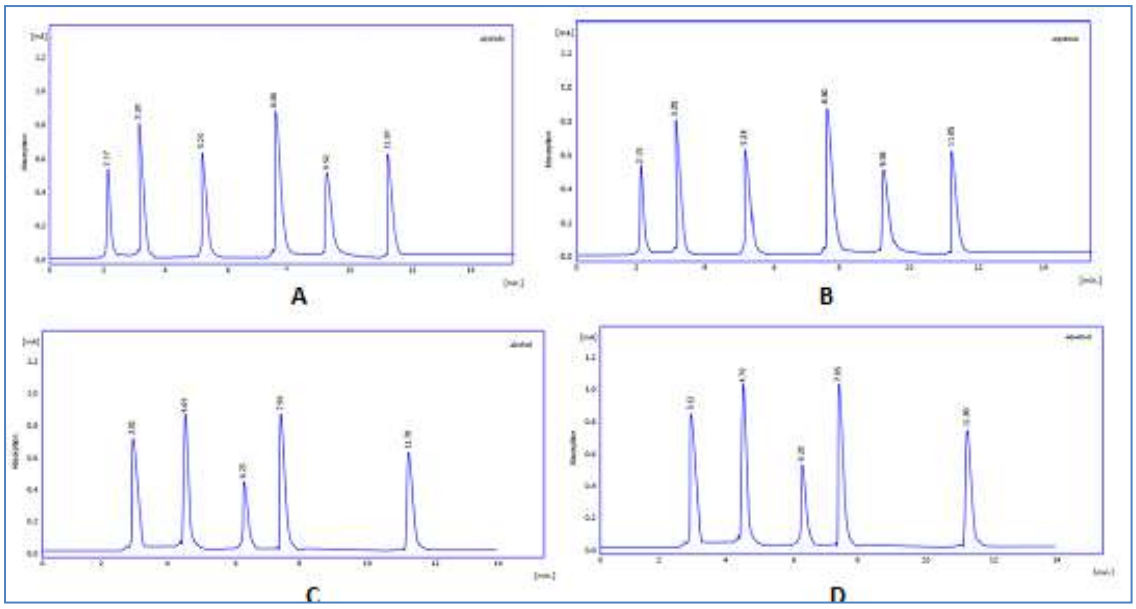

Figure 1 chromatogram showing the peaks of the active compounds obtained from the aqueous and alcoholic extract of carrot stems using HPLC technique.

Functional characteristics

Emulsifying ability

Table 7 indicates the effect of pH on the emulsification ability of samples of stem and leaf powders and vegetative parts of the carrots under study at pH numbers (4, 7, 10 and 12). It is clear that there is a gradual decrease in all parameters with increasing pH value. The values were (43.7, 42.3, 41.8 and 37.6%) for the stem, and (44.7, 43.9, 42.1 and 38.2%) for leaves, and in the whole vegetative parts, which includes both the stem and the leaves, it was noted that the decrease was slight between the treatments, with the values being equal at the pH7 and pH10. Then it decreased at pH 12, recording the lowest value among the treatments, as it was 33.9, 33.6, 33.6, and 27.8%, respectively .

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Table 6. The effect of pH on the percentage of emulsification ability and the percentage stability of the stem, lea

pH	Emulsifying ability				Emulsion stability			
	Stem	Leaves	Vegetative parts	L.S.D.	Stem	Leaves	Vegetative parts	L.S.D.
4	43.7	44.7	33.9	5.72*	36.6	32.0	26.8	4.69*
7	42.3	43.9	33.6	5.04*	34.8	37.0	30.2	4.22*
10	41.8	42.1	33.6	4.98*	35.5	38.6	29.3	5.61*
12	37.6	38.2	27.8	5.33*	32.9	32.4	21.4	5.03*
L.S.D.	4.79*	4.55*	5.17*		3.52 *	4.19 *	4.75 *	
*** (P≤0.05).**								

ves, and whole vegetative parts powder

Table 6 indicates the effect of pH on the stability of emulsion samples of powders of stems, leaves, and vegetative parts at pH values of (4, 7, 10 and 12). There is a variation in the degree of stability of most treatments with increasing pH value. The stem powder recorded the highest stability at pH 4 and 10, while the stability decreased at pH 7 and 12. The same table shows an increase in the percentage of emulsion stability in leaf powder treatments gradually with an increase in the pH value, then a decrease in stability at pH 12. For the vegetative parts, it is noted that there is an increase in the degree of emulsion stability at pH 7 and then a decrease with the increase in the basicity of the medium at the pH 10, then a sharp decrease at pH12, thus recording the lowest value among the treatments, as they were 26.8, 30.2, 29.3 and 21.4%, respectively.

