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Evaluation of Some Bakery Products Enriched with Purslane

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ABSTRACT

The goal of the current study was to assess the chemical and nutritional qualities of purslane leaves (PL) and purslane seeds (PS), as well as how adding purslane leaf and seed powder to biscuits and crackers would improve their nutritional content. Purslane leaves and seed powder recorded values of 5.55–8.52% moisture, 25.59–17.99% protein, 4.22–16.67% fat, 9.93–7.85% crude fiber and 13.6–10.72% ash on dry weight, respectively. Purslane leaves and seed powder contain adequate levels of the essential amino acids. Mineral compositions (mg/100g) were 2.2–1.4 Cu, 42.0–44.1 K, 4.5–4.1 Zn, 65.5–58.3 Ca, 88.2–87.3 Mg, 7.5–7.3 Mn, 4.9–4.1 Fe and 5.7–6.6 Na of purslane leaves and seeds, respectively. Purslane seed oil was rich in unsaturated fatty acids (88.16%) and saturated fatty acids (29.71%). The most abundant unsaturated fatty acids in purslane leaves and seeds were α-linolenic acid (41.69–55.92%) and linoleic acid (22.55–20.67%), respectively. Total phenolic (mg GAE/100g) was 255.3 and 576.56, total flavonoid (mg rutin equivalent/g DW) was 82.23 and 89.45 and antioxidant activity (mg/ml) was 1.84 and 3.35 for purslane leaves and seeds, respectively. 10% PL or 20% PS replaced in crackers increased the nutritional value and improved the functional properties, so it was selected. Sensory evaluation of biscuits with 5% PL or 20% PS replaced was the most acceptable level, having less significant ($p \leq 0.05$) color and sensory indices. Purslane seeds and leaves can be used in food applications as an excellent source of bioactive components. Egyptian cooking may benefit from purslane as a useful ingredient.

1. Introduction

While purslane (*Portulaca oleracea* L.) was a popular food in Ancient Egypt and the Roman Empire, its exact ancestry is unknown; the plant has been mentioned as far back as 4,000 years. Purslane may have evolved to survive in the Middle Eastern deserts based on its succulent leaves and stems. People eat purslane, which is considered to be the first vegetable ingested by humans. It is most popular in the Mediterranean region and is known as "Reglah" in Egypt (Rousseaux, 2023). In terms of its health advantages, *Portulaca oleracea* has been referred to as a "vegetable for a long life" in the Chinese medicinal culture of plants. It is used in folk and traditional medicine as a treatment for a variety of illnesses, such as dermatitis, abdominal pain, headache, inflammation, intestinal worms, high fever, urinary tract infections, etc., because it has a wide range of pharmacological effects (analgesic, antioxidant, anti-inflammatory, hypocholesterolemic, and hypoglycemic) (Fernández et al., 2021). Purslane is one of the richest plant sources of α-linolenic acid and is a high source of other omega-3 fatty acids as well. Additionally, it has a very intriguing omega-6/omega-3 ratio, which has been shown to be crucial for maintaining the right balance between these two types of essential fatty acids in the human body.

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This, in turn, helps to support healthy cardiovascular function, lower levels of cholesterol and triglycerides, and increase levels of healthy high-density lipoprotein (Liu et al., 2000; Azuka et al., 2014; and Stroescu et al., 2013). Proteins, carotenoids, and polysaccharides are all present in large quantities in this plant. It also contains a variety of minerals (Ca, Fe, Mn, P, and Se) and vitamins (A, C, E, and part of complex B) (Mishra et al., 2020). Abeer and Eman 2014, mentioned that purslane contains 24.0% protein, 5.26% fat, 22.66% ash, 8.0% fiber and 40.08% carbohydrates. Recent research has shown that purslane is an excellent supplier of vital amino acids as well (Stroescu et al., 2013). (Chen et al., 2019) found that the total amino acid content of purslane is 22.23 mg/g, whereas that of essential amino acids is 8.99 mg/g. The chemical composition of purslane powder revealed that crude fibers were 8.9% to 17.99% D.W. The plant material was characterised by high protein and ash content, which ranged from 18.58 to 24.9% and 16.50 to 27.0% DW, respectively (Hanan et al., 2014; Samuel et al., 2011; Shehata and Soltan, 2012). Polyphenols, which are found in abundance in purslane and include phenolic acids, total phenolic content, and total flavonoid content, have powerful antioxidant properties comparable to some naturally occurring antioxidants like vitamin C and vitamin E. Other components include dopamine, coumarins, alkaloids, saponins, a mucilage made of a neutral portion whose structure has been established, and anthocyanins. (Peksel et al., 2006; Farag and Zeinab, 2019).

