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Preparation and Evaluation of High Nutrition Value Crackers Enriched With Some Leafy Vegetables

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ABSTRACT

The present study is carried out to evaluate the nutritional, functional, and sensorial properties of crackers enriched with green leafy vegetables powder (GLVP) namely (chicory, dill, coriander, parsley, and rocket) at 5, 10 and 15 % replacement of dried leaves/100 g wheat flour. Crackers were found to be nutritionally rich in protein, fiber, minerals and antioxidant activity compared with control crackers. Sensory properties of crackers showed that up to 10% wheat flour replacement of green leaves powder were acceptable. Results showed that the highest content of protein observed in crackers with 10% parsley, the highest content of ash was in crackers with 10% dill and the highest content of crude fiber and fat content in crackers with 10% chicory compared with control. There was a significant increment in the antioxidant activity with the addition of green leaves powder. The highest content of antioxidant activity and total phenolic content of prepared crackers with dill (38.64% -83.06 mg /100g) respectively, but the highest content of total Flavonoids in crackers with 10% chicory (67.5 mg /100gm). The highest content of chlorophyll a was in the crackers with 10% rocket and the lowest content in the crackers with 10% dill but the highest content of chlorophyll b was in the crackers with 10% coriander and the lowest was in crackers with 10% dill on the other hand the highest carotenoids was in the crackers with 10% coriander but the lowest was in crackers with 10% dill.

1. Introduction

As a result of the increasing demand for functional foods, companies have led to the tendency to manufacture new products with nutritional value which considers a source of bioactive compounds. Green leafy vegetables are considered rich in total phenolic contents, flavonoids, pigments, carotenoids, and antioxidant activity (Zeb, 2017). In addition, it is an excellent source of water-soluble vitamins and vitamin A as well as minerals (like calcium, iron, zinc, and phosphorus), fiber, which have biological effect in human health (Kavitha and Ramadas 2013) and (Natesh et al., 2017). These effects include those that are anticancer (Vinholes and Vizzotto 2017), antidiabetic (Maser et al., 2023), anti-obesity (Paul and Majumdar 2022), antimicrobial, anti-Alzheimer's disease (Eruygur et al., 2019), anti-tyrosinase activity (Blahova et al., 2021) and reducing cholesterol levels (Otles and Ozgoz 2014). Chicory (Cichorium intybus L.) is a species of the Asteraceae family and is considered an annual plant. Dried roots are added to coffee to enhance flavor and fresh leaves can be added to salads and vegetable dishes (Jurgo et al., 2011). The plant reportedly has a significant source of chicoric acid and dietary fiber. By the side of, chicory contains saccharides, organic acids, polyphenols such as chlorogenic and caffeic acid (Denev et. al., 2014). Numerous clinical research have verified the health benefits of chicory and its products, which includes modification of gut microflora, improving immune response, Appetite control and body weight, mineral absorption, body

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weight, mineral absorption, and bone health (Micka et al., 2017). Dill (Anethum graveolens L.) is a species of the Apiaceae family and is fragrant herb that is used for flavoring various foods, including salads, sauces, soups and sea foods. Furthermore, dried dill leaves are utilized in conventional herbal medicine. Dill is utilized to treat some gastrointestinal disorders and many digestive problems (Derakhshan et al., 2017). Various compounds found in dill including vitamin C and polyphenols, which enhance its anticancer properties (Craig, 2021). Dill rich in minerals (Gautam et al., 2013) contains vitamin A plus fiber, which play an important role in regulating cholesterol and digested carbohydrates, (Hammod et al., 2019). Coriander (Coriandrum sativum) is a species of the Apiaceae family and is considered a valuable herb and has a pleasant aromatic odor. Leaves are particularly rich in vitamin A, vitamin C, and vitamin K, with a moderate of elements content (Dhanapakiam et al., 2008). Coriander improves digestion and treating gastrointestinal disorders (Jabeen et al., 2009). Dry coriander reduces acidity and cure diarrhea (Kaium, 2013). This plant has a wide range of biological effects including antioxidant activity, anti-diabetic, antimicrobial activity, anti-convulsant activity, hypnotic activity, anti-helminthic, and anti-mutagenic activity (Aissaoui & Lyoussi, 2011 and Rajeshwari & Andallu, 2011).

Parsley (Petroselium crispum) is a species of the Apiaceae family and utilized as an aromatic food additive and flavoring (Zhang et. al., 2006). Parts of Parsley are rich in minerals like iron, zinc, calcium, and phosphorous, also contain fatty acids like linolenic and palmitic acid, furanocoumarins, essential oils, flavonoids, carotenoids, vitamins like tocopherols, A, C, and B complex, (Petropoulos et. al., 2008). Parsley has various biological effects in human health such as antioxidant activity, hepatoprotective, antibacterial, antifungal, analgesic, diuretic, hypotensive and gastroprotective (Farzaei et al., 2013). It also helps control immune diseases such as inflammation, anemia, hyperlipidemia, diabetes as well as lessen the symptoms of allergies, chronic bronchitis, dyspepsia, hypotension, thrombosis, and stroke. (El-Sayed et al., 2018 and Chauhan et al., 2018). Rocket (*Eruca sativa*) is a species of the Brassicaceae family. It is a medicinal plant that is characterized by its pleasant bitter taste. (Khoobchandani et al., 2011). Vitamin C is abundant in Rocket leaves along with other vitamins, such as vitamins A, K, B complex (Gutiérrez et al., 2018). It also contains many bioactive compounds, mainly glucosinolates and polyphenolic compounds (Sut et al., 2018). High mineral content, and many health-promoting substances (Esiyok et al., 2010). It was used as an innovative cancer prevention agent and potent active component plant that may improve human health (Michael, 2011). Crackers are a kind of crunchy, crispy and thin baked snack food. They are prepared with a blend of flour, water, and other ingredients, such as salt, sugar, yeast, oil, or butter. Crackers are available in different shapes and sizes, and they can be plain or flavored with cheese herbs or spices (Manley, 2011). The objective of this work was to study the nutritional and functional of some dried green leafy vegetables (Chicory, Dill, Coriander, Parsley, and Rocket) powders in cracker manufacturing and the effect of adding these dried leaves on the sensory properties, nutritional and functional attributes of crackers.

