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Development of Gluten Free Snacks Fortified with Purslane *(Portulaca oleracea)* Powder

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Abstract: Portulaca oleracea (Portulacaceae family) is listed in the World Health Organization as one of the most used medicinal plants. It has been described as a "power food" of future because of its high nutritive and its anti-oxidant properties. Purslane, has high content of protein, ash and fiber and is a good source of minerals. Also, it has a high content of phenols (179.89 mg/100gm) and omega 3 fatty acid (44.29%). The radical scavenging activity (RSA) of purslane is high (89.23%). Rice flour was fortified by three levels of puslane powder and the snacks were subjected to the physicochemical and sensory analysis. The addition of purslane had significantly increased the protein, ash and fiber contents of extruded snacks as the amount of purslane increased. Also the addition of purslane caused increased in iron, zinc and calcium content to double. The total phenol content of the purslane fortified snacks increased as the amount of purslane increased. The addition of 10% purslane caused an increase in antioxidant to 87.28% compared with 67.44% for control. It can be noticed that, the addition of purslane had significantly increased linolenic (omega 3 fatty acid) and linoleic acid. The fortification with 2% purslane showed to be the most preferable fortified extrudes sample. Therefore, purslane could successfully be used to enrich snacks, giving an alternative utilization and healthy choice.

Keywords: Gluten Free, Snacks, *Portulaca oleracea*, Omega 3 Fatty Acid

1. Introduction

Purslane (Portulaca oleracea L.) is an annual green herb with ediblesucculent stems and leaves, slightly acidic and spinach-like taste. It could be found all over the world in the temperate and tropical regions starting from Europe and continuing to Africa, Asia, America and Australia. In Egypt, purslane, widely distributed throughout the Nile banks and different other areas. Purslane used as an ordinary dish, eaten cooked by the people of the Middle East, north east and central Africa [9]. About 935 tons of purslane are produced in Egypt [10].

Researchers reported purslane as a good source of compounds with a positive impact in human health and nutrition. Liu *et al.* [31] reported purslane to be rich in omega-3 fatty acids and β-carotene; while Aberoumand [5] showed high levels of vitamins and essential amino acids, α-tocopherols, ascorbic acid, and glutathione, as well as phenols in purslane.

Dkhil *et al.* [15] study revealed that, purslane is effective as an antioxidant agent, as well as providing nourishment for the liver, kidneys and testes of rats. While Caballero [11] has shown that purslane has an anti-oxidative effect in heart tissues in mice by increasing superoxide dismutase activity.

El-Sayed [17] reported purslane to be associated with significant reductions in fasting and postprandial blood glucose, insulin, body weight, and body–mass index (BMI), together with normalization of lipid profile. In a study by Esmaillzadeh *et al.* [18], purslane seeds were said to reduce body weight and BMI, serum triglycerides, and blood pressure. Wainstein *et al.* [50] reported purslane extract to be a safe, secondary treatment for Type 2 Diabetes Mellitus patients, significantly reducing systolic blood pressure.

Calder [12] reported that nutritional supplementation with omega-3 fatty acids has been shown to have some level of corrective effect on certain non-communicable diseases including inflammatory bowel disease (IBD). While Stroescu *et al.* [47], stated that Omega-3 polyunsaturated fatty acids (PUFAs) may protect against several diseases as cardiovascular, psychiatric, neurological, dermatological and rheumatologic disorders. Purslane presented high amounts of omega-3 (C18:3n3) and omega-6 (C18:2n6) polyunsaturated fatty acids, which are essential dietary fatty acids.

Garg and Singh [22] defined broken rice as the by-product of rice milling industry. Also, rice flour prepared from rice broken can be used as important ingredient for many ready–to-eat breakfast cereals and snacks. El-Hissewy [16] reported losses in rice, in Egypt, between 8.16 and 28.50% and longer storage periods increased the breakage percentage. Whereas, in the FAO report (2012) the moisture content of the rice grain was reported as an important factor in increasing the breakage. Omran and Hussien [36] stated the low commercial value of broken and chalky grains, could be used in suitable food products.