Purslane, a healthy vegetable used for human consumption, has been described in ancient Egyptian writings from the time of the Pharaohs. In addition to being consumed cooked as a soup sauce or as greens, purslane is also consumed raw as a salad. Purslane is regarded as a plant with many health benefits. (Sudhakar et al., 2010). Purslane powder-infused prepared ice cream and cookie samples are wholesome and suitable for consumption by people of all ages. Additionally, it will contribute to consumer health improvement. (Mastud et al., 2018). Biscuits and crackers are a great snack that lasts a long time. However, because they are high-energy foods, there is a pressing need to boost their nutritional value. They are a type of candy that has been dried to an extremely low moisture level and is easy to make as it is a small, thin, crisp cake prepared from flour (Klunklin and Savage, 2018). The best amount of purslane powder to add to bakery products is 10% of the amount of flour used in the recipe, which has no effect on the quality of the finished goods, but adding more purslane powder—more than 10% can partially degrade the products' organoleptic qualities (appearance, volume, and consistency). The 10% addition of purslane powder to baked goods enhances their quality and organoleptic properties (Gurbanov et al., 2023). The purpose of this research is to examine the chemical composition and nutritional value of purslane leaves and seeds, as well as the potential use of purslane leaves or seed powder in the manufacture of high-nutritional baked goods (crackers and biscuits).

2. Materials and Methods:

Materials

The farm at the Agricultural Research Center in Giza, Egypt, is where the fresh purslane leaves were gathered. Commercial wheat flour, purslane seeds, salt, baking powder, oil, chilli, cumin, sugar, vanilla, butter, eggs, and skim milk powder were purchased from a local market in Giza, Egypt. All chemicals used were of analytical reagent grade.

Methods

Preparation of purslane leaves and seeds

Purslane leaves have been cleaned and plucked, and damaged leaves have been removed. They have been thoroughly washed with water, allowed to air dry for 24 hours, and then dried in an oven at 50°C overnight. The purslane seeds were cleaned and plucked, and the damaged seeds were removed. The purslane leaves and seeds were then pulverised in a laboratory hammer mill (manufactured by the German company Brabbener) until they could pass through a 125 mesh, and the dried leaf powder was stored in plastic vials until use (Yeh, 2004).

Analytical methods

Proximate Analysis

Chemical constituents (moisture, ash, crude protein, crude fiber and fat content) of dried purslane leaves or seeds samples were determined according to methods cited in the (AOAC, 2015). The values obtained for protein, fat and carbohydrate were used to calculate the calorific content value of the samples as expressed by (AOAC, 2015):

Calorific value (kcal/100 g) = P×4.0+F×9.0+C×4.0.

Where:

P = protein content (%), F = fat content (%), and C = carbohydrate content (%).

Mineral content for purslane and its seeds (magnesium, sodium, zinc, manganese, iron, calcium, potassium and copper) by using the flame photometer (Galienkamp, FGA 330, England) and Perkin Elmer Atomic Absorption Spectrophotometer (Model 80, England) as described in (AOAC, 2015). Amino acid determination of samples was performed according to the Official Method (AOAC 2015) using an amino acid analyzer (Biochrom 30). The fatty acids of the oil were converted to methyl esters by using sodium methoxide according to the method of (Hougen and Bodo, 1973).

Determination of total flavonoids, total phenols, and DPPH radical scavenging activity:

Total flavonoids were determined in purslane leaves and seeds using the aluminum chloride colorimetric method, as reported by (Chang et al., 2002). Total phenol content was determined according to (Singleton and Rossi, 1965) using the Folin-Ciocalteu method. The absorbance was read at 725 nm. Using gallic acid as a standard. The free radical scavenging activity was determined using the 2.2-diphenyl-2-picryl-hydrazyl (DPPH) method and the absorbance at 517 nm with some modifications according to (Fischer et al., 2013). The scavenging activity was calculated using 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 substituted with different percent of purslane leaves or seed powder

The crackers were made using a slightly modified version of the formula from (Han et al., 2010) approach. The process for creating crackers was as follows: Using a laboratory mixer, 100g of wheat flour (used as the control) and all of the other ingredients - oil (10g), salt (4g), cumin (1g), curcuma (2g), red pepper (0.5g), sugar (3g), and baking powder (2g) -were combined with water for 4 minutes. The resulting dough was then allowed to rest for 15 minutes before being shaped into the desired shape and baked for 6 minutes at 200°C. After baking, the crackers were allowed to cool at room temperature for one hour before being stored. Purslane leaves or seed powders at various replacement levels (5, 10, 15 and 20%) were used to replace wheat flour.