Materials and Methods

Materials

-Fresh chicory, dill, coriander, parsley, and rocket were obtained from the local market in Zagazig, Sharqia governorate, Egypt.

-Wheat flour of 72% extraction rate, table salt, sodium bicarbonate, and vegetable oil required for the preparation of crackers were obtained from the local market. All chemicals used were of analytical reagent grade.

Methods

Preparation of raw materials

-Fresh chicory, dill, coriander, parsley, and rocket leaves were washed, then cut to thin slices and air dried then, completely dried in an oven with a fan at 50 ˚C for 15:20 minutes. Net weights after drying (100 g) leaves were (14.36, 12.48, 13.24, 13.60 and 14.08 g).

The dried leaves were milled and sieved at 72 mesh (around 210 μm) then kept in airtight jar and stored in dry place.

Analytical methods

Chemical analysis of dried leaves and prepared crackers

Moisture, protein, crude fiber, fat, and ash were determined according to methods cited in the (AOAC, 2016). The total carbohydrate content was calculated according to the following formula:

Total carbohydrates content % = (100 - ash% +fat% +crude protein% +crude fiber %)

According to (James 1995), the following formula was used to determine the meal formulation's overall energy value:

Total energy (kcal/100g) = [(% carbohydrates ×4) + (% protein ×4) + (% fat × 9)].

Elemental analysis for iron, calcium, and zinc was determined by using an atomic absorption spectrophotometer as described in (AOAC, 2019)

Total phenols and flavonoids determination

According to (Singleton and Rossi, 1965) total phenol content was determined using the Folin-Ciocalteu method. The absorbance was read at 765 nm using gallic acid as a standard. Total flavonoids were determined using the aluminum chloride colorimetric method, as reported by (Chang et al., 2002).

Determination photosynthetic pigment

Chlorophyll a, chlorophyll b, and total carotenoids contents (mg/g dry weight) were determined according to the method mentioned by (Gogoi & Basumatary 2018 and Nagata & Yamashita 1992).

Antioxidant activity

The antioxidant activity of dried leaves and crackers samples was measured by a DPPH assay. The antioxidant activity was evaluated by the 1, 1-diphenyl-2-picrylhydrazyl (DPPH) radical scavenging method according to the procedure of (Chen et al., 2008). The percentage inhibition of the DPPH radical by the samples was calculated according to the following equation:

DPPH radical-scavenging activity (%) = [(A - B)/A] ×100.

Where, A is the absorbance of the control and B is the absorbance of the samples.

Technological properties

Preparation of crackers

The crackers enriched with different levels of green leafy vegetable powder were prepared using wheat flour (72% extraction rate) as the control and with 5, 10, and 15% replacement of dried leaves/100 g wheat flour as follow:-, sodium bicarbonate (1g), salt (2g), sugar (1g),were mixed, then oil (20 ml), and water(15ml) were added according to the method mentioned by AACC (2000) with some modifications**.** Then, the dough was formed into a thin layer and shaped into triangles. It was baked in an oven for 15 minutes at 180°C.

Physical characteristics of crackers

Crackers enriched with different levels of green leafy vegetable powder were evaluated for their physical characteristics (weight, volume, and thickness) parameters according to **(**AACC 2004), and bulk density was measured according to (Abd Elmoneim et al., 2005).

Texture Profile Analysis (TPA)

The texture of the Crackers was carried out using the Brookfield CT3 instrument (Brookfield Engineering Laboratories, Inc., MA 02346-1031, USA) according to the method outlined in the AACC (2010). Both hardness which relates to the "force applied by the molar teeth to compress the food", and fractur ability which relates to the "ability to break food into pieces when it is bitten using the incisors" were expressed in Newton (N). The following test settings were used:

Target =3.0 mm, trigger load = 3.00 N, test speed = 3.00 mm/s, return speed = 3 mm/s, and number of cycles = 1.0.

Color measurement

The colorimetric measurements for crackers were measured in triplicate using a colorimeter (CR -10, Konica Minolta Sensing Inc., Japan), according to (McGurie, 1992). The color values were recorded as: L^* = lightness (0 = black, 100 = white), a^* (-a^*

= greenness, $+a^*$ = redness), and b^* ($-b^*$ = blueness, $+b^*$ = yellowness).

Determination of water activity (a_w)

Water activity was measured at 25±2 °C using a Decagon Aqualab meter series 3TE (Pullman, WA, USA). All crackers samples were broken into small pieces immediately before water activity measurement (Shahidi et al., 2008).

Sensory evaluation

Sensory evaluations for crackers enriched with different levels of GLVP were carried out by 10 members of the Crops Technology Department, Food Technology Research Institute, Agricultural Research Center, Giza, Egypt. The judges were asked to give a score color, flavor, smell, appearance, crispiness and overall acceptability on a 9-hedonic scale from one (dislike extremely) to nine (like extremely) according to according to (Akonor et al., 2016) with slightly modification.

Statistical analysis

The data obtained (mean of three replicates) were statistically analyzed according to statistical analyses system user's guide (SAS, 2004). Analysis of variance (ANOVA) and Duncan's multiple comparison procedure were used to compare the means. A probability of $p<0.05$ was used to establish statistical significance.

Results and Discussion

Chemical composition of green leafy vegetables powder (GLVP)

Nutritional composition of GLVP is shown in Table 1. It could be noticed that dried parsley leaves had the highest values of both fat (4.00%) and protein (21.88%). dried chicory leaves recorded the highest values of moisture and crude fiber (8.05 and 10.05%, respectively), and dried rocket and parsley leaves recorded the highest values of ash (12.5% and 11.8%, respectively). These results are confirmed by those obtained by (El Shewey et al., 2005 and Amer et al., 2009). Results also indicate that rocket leaf powder has high amounts of element content. On the other hand, the highest content of calcium and iron was found in dried rocket and parsley leaves (873.71 and 816.29 mg/100g) and 69.14 and 61.56 mg/100g, respectively, while zinc was found in dried rocket and dill leaves (11.78 and 8.55 mg/100g, respectively). These results agreed with (El Shewey et al., 2005), who reported that chicory leaves have minerals like calcium, zinc, and iron (853.77, 5.72, and 84.28 mg/100 g, respectively), (Georgi et al., 2018), who confirmed that Bulgarian and Italian rockets have zinc of (9.105, 1.507 mg/100g, respectively), and (Deepali and Roji 2020), who investigated that coriander leaf powder was rich in essential element content like calcium (2805.46 mg/100g) and iron (42.1mg/100g) in which there are variation in calcium content may be as a result of different environmental condition like temperature, soil type and fertilization.