For patients suffering from coeliac disease, gluten-free products are required and extrusion cooking is a suitable process for producing gluten-free expanded snack foods since, unlike bread, starch is the main component providing the desirable expanded structure in extruded snack foods [26].

Aim: The current study aimed to produce a high nutritional value trice snakes by adding purslane as a natural source of nutrients to broken rice flour.

2. Materials and Methods

2.1. Raw Materials

Purslane (Portulaca oleracea) plant was obtained from a farm of Quisna city Minufiya Governorate during 2015 season. Rice (broken rice) were purchased from local rice mill in Cairo, Egypt.

2.2. Preparation of Samples

Purslane was cleaned with water then rinsed with distilled water, external moisture wiped out with a dry cloth. The edible portion of the plant was separated, dried in a hot air oven, under vacuum, at 50°C for 1 h. The dried samples were then powdered in blander and maintained at sealed packages until use.

Broken rice was ground to get homogenous particles size of (400-600) micron by using a laboratory mill (Brabender Automat Mill Quandrumat Senior, Germany).

2.2.1. Extrusion Process

The broken rice flour was partially fortified by the ground purslane at levels of 2, 5 and 10%. The extrusion process was carried out using a Barabender Laboratory twin=screw extruder. The extrusion process conditions for zones temperatures were 90, 130 and 200°C for the screw speed was 249 min^{-1} and for the feeding screw speed was 160 min^{-1}. The resultant extrudates were directly dried in an air forced dryer oven at 110°C for 5 min and left to equilibrate at the room temperature. Modification was made for the above steps, samples fortified with purslane did not contain flavours or artificial colours.

2.2.2. Preparation of Cracker Samples

The control cracker sample was prepared according to the method described by Sath *et al.* [40]. 5%, 10% and 15% purslane powder incorporated in crackers instead of the same amounts in the tested control crackers.

2.3. Chemical Analysis

Purslane powder, rice flour and snacks were analyzed for its moisture, ash, protein and fat according to the standard AACC (2000) methods. Nitrogen content as estimated by Micro-Kjeldhal method and was converted to protein byusing a factor of 6.25. Carbohydrates are determined by difference. Dietary fiber contents was analyzed according to AOAC (1990).

2.4. Determination of Total Phenols

The amount of total polyphenols were determined in Purslane powder, rice flour, and snacks using Folin-Ciocalteu reagent and calibrated against gallic acid. The results are presented as Gallic Acid Equivalent (mg GAE/100gm) [44]. All tests were conducted in triplicate.

2.5. DPPH Radical Scavenging Activity

DPPH scavenging activity was determined using a modified method of Ohnishi *et al.* (1994). DPPH % scavenging activity (%SA) was calculated as %SA = (C-X) 100/C, where C is the absorbance of the control and X is the absorbance of the extract.

2.6. Fatty Acids Analysis

The standard procedure for analyzing the fatty acid contents of plants was used and the fatty acids were extracted and separated by the method described by Stroescu *et al.* [47]

2.7. Physical Properties

Expansion ratio was determined as method described by Halek and Chang [24]. Bulk density was determined as described by Rahman [35]. Water absorption index (WAI) and water solubility index (WSI) were determined as outlined by Anderson *et al.* [7] and Damardjati and Luh, [14].

Crackers were evaluated for weight (g), thickness (mm), diameter (mm), density (g/cm^3) and spread ratio as described by Gaines (1991).

2.8. Colour

Purslane powder, rice flour, and snacks were measured with a Hunter Lab Colorimeter (MiniScan XE Plus, Reston, VA) according to the method described by Abd El-Hady *et al.* [3]

2.9. Sensory Evaluation of Products

The sensory evaluation was carried out in order to get consumer response for overall acceptability of the 2%, 5% and 10% Purslane powder incorporated snacks compared to the control snacks. Panelists from Food Technology Research

Institute, Agricultural Research Center evaluated texture, taste, color, and overall acceptability according to the method described by Ibrahim et al. [27].