Physical properties of crackers

The physical properties of crackers (volume, weight, specific volume and height) were measured according to (Bose and Shams-Ud-Din, 2010).

Preparation of biscuits substituted with different percent of purslane leaves or seed powder

The following ingredients were used to make the biscuits: wheat flour (100g), sugar (30g), butter (30g), egg (15 ml), baking powder (1.5g), skim milk powder (1.5g), and vanilla (1.5g). The recipe was modified slightly from that in (AACC 2010). Using a Moulinex mixer, butter and sugar were combined to make the control biscuits for 5 minutes, or until a creamy hue developed. Whole eggs and vanilla were added, and the mixture was kept going for three minutes. Baking soda and flour were mixed and sifted before being added to the mixture and beating it for four minutes. The dough was then rolled out to a thickness of 0.25 cm and cut using a circular cutter with a diameter of 5 cm. The biscuits were placed on a baking sheet and baked at 175°C for 15 minutes. The biscuits were

wheat flour in the creaming stage to replace 5, 10, 15, and 20% of the levels of wheat flour (by weight). In polyethylene containers, several biscuit samples were maintained until examination.

Physical properties of biscuits samples

- Diameter or width, thickness (T), Spread ratio, weight, volume and specific volume were measured according to (AACC, 2010).
- Hardness: The force required to break the biscuits was measured according to the method of (Gómez-Aldapa et al., 1999) by using the digital force gauge (model FGN-50, Japan). The maximum force required to break the biscuits was reported in Neutin (N).

Sensory evaluation of prepared products

Sensory evaluation of crackers

Members of the Crops Technology Department, Food Technology Research Institute, Agricultural Research Center, Giza, Egypt, evaluated samples of crackers organoleptically. Each sample was coded, then shown in a random order according to (Levent and Şengül 2015) with slight modifications. The panel was asked to rate the various cracker samples on a nine-point hedonic scale, with nine being the most favorable and one being the least favorable, for appearance, color, odor, taste, crispness, and overall acceptability.

Sensory evaluation of biscuits

Members of the Crops Technology Department, Food Technology Research Institute, Agricultural Research Center, Giza, Egypt, evaluated samples of biscuits for their quality characteristics following baking and organoleptic evaluation. Each sample was coded before being presented in a random order. according to (Watts et al., 1989). The panelists were asked to rate the various biscuits on a 9-point shedonic scale, with 9 representing an intense likeness and 1 representing an extreme dislike, for appearance, color, texture, odor, taste, and overall acceptability.

Statistical analysis

Analysis of variance was performed on each piece of data. To compare two means, use Duncan's multiple range tests at the ($P \leq 0.05$) level. SAS Program 1996's PRO ANOVA technique was used to do the analysis.

3. Results and Discussion

Chemical Composition of Purslane leaves and seeds powder

Chemical composition of purslane leaves and seed powder is shown in Table 1. Data in Table 1. showed that purslane leaves powder had high contents in protein (25.59%), ash (13.60%) and fiber (9.93%), respectively, while purslane seed powder contains less amount of protein, ash and fiber (17.99, 10.72 and 7.85%). On the other hand, purslane seeds had the highest amount of fat (16.67%). These results are close to (Almasoud and Salem, 2014; Mastud et al., 2018; and Petropoulos et al., 2020). Mineral content of Purslane leaves and seeds (mg/100 g sample) is indicated in Table 1. Mineral composition analysis results found that magnesium (Mg) was the highest amount among all other minerals, followed by calcium (Ca), potassium (K), manganese (Mn), sodium (Na), iron (Fe), zinc (Zn) and copper (Cu) for both purslane leaves and seeds. Also, results showed that Mg, Ca, Mn, Fe, Zn and Cu contents in purslane leaves were higher than those found in purslane seeds. Variations in the mineral and chemical composition of purslane leaves reflect the difference in the floral origin of the plant and the plant growth conditions, such as soil and geographic origin. Results were lower than reported by (Hanan and Eman 2016) and higher than those of (Aberoumand, 2009). Purslane leaves and seeds were analysed for their contents of sixteen of the most quantitatively important amino acids, and the data obtained are presented in Table 1. Results showed that the major essential amino acids of purslane leaves and seeds were leucine (0.90, 1.19 g/100 g, respectively), followed by methionine + cysteine (0.72 g/100g) in purslane leaves and phenylalanine (0.90 g/100 g). These results are supported by (Jin et al., 2016), who found that the purslane leaves have fifteen amino acids. While (Tarkergari et al., 2013 and Almasoud and Salem, 2014) mentioned that the essential amino acid leucine was the highest (1.41%), while valine (0.7%) was in moderate amounts and low in threonine (0.57%).