Total phenolics, Total flavonoids, chlorophyll a and b, total carotenoids content, and antioxidant activity of green leafy vegetables powder (GLVP)

Total phenolic compounds found in plants which increase the natural antioxidants in human diets when consumed plant- based foods (Balasundram et al., 2006). Results in Table 2. showed that the total phenolic content of all green leafy vegetables powder was around 85 to 90 mg/100 g, with dill having the highest content (90.35 mg/100g) and coriander having the lowest content (85.94 mg/100g). Results also showed that chicory and coriander leaves had the highest content of total flavonoids (9.07 and 9.00 mg/100g), while parsley leaves contained the lowest content (4.5 mg/100g). From the same table, the highest value of chlorophyll a was in coriander leaves and the lowest value in dill and rocket leaves, but the highest value of chlorophyll b was in chicory leaves and the lowest value in parsley leaves. On the other hand, the highest carotenoid was in chicory and coriander leaves, but the lowest was in dill. Results in Table 2. showed the highest value of the antioxidant activity was in dill and chicory leaves (86.40 and 86.13%), while the lowest value was in coriander leaves (84.26%). These findings of antioxidant activity are confirmed by those of (Deepali and Roji 2020), who proved that the scavenging activity of coriander leaf powder was 93.34%.

Table 1. Nutritional composition of green leafy vegetables powder (g/100g dry weight basis)

Dried green leaves	Moisture %	Ash %	Protein %	Crude Fiber %	Fat %	Total Carbohydrates %	Element content (mg/100g)		
							Calcium	Zinc	iron
Chicory	8.05^{a} ±0.01	10.90^{c} ±0.19	20.46^{c} ±0.05	10.05^{a} ±0.02	3.90^{b} ±0.13	54.69^{c} ±0.22	745.54^{c} ±4.63	7.60^{d} ±0.007	57.50^{c} ±0.012
Dill	6.90^{d} ±0.12	10.50^{d} ±0.16	21.17^{b} ±0.02	9.16^{d} ±0.01	2.50^{d} ±0.19	56.67^{b} ±0.21	720.54^{d} ±9.91	8.55^{b} ±0.001	41.01^{e} ±0.013
Coriander	7.26^{c} ±0.01	9.60^{e} ±0.18	18.91^{e} ±0.07	9.45^{c} ±0.05	3.60^{c} ±0.18	58.44^{a} ±0.22	575.02^{e} ±5.29	8.13^{c} ±0.004	41.48^{d} ±0.001
Parsley	6.70^{e} ±0.10	11.80^{b} ±0.19	21.88^{a} ±0.04	9.05^{e} ±0.03	4.00^{a} ±0.15	53.37^{e} ±0.20	816.29^{b} ±4.87	7.44^{e} ±0.032	61.56^{b} ±0.001
Rocket	7.50^{b} ±0.10	12.50^{a} ±0.14	19.48^{d} ±0.02	9.95^{b} ±0.03	3.90^{b} ±0.13	54.17^{d} ±0.195	873.71^{a} ±5.53	11.78^{a} ±0.006	69.14^{a} ±0.007

Data are presented as means ± SDM (n=3) & Means within a column with different letters are significantly different at $P \leq 0.05$.

Table 2. Total phenolic, Total Flavonoids, chlorophyll a and b, Total carotenoids content and Antioxidant activity, of green leafy vegetables powder.

Dried green leaves	Total phenolic (mg /100gm)	Total Flavonoids (mg /100gm)	Chl. a (mg/g)	Chl. b (mg/g)	Total Carotenoids (mg/g)	Antioxidant activity (%)
Chicory	90.09^{ab}±1.46	9.07^{a}±1.02	0.488^{b}±0.002	1.25^{a}±0.001	0.238^{a}±0.003	86.13^{a}±0.075
Dill	90.35^{a}±1.56	8.50^{a}±1.2	0.461^{d}±0.001	1.126^{e}±0.002	0.221^{d}±0.001	86.40^{a}±0.377
Coriander	85.94^{c}±0.81	9.00^{a}±2	0.496^{a}±0.003	1.229^{b}±0.001	0.238^{a}±0.002	84.26^{c}±0.105
Chicory	87.80^{bc}±1.47	4.50^{c}±2.2	0.481^{c}±0.002	1.158^{d}±0.002	0.229^{c}±0.002	85.75^{b}±0.16
Rocket	86.53^{c}±1.24	5.91^{b}±1.03	0.462^{d}±0.001	1.216^{c}±0.001	0.236^{b}±0.001	85.50^{b}±0.03

Data are presented as means ± SDM (n=3) & Means within a column with different letters are significantly different at P ≤ 0.05.

Sensory evaluation of crackers enriched with green leafy vegetables powder (GLVP)

Crackers enriched with different levels of green leafy vegetable powder (GLVP) were evaluated for their sensory qualities and overall acceptability, as presented in Table (3). Results show that there is no significant effect in samples enriched with 5% or 10% with (GLVP) and control sample in overall acceptability. The results of sensory evaluations indicated that sensory qualities and overall acceptability scores of crackers decreased by increased levels of (GLVP) up to 10% replacement in samples as compared to control sample (100% wheat flour). Also, there are no significant differences between control sample and other samples enriched with 10% (GLVP) in flavor, appearance and overall acceptability. Therefore, it could be recommended that it could produce crackers with good quality and acceptable sensory quality attributes with enriched up to 10 % of (GLVP). Those results agree with (Jyoti, et al., 2022) who investigated that cookies and biscuits were found acceptable up to 10 % level of fortification of green leafy vegetables.