2.10. Statistical Analysis

Statistical analyses were carried out by SPSS 16 program. Data were expressed as means ± SEM and the Statistical analysis was performed using one-way analysis of variance followed by Duncan's tests. (SPSS, 2000)

3. Results and Discussion

3.1. Chemical Composition of Ingredients

Table 1. *Chemical Composition of Ingredients (dry weight bases).*

	Rice	Purslane
Macronutrients		
Protein	6.70±0.08	23.75±0.03
Fat	1.45±0.30	4.70±0.70
Carbohydrate	89.17±0.70	38.69±0.11
Ash	0.60±0.03	11.10±0.20
Dietary Fiber	2.08±0.11	21.76±0.30
Micronutrients		
Zn (mg/100gm)	0.98±0.11	5.99±0.08
Ca (mg/100gm)	16.00±0.57	131.44±3.21
Fe (mg/100gm)	1.60±0.02	7.29±2.05
Total phenols (mg GAE*/100gm)	12.90 ± 1.95	179.99±0.03
Radical scavenging activity (%RSA)	50.20± 1.23	89.13±0.05
Colour		
L	85.17±0.70	31.74±0.83
A	1.35±0.02	-8.94±0.11
B	13.76±0.07	12.12± 1.23

* GAE= Gallic Acid Equivalent.

Data from table (1) showed high contents of protein (21.75%), ash (21.76%) and fiber (11.10%) in purslane powder, but moderate levels of fat (4.70%). Our results agreed with work of Almasoud and Salem [6] and Aberoumand [5] who reported the amount of 23.47%, 22.66% and 8.0% for protein, ash and fiber respectively. Purslane is a good source of calcium (130.0 mg/100gm), our results were lower than (227mg/100gm) [41] but higher than 18.71mg/100gm that was mentioned by Aberoumand [4].

The mineral content of iron and zinc were (7.29 mg/100gm) and (5.99 mg/100gm) respectively. The results were lower than (16.17mg/100gm) reported by Sheela *et al.* [41] and higher than (0.48mg/100gm) of Aberoumand [4]. Ezekwe *et al.* [19] referred the variation in results to be due to the difference in planting location and planting time as reported by. Another approach by Mohamed and Hussein [32] referred the difference to different growth stages of the plant. On the other hand, rice flour contains low levels of protein, ash and fiber which agrees with work by Omran and Hussien [36].

Purslane has a high content of phenols (179.99 mg/100gm) compared with rice. The results are in range with findings of Lim and Quah [30] who reported that phenols to be between 157 and 304mg/100gm. As for the radical scavenging activity (RSA), Our results (89.13%) are higher than those reported by Abas *et al. [2]* (70.4%), but lower than Odhava *et al. [33]* who reported RSA to be 95% in fresh leaves. The variability could be due to environmental factors and collection period. Lim and Quah [30] studies have indicated that the level of active compounds increased when sunlight and temperature increased. As for rice, the analysis of agrees with work by Chi *et al.* [13].

The fatty acids composition of purslane and rice are shown in Table (2)

Table 2. *Fatty Acid Composition of Purslane and Rice (on dry weight basis).*

Fatty Acid	Purslane (%)	Rice (%)
Lauric (12:0)	-	-
Myristic (14:0)	0.45±0.01	0.77±0.05
Palmitic (16:0)	16.34±0.25	22.39±0.50
Palmitoleic (16:1)	1.56±0.05	0.14±0.01
Stearic (18:0)	2.67±0.12	2.23±0.05
Oleic (18:1)	19.59±0.21	41.45±0.42
Lenoleic (18:2)	24.03±0.15	35.01±0.35
Lenolenic (18:3)	44.29±0.10	1.31±0.05
Arachidic (20:0)	0.83±0.05	0.52±0.03
Gadoleic (20:1)	0.20±0.01	0.35±0.01

Values are means of three replicates ±SD.