Table 1. Chemical composition of purslane leaves and seeds (g/100g dry weight basis)

Sample	Moisture (%)	Protein (%)	Fat (%)	Crude fiber (%)	Ash (%)	Carbohydrate %	Calories (Kcal)
Purslane leaves	5.55± 0.23	25.59± 0.54	4.22± 0.08	9.93± 0.08	13.60± 0.07	41.11± 0.95	304.78
Purslane seeds	8.52± 0.04	17.99± 0.49	16.67± 0.15	7.85± 0.09	10.72± 0.11	38.25 ± 0.98	374.99

Minerals content (mg/100gm sample)

Sample	Cu	K	Zn	Ca	Mg	Mn	Fe	Na
Purslane leaves	2.2	42.0	4.5	65.5	88.2	7.5	4.9	5.7
Purslane seeds	1.4	44.1	4.1	58.3	87.3	7.3	4.1	6.6

Amino acids content

Essential Amino acids	g/100 gm protein		Non-Essential Amino acids	g/100 gm protein	
	Purslane leaves	Purslane seeds		Purslane leaves	Purslane seeds
Lysine	0.59	0.78	Glutamic	2.60	2.36
Methionine + cysteine	0.72	0.57	Aspartic	1.36	1.46
Isoleucine	0.54	0.65	Proline	0.52	0.73
Leucine	0.90	1.19	Alanine	0.59	0.84
Phenylalanine	0.65	0.90	Glycine	1.25	0.87
Tyrosine	0.71	0.29	Serine	0.53	0.63
Threonine	0.53	0.62	Arginine	1.52	0.79
Valine	0.66	0.79	Histidine	0.43	0.47
Total E.A.A.	5.3	5.79	Total Non E.A.A.	8.8	8.15

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

Fatty acids composition of Purslane leaves and seed powder

The composition of purslane leaves and seed oil was investigated using gas liquid chromatography. Table 2. provides information on the relative fraction of the detected fatty acids. From the tabulated data in Table 2., it was noticed that linolenic acid was the major unsaturated fatty acid in purslane leaves and seeds; it was high in seeds (55.92%) compared with the percent in leaves (41.69%).

Meanwhile, palmitic acid was the major saturated fatty acid in the investigated purslane leaves and seed oil (9.22 and 10.84%), followed by stearic acid, which is high in leaves (8.6%). Also, results have shown that GLA ($C_{18:3\ n6}$) was found in a small amount in both leaves (0.35%) and seeds (0.81%). On the other hand, the total saturated fatty acids (SFA) and unsaturated fatty acids (USFA) were 25.67, 29.71, and 80.72, 88.16% respectively, in leaves and seeds, respectively.

These outcomes are validated by (Osman and Hussein 2015; Almashad et al., 2019 and Petropoulos et al., 2019), who discovered that the most prevalent fatty acids in purslane seeds and leaves are linolenic acid, palmitic acid, and linoleic acid.

Purslane has the largest concentration of α-linlenic acid (3 fatty acids) among leafy green vegetables, which are crucial for human nutrition. (Kamal-Uddin et al., 2014).