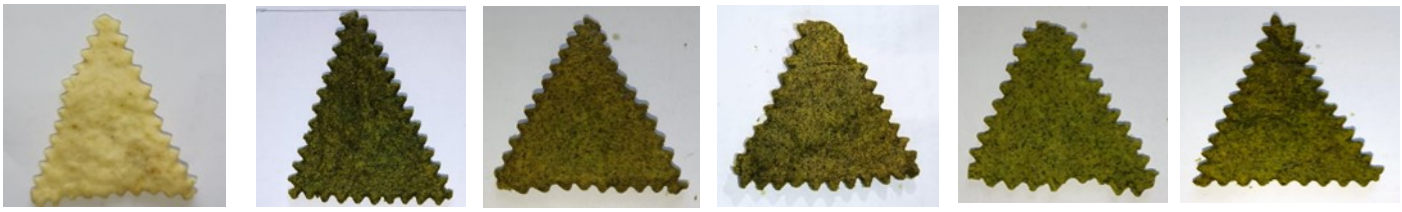
Physical properties of crackers enriched with (GLVP)

Physical properties weight (g), volume (cm^3), bulk density (g/cm3), and thickness (mm) are important for both manufacturers and consumers. Table 4. shows the physical properties of the resultant crackers prepared from a mixture of wheat flour and 10% GLVP replacement for several physical characteristics. There was a significant increment in the weight, volume, and bulk density of cracker samples, especially with chicory, after supplementation (17.21g, 30.5cm^3, and 0.65g/m^3, respectively) compared with the control cracker sample (100% wheat flour) (11.96g, 15.0cm^3, and 0.55g/cm^3), respectively. This increase might be due to an increase in fiber and protein content in the prepared crackers. Similar results were obtained by (Yadav 2022). The thickness of the control crackers and the enriched crackers was 2.50, 1.95, 2.00, and 2.20 mm. (Johry et al., 2016) explained the increase in the high-water holding capacity of the additive.

Table 3. Sensory evaluation of crackers enriched with green leafy vegetables powder

Treatments	Color (9)	Smell (9)	Flavor (9)	Appearance (9)	Crispness (9)	Overall Acceptability (9)
Control	8.33^{a}±.816	8.33^{a}±0.82	8.00^{a}±1.10	8.00^{a}±1.10	8.08^{a}±1.02	8.16^{a}±0.52
Chi 1	6.83^{ab}±1.84	7.33^{ab}±2.25	7.83^{ab}±1.17	6.75^{ab}±1.89	8.00^{ab}±0.89	7.66^{ab}±0.03
Chi 2	5.75^{b}±2.57	6.16^{b}±1.84	6.50^{ab}±1.52	6.50^{ab}±2.43	7.66^{abc}±1.03	7.40^{ab}±1.36
Chi 3	4.91^{b}±2.50	5.83^{b}±1.94	6.00^{b}±1.41	5.83^{b}±2.14	6.50^{bc}±1.05	6.33^{b}±1.37
Par 1	6.33^{ab}±2.16	6.41^{ab}±1.91	6.25^{ab}±1.78	6.91^{ab}±1.28	7.33^{abc}±1.03	7.00^{ab}±1.10
Par 2	6.00^{ab}±1.90	6.50^{ab}±1.05	6.33^{ab}±1.63	6.33^{ab}±1.47	7.41^{abc}±1.36	6.79^{ab}±1.72
Par 3	5.50^{b}±2.43	6.66^{ab}±1.75	6.66^{ab}±1.63	6.33^{ab}±1.97	7.00^{abc}±1.055	6.33^{b}±1.51
Cor 1	6.00^{ab}±1.41	6.50^{ab}±1.23	6.33^{ab}±1.63	6.00^{ab}±1.33	7.16^{abc}±1.17	7.16^{ab}±1.17
Cor 2	6.16^{ab}±2.14	7.00^{ab}±0.89	6.50^{ab}±1.64	6.33^{ab}±1.97	7.3^{abc}±1.21	7.41^{ab}±1.02
Cor 3	6.00^{ab}±2.28	6.5^{ab}±1.64	6.50^{ab}±1.05	6.33^{ab}±1.51	7.50^{abc}±1.38	6.50^{b}±1.23
Dil 1	7.08^{ab}±1.36	6.66^{ab}±1.37	6.83^{ab}±1.47	7.00^{ab}±1.67	7.66^{abc}±0.99	7.00^{ab}±1.27
Dil 2	6.16^{ab}±2.32	6.58^{ab}±0.92	6.41^{ab}±1.56	7.00^{ab}±1.41	7.41^{abc}±1.02	7.16^{ab}±1.17
Dil 3	5.50^{b}±1.87	6.5^{ab}±1.38	6.33^{ab}±1.63	6.58^{ab}±1.63	7.25^{abc}±1.61	6.50^{b1}.64
Roc1	6.61^{ab}±1.02	5.77^{b}±0.75	6.16^{ab}±0.75	6.61^{ab}±0.49	6.16^{c}±0.75	6.83^{ab}±0.41
Roc2	6.22^{ab}±0.40	6.04^{b}±1.14	6.11^{ab}±0.78	6.16^{ab}±0.41	6.16^{c}±0.75	6.61^{ab}±0.80
Roc3	5.61^{b}±1.18	5.94^{b}±0.91	6.00^{b}±0.00	6.55^{ab}±0.50	6.16^{c}±0.75	6.11^{b}±0.17

In which, Control: cracker with %100 wheat flour, Chi 1, 2,3: cracker with5 ,10 and 15% chicory powder; Par 1, 2,3: cracker with 5 ,10 and 15% Parsley powder; Cor 1, 2,3: cracker with5 ,10 and 15%coriander powder; Dil 1, 2,3: cracker with5 ,10 and 15% dill powder and Roc 1, 2,3: cracker with5 ,10 and 15% rocket powder.
Data are presented as means ± SDM (n=10) & Means within a column with different letters are significantly different at $P \leq 0.05$.



Control Chi 2 Par 2 Cor 2 Dil 2 Roc 2

Figure 1. Crackers enriched with green leafy vegetables powder

In which,
Control: cracker with %100 wheat flour. **Chi 2**: cracker with10 % chicory powder. **Par 2**: cracker with 10% parsley powder.
Cor2: cracker with10% coriander powder. **Dil 2**: cracker with 10% dill powder. **Roc2**: cracker with 10% rocket powder.