Cabra et al. [43] mentioned that the mechanism of action of emulsifying materials depends on that when water mixed with oil, the surface tension between the two phases is high, as the oil molecules tend to bond with each other (hydrophobic bonding) and separate from the aqueous phase which leads to the mixture separating in the form of two layers, and when emulsifying materials are added, these materials move to the surface separating the two phases (reducing the surface tension) and work to disengage the protein bounding and surround the oil molecules, and then form droplets spread in the aqueous phase.

Akinsola et al. [44] studied protein isolates prepared from eggplant leaves (ELI), amaranth (ALI), and a type of squash (FLI), and found that FLI gave a good emulsion stability at pH 9.0 (79.66-96.91%) at all concentrations tested, followed by ELI. The emulsions were less stable at lower pH values regardless of protein concentration. This indicates that there are not sufficient electronic

repulsive forces to prevent the coalescence of oil droplets when compared with emulsions prepared at pH values between 7.0 and 9.0. They also noted that all emulsions prepared at acidic pH values using a protein concentration of 5 mg/ml were formed and were more stable than emulsions prepared from a higher concentration.

Water Holding Capacit

Table 7 indicates the effect of pH on the percentage of water holding capacity in samples of stem, leaf and vegetative parts powders of carrots at pH values of (4, 7, 10, 12). It is clear that the percentage of water holding capacity at pH 7 was the highest for the stem treatment, and it decreased with the increase in the pH values, as it was 4.4, 4.9, 3.5 and 2.9%. The values of the leaves powder were similar to the total vegetative parts, with an increase in the water holding values recorded with the increase in the pH values. The highest

values were recorded at pH 10, and then a clear decrease was recorded at the end of the experiment, as it was 12.2, 14.5, 17.4, and 14.6%, respectively in the leaves and 6.3, 6.6, 7.3, and 6.8%, respectively in the vegetative parts.

According to Kinseilla [45], the ability to hold water increases as the protein concentration increases due to the ability of the protein to sequester, swell and expand, thus exposing more sites to binding, while carbohydrates and other components may do the opposite, i.e. cause a weakening of the segregation and binding capacity. The differences resulting from a change in the pH can be due to the effect of ions on the aggregates that contribute to binding water molecules. The water holding value depends on the source of the fibers and its chemical, physical and structural properties [46].

The value of pH of the system greatly affects the ability to absorb water due to changes in the surface charges of the protein. Any change in pH from the isoelectric point leads to an increase in the ability to absorb water by causing an imbalance in the charge [47]. Despite the positive effects, known to increase the water holding capacity of isolated preparations, the high affinity for water causes a negative effect that can lead to deterioration the texture of

manufactured products [48].

Sahni and Shere [7] found that the WHC value for carrot powder amounted to 5.624 g/g, and it was higher than the values recorded for both apple and beet waste powder.

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Table 7. Water holding capacity and Oil binding capacity of carrot stem, leaves and vegetative parts powders

	Water holding capacity (%)				Oil binding capacity (%)			
pH	**Stem**	**Leaves**	**Vegetative parts**	**L.S.D.**	**Stem**	**Leaves**	**Vegetative parts**	**L.S.D.**
4	4.4	12.2	6.3	2.48*	7.3	2.4	4.3	2.08*
7	4.9	14.5	6.6	3.51*	6.7	2.2	3.9	1.79*
10	3.5	17.4	7.3	3.95*	5.4	2.0	2.9	1.84*
12	2.9	14.6	6.8	3.62*	5.1	1.9	2.1	2.05*
L.S.D.	1.48*	3.07*	1.15 NS		1.63*	0.667 NS	1.72*	

*** (P≤0.05).**

Oil Holding Capacity

Table 10 indicates the effect of pH on the oil-holding ability of samples of stem and leaf powders and vegetative parts of carrots at different pH values (4, 7, 10, 12). It is clear from the table that there is a gradual decrease in all parameters with an increase in the pH value. In the stem, the values of oil binding capacity were 7.3, 6.7, 5.4, and 5.1%, in the leaves, 2.4, 2.2, 2.0, and 1.9%, and in the vegetative parts, which include both the stem and the leaves, 4.3, 3.9, 2.9, and 2.1%, respectively.