Table 2. Fatty acids composition (%) of purslane seeds and leaves

Saturated Fatty acids	Leaves	Seeds	UnSaturated Fatty acids	Leaves	Seeds
Plamitic acid, ($C_{16:0}$)	9.22	10.84	Palmitoleic acid, $C_{16:1}$	1.14	1.58
Margarinic acid, $C_{17:0}$	0.75	2.79	Oleic acid, $C_{18:1}$	12.64	9.02
Stearic acid, $C_{18:0}$	8.6	7.99	Linoleic acid, $C_{18:2}$	22.55	20.67
Arachidic acid, $C_{20:0}$	1.55	1.14	α-Linolenic acid, $C_{18:3\ n6}$	0.35	0.81
Behenic acid, $C_{22.0}$	1.25	3.24	α-Linolenic acid, $C_{18:3\ n9}$	41.69	55.92
Lignoceric acid, $C_{24.0}$	1.85	2.26	Eicosenic acid, $C_{20:1}$	2.35	0.16
Cerotic acid, $C_{26.0}$	2.45	1.45	-	-	-
SFA	25.67	29.71	USFA	80.72	88.16

Total phenolic, total flavonoid content and antioxidant activity

Data presented in Table 3. showed that Total phenolic contents ranged between 255.3 mg GAE /100g to 576.56 mg GAE /100g DW in the purslane leaves and purslane seeds, respectively. The results of current analysis revealed that purslane seeds contained a considerably high amount of phenolic ingredients. The flavonoid contents were also higher in the purslane seeds with a value of 89.45 mg rutin equivalent/g DW compared to the purslane leaves at 82.23 mg rutin equivalent. From the obtained results (Table 3.) which showed that The IC_{50} of DPPH scavenging activity of the methanolic extract, was 3.35 mg/ml in the purslane seeds and 1.84 mg/ml in the purslane leaves, this results agreement with (Alam et al., 2014) who found that IC_{50}value for the 13 accessions of purslane extract in the study was determined and varied between 2.52 ± 0.03 mg/ml and 3.29 ± 0.01mg/ml indicating the highest antioxidant activity.

Table 3. Total phenolic, total flavonoid content and antioxidant activity.

Samples	Total phenolic (mg GAE/100g)	Total flavonoid (mg rutin equivalent/g DW)	Antioxidant activity (mg/ml)
Purslane leaves	255.3	82.23	1.84
Purslane seeds	576.56	89.45	3.35

Quality characteristics of prepared products

Sensory evaluation of crackers

Sensory evaluation of crackers made from different blends of wheat flour and purslane (leaves or seed powder) is shown in Table 4. Statistical analysis data for sensory scores of crackers containing different levels of purslane (leaves or seed powder) were used to choose accepted percent of purslane (leaves or seeds) suitable for producing high-quality crackers, and the means of sensory scores are given in Tables 4.

Results in Table 4. showed that replacing 20% of wheat flour with purslane seed powder in crackers formula didn't have any significant ($P \leq 0.05$) effects on taste, crispiness, or overall acceptability of crackers compared with the control sample (made of 100% wheat flour). Meanwhile, a significant ($P \leq 0.05$) decrease in taste, odor, crispiness, and overall acceptability was observed when increasing the purslane leaves by more than 10% replacement. This means it could produce high-quality crackers with 10% replacement of purslane leaves or with 20% purslane seed powder.

Table 4. Sensory acceptability scores of prepared crackers

Sample	Appearance (9)	Color (9)	Oder (9)	Taste (9)	Crispiness (9)	Overall acceptability (9)
Control	8.9[a]	8.95[a]	8.95[a]	8.85[a]	8.80[a]	8.95[a]
5% L	8.45[d]	8.05[c]	8.90[a]	8.45[c]	8.95[a]	8.85[b]
10% L	8.35[e]	7.05[d]	8.55[c]	8.1[e]	8.65[cd]	8.45[d]
15% L	7.05[g]	6.9[d]	7.75[e]	7.2[f]	7.8[e]	6.85[e]
20% L	5.0[h]	5.9[e]	6.75[f]	5.85[g]	6.55[f]	5.7[f]
5% S	8.9[a]	8.30[b]	8.95[a]	8.85[a]	8.9[a]	8.85[b]
10% S	8.80[b]	8.32[b]	8.95[a]	8.85[a]	8.9[a]	8.95[a]
15% S	8.6[c]	8.0[c]	8.75[b]	8.75[b]	8.8[ab]	8.63[c]
20% S	8.1[f]	8.1[c]	8.35[d]	8.05[d]	8.5[d]	8.55[d]

In which, control:-100% wheat flour, -5%L,10%L,15%L, and 20%L,- wheat flour substituted with 5,10,15,and 20 % of purslane leaves powders -5%S, 10%S, 15%S, and 20%S, wheat flour substituted with 5, 10, 15, and 20 % of purslane seeds powders.