Table 4. Physical properties of crackers enriched with green leafy vegetables powder

Treatments	Weight (g)	Volume (cm^3)	Bulk density (g/cm^3)	Thickness (mm)
Control	11.96^{e}±0.28	15.0^{e}±0.6	0.55^{bc}±0.005	2.50^{a}±0.01
Chi 2	17.21^{a}±0.99	30.5^{a}±0.5	0.65^{ab}±0.005	1.95^{d}±0.01
Par 2	14.88^{c}±1.02	21.5^{c}±0.5	0.69^{a}±0.1	2.00^{c}±0.02
Cor2	14.84^{c}±1.07	29.5^{b}±0.5	0.56^{bc}±0.2	2.00^{c}±0.01
Dil 2	15.65^{b}±1.35	30.5^{a}±0.5	0.50^{c}±0.1	2.00^{c}±0.02
Roc2	12.20^{d}±0.4	19.9^{d}±1	0.60^{b}±0.05	2.20^{b}±0.02

In which,
Control: cracker with %100 wheat flour. **Chi 2**: cracker with10 % chicory powder **Par 2**: cracker with 10 % parsley powder.
Cor2: cracker with10% coriander powder. **Dil 2**: cracker with 10% dill powder **Roc2**: cracker with 10% rocket powder.
Data are presented as means ± SDM (n=3) & Means within a column with different letters are significantly different at $P \leq 0.05$.

Proximate chemical composition of crackers enriched with (GLVP)

The proximate chemical composition of the produced crackers enriched with (GLVP) is presented in Table 5. Moisture, protein, fat, crude fiber, and ash of crackers made from wheat flour (control) were found to be significantly increased with the addition of (GLVP). The result revealed that enriched crackers would be of better quality as compared with 100% wheat flour crackers. The highest value of protein was observed in (Par 2) the sample with10% parsley, the highest value of ash was in (Dil 2) the sample with 10 % dill, and the highest value of crude fiber and fat content was in (Chi 2) the sample with 10% chicory, while the highest total carbohydrate and total energy were observed in the control. The decrease in carbohydrate content as the supplementation with dried green leaves increased may be due to the low carbohydrate content in dried green leaves. These results are similar to those of (Deepali and Roji, 2020). The highest values of total carbohydrate and total energy were observed in the control sample.

Table 5. Proximate chemical composition of crackers enriched with green leafy vegetables powder

Treatments	Moisture %	Ash %	Protein %	Crude fiber %	Fat %	Total Carbohydrates %	Total energy (kal/100gm)
Control	$3.0^{d}\pm0.13$	$0.46^{d}\pm0.01$	$11.35^{e}\pm0.04$	$0.56^{f}\pm0.12$	$15.02^{c}\pm0.01$	$72.57^{a}\pm0.12$	$470.86^{a}\pm0.5$
Chi 2	$3.7^{c}\pm0.15$	$1.1^{ab}\pm0.1$	$13.98^{c}\pm0.02$	$3.9^{a}\pm0.14$	$15.9^{a}\pm0.10$	$65.12^{f}\pm0.12$	$459.50^{d}\pm0.5$
Par 2	$4.5^{a}\pm0.19$	$0.86^{c}\pm0.01$	$14.49^{a}\pm0.03$	$1.8^{e}\pm0.17$	$15.8^{ab}\pm0.14$	$67.05^{b}\pm0.03$	$468.36^{b}\pm0.9$
Cor2	$4.1^{b}\pm0.17$	$1.01^{b}\pm0.01$	$14.27^{b}\pm0.02$	$3.4^{c}\pm0.11$	$15.4^{b}\pm0.12$	$65.92^{e}\pm0.03$	$459.36^{de}\pm0.9$
Dil 2	$4.1^{b}\pm0.14$	$1.3^{a}\pm0.1$	$13.84^{cd}\pm0.04$	$2.5^{d}\pm0.18$	$15.4^{b}\pm0.13$	$66.96^{c}\pm0.12$	$461.80^{c}\pm1.3$
Roc2	$3.8^{c}\pm0.13$	$0.99^{bc}\pm0.02$	$13.31^{d}\pm0.02$	$3.7^{b}\pm0.16$	$15.7^{ab}\pm0.15$	$66.30^{d}\pm0.2$	$459.73^{d}\pm0.04$

In which,
Control: cracker with %100 wheat flour. **Chi 2**: cracker with10 % chicory powder. **Par 2**: cracker with 10 %parsley powder. **Cor2**: cracker with10% coriander powder. **Dil 2**: cracker with 10% dill powder **Roc2**: cracker with 10% rocket powder.
Data are presented as means ± SDM (n=3) & Means within a column with different letters are significantly different at $P \leq 0.05$.

Textural properties and water activity of crackers enriched with (GLVP)

Texture is an important factor that affects the final product acceptability. Texture analysis is used to determine the hardness of the product (Gumte et al., 2018). The data in Table 6. showed that hardness and fractur ability decreased with the addition of GLVP compared with the control (77.92 N). The results are in agreement with the work by (Thanaa et al., 2019 and Afify, 2022). The crackers enriched with green leafy vegetables showed a significant difference in a_w; the value of a_w ranged from 0.184–0.364 in present study. The highest value of a_w was in (Roc 2) crackers enriched with 10 % rocket (0.364) when compared with the control (0.264). All samples presented showed values of a_w less than 0.50. (Fontana,1998) demonstrated that the measurement of water activity can help predict food stability and safety in terms of microbial growth, deterioration reactions, and chemical and physical characteristics.

The color properties of crackers enriched with green leafy vegetable powder are presented in Table 6 in terms of L^*, a^*, and b^* values. The lightness values were in the range of 47.59 to 84.33, which was significantly reduced by the addition of green leafy vegetable powder compared to the control. a^* values varied between -0.80 and -4.90, indicating significant increases in the green color of the crackers as the wheat flour was partially replaced with GLVP. a^* values were significantly increased with the incorporation of dill and rocket powder. On the other hand, b^* values varied between 12.76 and 20.42 as the proportion of green leafy vegetable powder increased due to the green and yellow colors originating from green leafy vegetable powder.