Although purslane contains large quantities of fatty acids, Linolenic acid (omega 3 fatty acid) was the most abundant (44.29%), lenoleic acid was the second (24.03%), these results are higher than the results given by Gharneh and Reza [23] who reported linolenic acid to be between 19.69 and 30.15% and lenoleic between 4 and 6.31%. Palmitic acid (16.34%) and oleic acid (9.59%) were lower than that reported by Oliveira et al. [35] who found that palmitic and oleic were from (19.26 to 24.26 and 11.55 to 19.49%) respectively. Liu et al. [31] reported the difference to be due to the difference in plant tissues and origin On the other hand, the analysis of rice agrees with work by Kang et al. [28].

3.2. Chemical Composition of Rice Snacks

Purslane has a high nutritional value, since it has high protein, ash and fiber contents in comparison with some other edible plants. The results of chemical composition of rice snacks are shown in Table (3).

The addition of purslane had significantly increased protein, ash and fiber content of extruded rice snacks. The increase in the fortification level resulted in a directly proportional increase in protein, ash and fiber. This is mainly due to the high content of protein, ash and fiber in purslane compared with rice [4]. The mineral content (iron, zinc and calcium) doubled, as purslane had high content of these minerals.

Table 3. *Chemical Composition of the Extruded Rice Snacks and Crackers Fortified with Purslane (dry weight bases).*

Sample	Moisture (%)	Protein (%)	Fat (%)	Carbohydrate (%)	Ash (%)	Dietary Fiber (%)
Extruded Snacks						
Control	4.55±0.19 ^{a}	7.54±0.16 ^{d}	1.88±1.12 ^{d}	90.58±1.00 ^{a}	0.95±0.21 ^{d}	1.50±0.26 ^{d}
2%	4.44±0.38 ^{b}	7.90±0.11 ^{c}	2.09±0.05 ^{c}	90.01±0.12 ^{b}	1.77±0.12 ^{c}	3.41±0.12 ^{c}
5%	4.22±0.19 ^{c}	8.25±0.14 ^{b}	2.51±0.36 ^{b}	89.24±0.45 ^{c}	2.49±0.14 ^{b}	4.08±0.17 ^{b}
10%	3.44±0.38 ^{d}	9.02±0.13 ^{a}	2.97±0.24 ^{a}	88.01±0.33 ^{d}	3.64±0.04 ^{a}	5.00±0.28 ^{a}
Crackers						
Control	5.50±0.12 ^{d}	8.37±0.23 ^{d}	22.16±0.14 ^{d}	69.47±0.41 ^{d}	2.80±0.09 ^{d}	3.35±0.09 ^{d}
5%	6.26±0.07 ^{c}	8.82±0.12 ^{c}	22.33±0.09 ^{c}	68.85±0.10 ^{c}	3.17±0.12 ^{c}	4.46±0.14 ^{c}
10%	6.60±0.21 ^{b}	9.29±0.09 ^{b}	22.55±0.12 ^{b}	68.16±0.30 ^{b}	4.83±0.16 ^{b}	6.62±0.11 ^{b}
15%	6.83±0.15 ^{a}	9.76±0.15 ^{a}	22.89±0.11 ^{a}	67.35±0.23 ^{a}	5.15±0.11 ^{a}	7.12±0.22 ^{a}

Table 3. *Continued.*

Sample	Zn	Ca	Fe	Total phenols	Radical scavenging activity (%RSA)
Extruded Snacks					
Control	0.52±0.01 ^{d}	20.14±2.84 ^{d}	1.67±0.05 ^{d}	3.30±0.25 ^{d}	67.44±3.11 ^{d}
2%	0.91±0.03 ^{c}	29.83±3.24 ^{c}	2.25±0.01 ^{c}	3.37±0.30 ^{c}	72.91±2.34 ^{c}
5%	1.41±0.17 ^{b}	37.16±0.95 ^{b}	3.67±0.09 ^{b}	4.25±0.21 ^{b}	81.22±4.78 ^{b}
10%	1.60±0.01 ^{a}	50.52±5.95 ^{a}	4.16±0.15 ^{a}	4.84±0.14 ^{a}	87.28±4.72 ^{a}
Crackers					
Control	0.95±0.14 ^{d}	150.70±0.13 ^{d}	1.45±0.12 ^{d}	3.23±0.20 ^{d}	20.60±0.14 ^{d}
5%	1.09±0.17 ^{c}	202.61±0.11 ^{c}	2.19±0.09 ^{c}	3.96±0.12 ^{c}	31.59±0.10 ^{c}
10%	1.55±0.12 ^{b}	232.00±0.14 ^{b}	2.73±0.21 ^{b}	4.40±0.17 ^{b}	44.22±0.15 ^{b}
15%	1.93±0.20 ^{a}	253.75±0.12 ^{a}	5.41±0.17 ^{a}	4.48±0.10 ^{a}	51.25±0.11 ^{a}