Physical properties of highly accepted crackers

The physical properties of crackers made from different blends of wheat flour and purslane (leaves or seed powder) are shown in Table 5. Volume, weight, specific volume and thickness of crackers containing 20% of purslane seeds have a slight increase but are not significant (5.7, 4.18, 1.46, and 0.57, respectively) compared with control (5.57, 4.17, 1.44, and 0.55, respectively), while the volume, weight, specific volume and thickness of crackers containing 10% of purslane leaves have a significant decrease compared with control (100% wheat flour). There is a very slight, but not significant, decrease in hardness of crackers containing 20% purslane seeds compared with control (19.26 and 19.33, respectively). On the other hand, there is a significant increase in the hardness of crackers that contain 10% purslane leaves (21.05 N) compared with the control.

Table 5. Physical properties of highly accepted crackers

Samples	Volume (cm^3)	Weight (g)	Specific volume (cm^3/g)	Thickness (cm)	Hardness (N)
Control	5.57[a]	4.17[a]	1.44[a]	0.55[a]	19.33[a]
10%L	5.30[b]	3.93[b]	1.36[b]	0.47[b]	21.05[b]
20%S	5.70[a]	4.18[a]	1.46[a]	0.57[a]	19.26[a]

In which, control:-100% wheat flour,
-10%L:- wheat flour substituted with 10% of purslane leaves powders,
- 20%S:- wheat flour substituted with 20 % of purslane seeds powders.

Chemical composition of highly accepted crackers:

Chemical composition of crackers from different blends of wheat flour and purslane (leaves or seed powder) is shown in Table 6. Crackers that contain 10% of purslane leaves have the highest amount of protein (12.2%) compared with crackers that contain 20% of purslane seeds (11.9%) and control (10.6%). Also, there is an increase in the percentage of crude fiber, ash, and fat in crackers that contain 20% purslane seeds, followed by crackers that contain 10% purslane leaves and then control crackers (100% wheat flour).

Table 6. Chemical composition of highly accepted crackers

Samples	Moisture (%)	Crude Protein (%)	Crude fiber (%)	Ash (%)	Fat (%)	Total Carbohydrates (%)
Control	4.37[a]	10.6[c]	0.75[c]	2.8[c]	8.1[b]	73.38[a]
10%L	3.62[b]	12.2[a]	1.02[b]	4.39[a]	8.28[b]	70.49[a]
20%S	4.72[a]	11.9[b]	1.16[a]	4.54[a]	11.08[a]	66.6[b]

In which, control:-100% wheat flour,
-10% L:- wheat flour substituted with 10 % of purslane leaves powders
- 20%S:- wheat flour substituted with 20 % of purslane seeds powders.

Sensory evaluation of prepared biscuits

The highly regarded percent of purslane (leaves or seeds) suitable for producing high-quality biscuits was selected using statistical analysis data for sensory scores of biscuits containing different levels of purslane (leaves or seed powder). The means of sensory scores are given in Tables 7. Results in Table 7. showed that fortified wheat biscuits with 20% purslane seeds powder improved all studied sensory characteristics. Meanwhile, replacing more than 5% of wheat flour with purslane leaves powder in the biscuit formula was not accepted compared with control sample. Also, there were significant differences between the tested samples, including their overall acceptability. This means it could produce accepted biscuits with 5% replacement of purslane leaves or with 20% purslane seeds powder.

Table 7. Sensory evaluation of prepared biscuits

Sample	Appearance (9)	Color (9)	Texture (9)	Oder (9)	Taste (9)	Overall acceptability (9)
Control	8.93[a]	8.93[a]	8.77[a]	8.88[a]	8.88[a]	8.93[a]
5% L	8.53[c]	8.42[c]	8.47[b]	8.4[cd]	8.13[d]	8.72[c]
10% L	7.23[d]	6.73[d]	7.03[c]	6.58[e]	6.3[e]	6.5[f]
15% L	6.83[e]	5.47[e]	5.39[d]	5.13[f]	6.03[f]	5.17[g]
20% L	3.33[f]	4.03[f]	4.48[e]	4.23[g]	5.27[g]	4.85[h]
5% S	8.87[a]	8.87[a]	8.85[a]	8.83[ab]	8.9[a]	8.89[ab]
10% S	8.78[b]	8.57[b]	8.77[a]	8.73[b]	8.73[ab]	8.8[bc]
15% S	8.57[c]	8.4[c]	8.7[a]	8.47[c]	8.68[b]	8.5[d]
20% S	8.57[c]	8.35[c]	8.73[a]	8.3[d]	8.48[c]	8.38[e]

In which, control:-100% wheat flour,
-5%L,10%L,15%L,and 20%L:- wheat flour substituted with 5,10,15,and 20 % of purslane leaves powder.
-5%S, 10%S,15%S,and 20%S:- wheat flour substituted with 5,10,15,and 20 % of purslane seeds powder.