Table 6. Water activity, textural properties and color properties of crackers

Treatments	Water activity (a_w)	Hardness (N)	Fracturability (N)	color properties		
				L*	a*	b*
Control	0.264^{b}±0.009	77.92^{a}±0.02	77.92^{a}±0.02	84.33^{a}±0.78	-0.80^{a}±0.22	19.61^{b}±0.29
Chi 2	0.232^{c}±0.002	53.81^{b}±0.03	53.81^{b}±0.03	47.59^{d}±0.19	-2.62^{c}±0.09	12.76^{e}±0.08
Par 2	0.231^{c}±0.001	52.95^{c}±0.01	13.62^{f}±0.02	50.71^{c}±1.19	-1.36^{b}±0.11	15.79^{c}±0.22
Cor2	0.209^{e}±0.002	27.35^{e}±0.02	21.4^{d}±0.05	48.37^{d}±0.02	-2.47^{c}±0.08	13.65^{d}±0.2
Dil 2	0.184^{f}±0.003	41.62^{d}±0.01	20.4^{e}±0.03	51.30^{c}±0.32	-4.90^{e}±0.12	19.47^{b}±0.33
Roc2	0.364^{a}±0.005	26.16^{f}±0.05	24.98^{c}±0.01	52.48^{b}±0.08	-3.38^{d}±0.06	20.42^{a}±0.08

In which,
Control: cracker with %100 wheat flour. **Chi 2**: cracker with10 % chicory powder. **Par 2**: cracker with 10 %parsley powder; **Cor2**: cracker with10% coriander powder. **Dil 2**: cracker with 10% dill powder **Roc2**: cracker with 10% rocket powder.
L* = lightness (0 = black, 100 = white), a* (-a* = greenness, +a* = redness), and b* (-b* = blueness, +b* = yellowness).
Data are presented as means ± SDM (n=3) & Means within a column with different letters are significantly different at P ≤ 0.05.

Total phenolic, Total Flavonoids, chlorophyll a and b, Total carotenoids content and Antioxidant activity

There was a significant increase in the antioxidant activity, total phenols, and total flavonoids in the sample with the addition of green leaf powder which is presented in Table 7. The results in the same table showed the highest value of antioxidant activity and total phenolic content of Dil 2 (38.64% –83.06 mg/100 g), respectively, but the highest value of total flavonoids in Chi 2 (67.5 mg/100 g). Our findings agree with work by (Jyoti et al., 2022), who reported higher antioxidant activity in biscuits supplemented with spinach leaf powder compared with control. It could be shown in Table 7. that there were significant differences in the total carotenoids and chlorophyll of crackers enriched with green leafy vegetable powder. The highest value of chlorophyll a was in Roc 2 (0.474 mg/g) and the lowest value in Dil 2 (0.184 mg/g), but the highest value of chlorophyll b was in Cor 2 (0.465 mg/g) and the lowest in Dil 2 (0.106 mg/g). On the other hand, the highest carotenoids were in Cor 2 (0.169 mg/g), but the lowest were in Dil 2 (0.110 mg/g).

Table 7. Total phenolic, Total Flavonoids, chlorophyll a and b, Total carotenoids content and Antioxidant activity, of crackers enrichment with green leafy vegetables powder.

Treatments	Total phenolic content (mg/100g)	Total Flavonoids (mg/100g)	Chl. a (mg/g)	Chl. b (mg/g)	Total Carotenoids (mg/g)	Antioxidant activity (%)
Control	33.38^{e}±3.12	19.1^{e}±1.95	ND	ND	ND	6.43^{e}±0.15
Chi 2	72.81^{ab}±2.19	67.5^{a}±2.10	0.215^{d}±0.001	0.289^{d}±0.002	0.139^{c}±0.002	37.88^{b}±0.26
Par 2	66.67^{c}±1.84	20.7^{de}±1.80	0.282^{b}±0.003	0.300^{c}±0.001	0.157^{b}±0.003	37.76^{b}±1.26
Cor 2	61.99^{d}±1.12	23.5^{d}±1.85	0.263^{c}±0.002	0.465^{a}±0.003	0.169^{a}±0.001	31.62^{d}±2.33
Dil 2	73.06^{a}±1.63	39.1^{c}±1.85	0.184^{e}±0.002	0.106^{e}±0.011	0.110^{d}±0.003	38.64^{a}±1.85
Roc 2	71.52^{b}±0.99	55.7^{b}±1.90	0.474^{a}±0.001	0.410^{b}±0.001	0.135^{c}±0.001	37.33^{c}±1.73

In which,
Control: cracker with %100 wheat flour. Chi 2: cracker with10 % chicory powder. Par 2: cracker with 10% parsley powder.
Cor2: cracker with10% coriander powder. Dil 2: cracker with 10% dill powder Roc2: cracker with 10% rocket powder.
ND: non detected .
Data are presented as means ± SDM (n=3) & Means within a column with different letters are significantly different at P ≤ 0.05.

4. Conclusion

Healthy diet should include a lot of Green leafy vegetables, and their sufficient daily consumption could help prevent a lot of diseases. These leaves may help to meet our daily requirements of these and other essential nutrients, and they can form the cheapest and most readily available sources of protein (18.91-21.88%), fibers (9.05-10.05%), and ash (9.60-12.50%). Higher amounts of calcium and iron were found in dried rocket and parsley leaves (873.71 and 816.29 mg/100g) and (69.14 and 61.56 mg/100g), respectively, while zinc was higher in dried rocket and dill leaves (11.78 and 8.55 mg/100g, respectively). Crackers enrichment with green leafy vegetables powder (GLVP) could produce acceptable sensory quality attributes crackers with enrichment up to 10 % of (GLVP) with higher content of protein, fiber and mineral. Developing and consuming these value-added products can significantly improve the population's nutritional status, particularly for those suffering from micronutrient deficiency.

References

A.A.C.C. (2000). American Association of Cereal Chemists. Approved Methods. Ed. St. Paul. Minnesota, USA.

A.A.C.C. (2004). Approval Method of American Association of cereal Chemists Publ. by American Association of Cereal Chemists, In. St. Paul. Minnesota, USA. 2

A.A.C.C. (2010). Approved methods of Analysis 11th edition, Methods 10-15D, and 44-15. St-, Plau. MN.

A.O.A.C. (2016). Association of Official Analytical Chemists International Official Methods of Analysis 20th ed. Washinton, DC, USA

A.O.A.C. (2019). Association of Official Analytical Chemists. Official Methods of Analysis, 21st ed. Washington, D.C.

Abd Elmoneim O., Al-Khalifa, B. and Schiffler, R. Bernhard (2005). Effect of fermentation on the functional properties of sorghum flour. Food Chemistry 92(1):1-5

Aissaoui, A., Zizi, S., Israili, Z.H. & Lyoussi, B. (2011). Hypoglycemic and hypolipidemic effects of *Coriandrum sativum L.* in meriones shawi rats. Journal of Ethnopharmacology, 137 (1), 652-661.