Jayabrata Saha & Sankar Chandra Deka [51] found that the values of the oil binding capacity of the protein isolate prepared from the leaves of the edible fern plant reached between 7.41 and 7.55 g/g, and they indicated that these relatively high values may be due to the low size of the oil droplets and to the nature of the interactions between protein and oil, which led to an increase in the percentage of binding to proteins as a result of increasing the exposed surface area.

Sahni and Shere [7] found that the oil adsorption capacity of the dried dried preparation prepared from pumas of carrots amounted to 2.442 g/g, and they interpreted these values based on the particle size of the powder, as the oil adsorption capacity to the particles increases the smaller they are in size for the same mass that is subject to the test.

The oil holding capacity is an important property for the product because the oil acts as a flavor preservative, improves palatability, increases mouthfeel, and extends the shelf life of the product[50]. Therefore, the high values of oil binding capacity are one of the positive properties of the prepared powder.

Foaming ability

Table 11 indicates the effect of pH on the foaming ability for samples of powders of stems, leaves, and vegetative parts of carrots at different pH values (4, 7, 10 and 12). It is evident that there is a gradual increase in all

parameters with increasing pH value, except pH 12, as the values were 10, 20, 29 and 19% in the stem powder and 31, 55, 63 and 51% in the leaves powder, and 22, 40, 70, and 60%, in the vegetative part powder, which includes both the stem and leaves, respectively.

Table 8 indicates the effect of pH on the foam stability of samples of carrot stems, leaves, and vegetative parts powders under study at different pH values (4, 7, 10, 12), and during 15, 30, 45, and 60 minutes.

The results of the table indicate that the foam disappears after 15 minutes at pH 4 for all powders (stem, leaves, and vegetative parts), where the percentage of foam stability was zero for all times. It is clear from the table that the highest foam stability is at minute 15 and for all powders for the other pH values. The results of stem parameters indicate similar decline values for all remaining times, as they were 50%, except for the time of 30 minutes at pH 12, which recorded a higher value, amounting to 66.6%.

Aletor et al. [52] reported that the values of foam formation ability and foam stability of protein isolates prepared from the leaves of some plant species, including fernonia, green figs, and telferia squash, amounted to 8.1% (range, 4.1 to 18.0) and 2.2% (range, 2.0 to 2.9), respectively. This indicates that these values are very low compared to the current study. The reason for this is that these values belong to the protein part only, while our study dealt with powdered vegetable parts, which contain other components in addition to proteins. These components may contribute to increasing the ability to form foam and its stability.

Jayabrata Saha and Sankar Chandra Deka [51] found that the foaming ability of protein concentrate prepared from edible fern leaves was between 31.10 and 36.36%, and foam stability values were between 6.99 and 7.27%.

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Table 8. Effect of pH on foam stability of stem, leaf, and vegetative part powders

Foam stability (%)													Foaming ability (%)			
Sample	Stem				Leaves				Vegetative parts				L.S.D.				
Time / pH	15	30	45	60	15	30	45	60	15	30	45	60		Stem	Leaves	Vegetative parts	L.S.D.
4	50	50	50	50	50	50	50	50	50	50	50	50	2.50 NS	10	31	22	5.77 *
7	75	50	50	50	85.7	85.7	57.1	42.8	50	50	40	40	8.42 *	20	55	40	7.04 *
10	75	50.0	50.0	50.0	66.6	66.6	66.6	61.6	78.0	66.0	50.0	40.0	7.97 *	20	63	70	8.66 *
12	66.6	66.6	50.0	50.0	87.9	75.0	62.5	62.5	77.5	70.0	53.5	45.0	8.65 *	19	51	60	8.59 *
L.S.D.	7.02 *	6.69 *	2.75 NS	2.75 NS	7.95 *	8.02 *	7.44 *	7.37 *	8.55 *	7.21 *	6.79 *	5.88 *		4.39 *	8.52 *	8.71 *	

* (P≤0.05)

Conclusion

Carrot leaves and stems had relatively high percentages of carbohydrates, proteins and lipids. This makes them an excellent choice for enrichment of some low nutritional value food products. Active compounds in leaves and stems carrots, suggest that are a beneficial source of some products

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