Physical properties of highly accepted biscuits

Data in Table 8. represent the physical properties of biscuits. There is a very slight increase in volume and spread ratio, but not significant, in biscuits that contain 20% purslane seeds compared with control. On the other hand, there is a slight decrease, but not significant, in weight, specific volume, diameter, thickness, and hardness of biscuits that contain 20% purslane seeds compared with the control. Otherwise, biscuits containing 5% purslane leaves show a significant decrease in all physical property parameters (volume, weight, specific volume, thickness, and spread ratio) compared with control except hardness, which shows a significant increase.

Table 8. Physical properties of highly accepted biscuits

Samples	Volume (cm^3)	Weight (g)	Specific volume (cm^3/g)	Diameter (cm)	Thickness (cm)	Spread ratio	Hardness (N)
Control	16.7^a	10.78^a	1.72^a	5.34^a	0.81^a	6.21^a	16.12^a
5%L	15.3^c	9.57^b	1.51^b	5.08^a	0.67^b	6.12^b	18.33^b
20%S	16.9^a	10.63^a	1.70^a	5.33^b	0.80^a	6.23^a	16.05^a

In which, control:-100% wheat flour,
-5%L:- wheat flour substituted with 5 % of purslane leaves powders
- 20%S: - wheat flour substituted with 20 % of purslane seeds powders.

Chemical composition of highly accepted biscuits

The Purslane biscuit samples' chemical composition was determined, and the results are displayed in Table 9. The results indicated that the protein content was increased from 14.09% in the control sample to 14.85% in 5%L sample and to 15.77% in the PS sample. There was a significant ($P \leq 0.05$) difference between control samples and when purslane leaves or seeds were added. These results showed that the 20% purslane seeds in the biscuit sample had the highest fat, ash, and fiber contents, with significant differences (13.40, 1.01, and 0.87%, respectively), followed by the 5% purslane leaves in the biscuit sample (11.37, 0.88, and 0.65%, respectively). While the control samples of biscuits (made with 100% wheat flour) had significantly lower levels of protein, fiber, ash, and fat.

Table 9. Chemical composition of highly accepted biscuits

Samples	Moisture %	Protein %	Crude fiber %	Ash %	Fat %	Carbohydrates %
Control	5.13^b	14.09^c	0.61^c	0.54^c	11.30^b	68.33^a
5%L	5.33^a	14.85^b	0.65^b	0.88^b	11.37^b	66.92^b
20%S	4.77^c	15.77^a	0.87^a	1.01^a	13.40^a	64.18^c

In which, control:-100% wheat flour,
-5%L:- wheat flour substituted with 5 % of purslane leaves powders
- 20%S: - wheat flour substituted with 20 % of purslane seeds powders.

4. Conclusions

Due to the high content of macronutrients, including proteins, fats, and carbs, in purslane's leaves and seeds powder, it is highly valued for its high nutritional value. Other beneficial elements of purslane leaves and seed powder include minerals including calcium, potassium, zinc, and phosphorus, as well as a high level of omega-3 fatty acids, particularly α-linolenic acid. Additionally, purslane leaves and seed powder's phenolic and flavonoid components have been said to possess antioxidant capabilities. As a result, purslane leaves and seed powder can be utilised to make exceptionally nutrient-dense bakery goods like crackers and biscuits. Purslane leaves powder can be added to crackers and biscuits at rates of 10% and 5%, respectively, without changing their sensory qualities. Similar to crackers, purslane seed powder can be added to biscuits at a rate of 20% while still maintaining acceptable quality attributes for consumers.

According to research, purslane seeds and leaves are a great source of bioactive ingredients that can be employed in food applications. Additionally, it can be useful to promote an Egyptian cuisine made with purslane as a useful food.

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