Akonor, P. T., Nanam, T., Dziedzoave, E. S., Buckman, E., Mireku, Essel., Francis L. and Keith, Tomlins. (2016). Sensory optimization of crackers developed from high-quality cassava flour, starch, and prawn powder. Food science and Nutrition. 1-6

Amer, Thanaa A. M., S. L.L. Louz and Mona M. M. Doweidar (2009). Biochemical and technological evaluation of biscuits supplemented with nutritional plant sources rich in antioxidants. J. Agric. Sci. Mansoura Univ., 34 (4): 2953 – 2967.

Balasundram N., Sundram K., Samman S. (2006). Analytical, Nutritional and Clinical Methods Phenolic compounds in plants and agri-industrial by-products: Antioxidant activity, occurrence, and potential uses. Food Chem., 99: 191–203.

Blahova J, Martiniakova M, Babikova M, Kovacova V, Mondockova Vand Omelka R. (2021). Pharmaceutical drugs and natural therapeutic products for the treatment of type 2 diabetes mellitus. Pharmaceuticals 14(8): 806.

Chang L. W., Yen W. J., Huang S.C., and Duh P. D (2002). Antioxidant activity of sesame-coat. Food Chem, 78: 347–354

Chauhan, E. and Aishwarya, J. (2018). Nutraceuticals Potential of Petroselinum crispum: A Review. J. Complement. Med. Altern. Healthc., 7, 1–6.

Chen, Y.W., Wu, S.W., Ho, K.K., Lin, S.B., Huang, C. Y., and Chen, C. N. (2008). Characterization of Taiwanese propolis collected from different locations and seasons. J. Sci. of Food and Agriculture, 88(3): 412-419.

Craig, W.J. (2021). Health-promoting properties of common herbs, American Society for Clinical Nutrition, 491S-499S.

Deepali Mohite and Roji Waghmare (2020). The Fortification of Biscuits with Coriander Leaf Powder and its Effect on Physico-Chemical, Antioxidant, Nutritional and Organoleptic

Characteristics. International Journal of Food Studies, 9, 225-237.

Denev P, Petkova N, Ivanov I, Sirakov B, Urancheva R and Pavlov A. (2014). Determination of biologically active substances in taproot of common chicory (*Cichorium intybus L.*). Scientific Bulletin Series F. Biotechnologies 18:124–129.

Dhanapakiam, P., Joseph, J.M., Ramaswamy, V. K., Moorthi, M. and Kumar, A.S. (2008). The cholesterol lowering property of coriander seeds (*Coriandrum sativum*): Mechanism of action. Journal of Environmental Biology, 29 (1), 53 (56).

EL. Shewey, Madeha A., Ashgan E. nassef, Sahar o. Allam and Samiha M. Abdel Salam (2005). Fortification of some types of biscuit with iron – Rich plant additives. Egypt J. Agric. Res.,83(4).

El-Sayed, M.M., Metwally, N.H., Ibrahim, I.A., Abdel-Hady, H., Abdel-Wahab, B.S.A. (2018) Antioxidant Activity, Total Phenolic and Flavonoid Contents of Petroselinum crispum Mill. J. Appl. Life Sci. Int., 19, 1–7.

Eruygur N, Koçyiğit UM, Taslimi P, Ataş M, Tekin M and Gülçin İ. (2019). Screening the in vitro antioxidant, antimicrobial, anticholinesterase, antidiabetic activities of endemic Achillea cucullata (Asteraceae) ethanol extract. S Afr J Bot 120: 141-145.

Eşiyok, D., Bozokalfa, M.K., Yağmur, B. and Kaygisiz Aşçioğul, T. (2010). Nutrional value and economic plant properties of *E. sativa* accessions. Cruciferae Newsletter, 29, 42-45.

Farzaei, M.H., Abbasabadi, Z., Reza, M.; Ardekani, S., Rahimi, R., Ardekani, M.R.S., Rahimi, R., and Farzaei, F. (2013) Parsley: A review of ethnopharmacology, phytochemistry and biological activities. J. Tradit. Chin. Med., 33, 815–826.

Fontana A.J. (1998). Water activity: why it is important for food safety. Paper presented at the proceedings of the First NSF International Conference on Food Safety.

Gautam, P., Singh, K., Kalra, S., Khanna, D., Paliwal, Y.K. and Mehan, S. (2013). Dill Herb: Wall Against Dysfunctions: An Updated Profile. Int. J. Recent Adv. Pharm. Res. 4, 1–8.

Georgi Matev, Petya Dimitrova, Nadezhda Petkova, Ivan Ivanov and Dasha Mihaylova (2018). Antioxidant activity and mineral content of rocket (*eruca sativa*) plant from italian and bulgarian origins. J Microbiol Biotech Food Sci. 8(2):756-759.

Gogoi, M. and Basumatary, M. (2018). Estimation of the chlorophyll in seven citrus species of Kokrajhar district, BTAD, Assam, India. An Inter. J. Society for Tropical Plant Res. 5 (1):83-87.

Gumte, S.V., Taur, A.T., Sawate, A.R., and Kshirsagar, R.B. (2018). Effect of fortification of mango (*Mangifera indica*) kernel flour on nutritional, phytochemical and textural properties of biscuits. Journal of Pharmacognosy and Phytochemistry, 7(3), 1630–1637.

Gutiérrez, D.R., Lemos, L., Rodríguez, S.D.C. (2018) Effect of UV-C and ozone on the bioactive compounds and antioxidant capacity of minimally processed rocket (*Eruca Sativa Mill.*). Int. J. New Technol. Res., 4, 23–29.

Hammod, A. J., Areaaer, A.H. and Gatea, S.M. (2019). The effect of adding Dill (Anethum graveolens) leaves powder in the diets of broiler on some physiological properties. International Conference on Agricultural Sciences, Series: Earth and Environmental Science, 388,1-4.

Hayat M. N. Afify (2022). Use of Garden Cress (Lepidium sativum L.) Seeds to Produce some Healthy Bakery Products. Asian Food Science Journal 21(11): 12-21.

Jabeen, Q., Bashir, S., Lyoussi, B. and Gilani, A.H. (2009). Coriander fruit exhibits gut modulatory, blood pressure lowering and diuretic activities. Journal of Ethnopharmacology, 122(1):123-130.

James, C.S. (1995). General Food Studies. In: Analytical Chemistry of Foods, Blachie Academicand Professional, London, New York, Tokyo, Chapter 6, p 135.

Johry P., Samsher G.R., Singh B.R., Singh V., Chandra S. (2016). Development of cookies from potato flour and their quality evaluation. South Asian J. Food Technol. Environ; 2(1):309 -312.

Jyoti, Veenu Sangwan and Sudesh Jood (2022*)*. Sensory and Nutritional Analysis of Spinach Powder Fortified Biscuits Current Journal of Applied Science and Technology 41(8): 10-16.

Kaium, A. (2013). Yield and yield contribute of coriander (*Coriandrum Sativum L.)* as inuenced by spacing and variety (Doctoral dissertation, Department of Agricultural Botany, Sher-e-Bangla Agricultural University)

Kavitha V., Ramadas V.S. (2013). Nutritional composition of raw fresh and shade dried form of spinach leaf (*Spinach oleracea*). Bio Med Rx.1 (8):767 -770.

Khoobchandani, M., Ganesh, N., Gabbanini, S., Valgimigli, L., Srivastava, M. (2011) Phytochemical potential of *Eruca sativa* for inhibition of melanoma tumor growth. Fitoterapia, 82, 647 –653.

Manley, D. (2011). Manley's Technology of biscuits crackers and cookies. Wood head publishing series in food science, technology and nutrition. Elsevier Science, 4th Edition Pp. 54.

Maser W.H., Maiyah N., Nagarajan M., Kingwascharapong P., Senphan T., Ali A.M.M. and Bavisetty S.C.B. (2023). Effect of different extraction solvents on the yield and enzyme inhibition (a-amylase, aglucosidase, and lipase) activity of some vegetables. Biodiversitas 24 (6): 320-3331.

McGuire, R.G. (1992). Reporting of Objective Color Measurements. HortScience, 27, 1254-1255.

Michael, H.N., Shafik, R.E., Rasmy, G.E. (2011). Studies on the chemical constituents of fresh leaf of *Eruca sativa* extract and its biological activity as anticancer agent in vitro. Journal of Medicinal Plants Research, 5(7), 1184–1191.

Micka, A., Siepelmayer, A., Holz, A., Theis, C.H. and Scho¨n C. (2017). Effect of consumption of chicory inulin on bowel function in healthy subjects with constipation a randomized, double-blind, placebo-controlled trial. International Journal of Food Science and Nutrition 68:82–89.

Nagata, M. and Yamashita, I. (1992). Simple method for simultaneous determination of chlorophyll and carotenoids in tomato fruit. Vol 39. No, 10 :925-928.

Natesh, H., Abbey, L. and Asiedu S.K. (2017). An overview of nutritional and antinutritional factors in green leafy vegetables. Hortic. Int.l J. 1 (2): 58-65.

Otles, S. and Ozgoz, S. (2014). Health effects of dietary fiber. Acta Scientiarum Polonorum Technologia Alimentaria. 13(2):191-202.

Paul S. and Majumdar M. (2022). Comparative study of six antidiabetic polyherbal formulation for its multimodal approaches in diabetes management. 3 Biotech 12: 114.

Petropoulos, S.A., Daferera, D., Polissiou, M.G., Passam, H.C. (2008). The effect of water deficit stress on the growth, yield and composition of essential oils of parsley. Sci. Hortic., 115, 393–397.

Rajeshwari, C.U. and Andallu, B. (2011). Oxidative stress in niddm patients: Inuence of coriander (Coriandrum sativum) seeds. Research Journal of Pharmaceutical, Bio logical and Chemical Sciences, 2, 31(41).

Safoura Derakhshan, S., Navidinia, M. and Ahmadi, A. (2017). Antibacterial Activity of Dill (Anethum graveolens) Essential Oil and Antibiofilm Activity of Cumin (Cuminum cyminum) Alcoholic Extract. Infection Epidemiology and Microbiology, 3(4), 122-126.

SAS, (2004). Statistical Analysis System. SAS user's guide. Satatistics. SAS Inst. Inc. Ed., Cary, NC, U.S.A.

Shahidi, F., Sedaghat, N., Farhoosh, R., and Mousavi-Nik, H. (2008). Shelf-life determination of saffron stigma: Water activity and temperature studies. World Applied Sci. J., 5(2):132-136.

Singleton V. L. and Rossi J. A. (1965). Colorimetry of total phenolics with phosphomolybdic-phosphotungstic acid reagents. Am J. EnolVitic, 16:144–158.

Sut, S., Boschiero, I., Solana, M., Malagoli, M., Bertucco, A., Dall'Acqua, S. (2018). Supercritical CO2 Extraction of Eruca sativa using cosolvents: Phytochemical composition by LC-MS analysis. Molecules, 23, 3240.

Thanaa M. Amer Shams S.R. Omima, Hanan A. Hussien (2019). Production and evaluation of gluten free biscuits supplemented with chick-peas and carob. J. Biol. Chem. Environ Sci.;14 (3):57-71.

Vinholes J. and Vizzotto M. (2017). Synergisms in alpha-glucosidase inhibition and antioxidant activity of Camellia sinensis L. Kuntze and Eugenia uniflora L. ethanolic extracts. Pharmacognosy Res. 9(1):101-107.

Yadav, K.C., Sharad Bhattarai, Lila Devi Shiwakoti, Samrat Paudel, Milan Subedi, Bhoj Raj Pant, Mahendra Paudel, Shristi Dhugana, Saraswati Bhattarai, Tribhuwan Tiwari, Niranjan Koirala, Nada H. Aljarba, Saad Alkahtani, Gaber El-Saber Batiha, Ramesh Shiwakoti, and Jitendra Upadhyaya (2022). Sensorial and chemical analysis of biscuits prepared by incorporating Moringa flower powder and leaf powder. International journal of food properties. 25, 1, 894–906.

Zeb, A. (2017). A simple, sensitive HPLC-DAD method for simultaneous determination of carotenoids, chlorophylls and alpha tocopherol in leafy vegetables. J. Food Meas Charact 11 (3):979–986.

Zhang, H., Chen, F., Wang, X., Yao, H. (2006). Evaluation of antioxidant activity of parsley (*Petroselinum crispum*) essential oil and identification of its antioxidant constituents. Food Res. Int., 39, 833–839.