* GAE= Gallic Acid Equivalent. Values are means of three replicates ±SD, and numbers in the same raw followed by the same letter are not significantly different at 0.05 level.

**Values are means of three replicates ±SD, numbers in the same column followed by the same letter are not significantly different at 0.05 level.

Table 4. *Fatty Acid Composition of Extruded Rice Snacks and Crackers Fortified with Purslane (on dry weight basis).*

	Lauric (12:0)	Myristic (14:0)	Palmitic (16:0)	Palmitoleic (16:1)	Stearic (18:0)	Oleic (18:1)	Lenoleic (18:2)	Lenolenic (18:3)	Arachidic (20:0)	Gadoleic (20:1)
Extruded										
Control	-	0.99±0.02 ^{a}	34.57±0.71 ^{d}	0.26±0.04 ^{d}	2.19±0.02 ^{d}	44.31±0.51	0.30±0.05 ^{d}	10.78±0.21 ^{d}	0.24±0.02 ^{d}	0.21±0.01 ^{d}
2%	-	0.94±0.01 ^{b}	36.43±0.52 ^{c}	1.08±0.03 ^{c}	3.21±0.05 ^{c}	38.86±0.42	0.63±0.02 ^{c}	20.34±0.52 ^{c}	0.36±0.01 ^{c}	0.34±0.06 ^{c}
5%	-	0.89±0.03 ^{c}	37.52±0.43 ^{b}	1.11±0.05 ^{b}	3.41±0.03 ^{b}	38.71±0.25	0.98±0.03 ^{b}	23.44±0.07 ^{b}	0.41±0.03 ^{b}	0.42±0.03 ^{b}
10%	-	0.86±0.02 ^{d}	38.14±0.51 ^{a}	1.18±0.05 ^{a}	3.60±0.15 ^{a}	38.23±0.35	0.99±0.01 ^{a}	27.88±0.09 ^{a}	0.44±0.02 ^{a}	0.47±0.01 ^{a}
Crackers										
Control	-	1.39±0.25 ^{a}	34.91±0.43 ^{d}	0.34±0.06 ^{d}	3.76±0.02 ^{d}	40.91±0.03 ^{d}	13.30±0.05 ^{c}	11.45±0.51	0.32±0.09 ^{d}	0.19±0.06 ^{d}
5%	-	1.33±0.03 ^{c}	36.28±0.25 ^{c}	0.35±0.09 ^{c}	4.13±0.15 ^{c}	42.45±0.51 ^{c}	14.25±0.43 ^{b}	21.52±0.09	0.47±0.06 ^{c}	0.21±0.25 ^{c}
10%	-	1.38±0.09 ^{b}	37.31±0.51 ^{b}	0.41±0.03 ^{b}	4.14±0.09 ^{b}	43.46±0.25 ^{b}	14.73±0.15 ^{b}	25.63±0.06 ^{b}	0.55±0.05 ^{b}	0.23±0.02 ^{b}
15%	-	1.38±0.51 ^{b}	38.57±0.09 ^{a}	0.51±0.15 ^{a}	4.88±0.05 ^{a}	45.67±0.43 ^{a}	15.47±0.02 ^{a}	28.67±0.25 ^{a}	0.59±0.15 ^{a}	0.25±0.09 ^{a}

Values are means of three replicates ±SD, and numbers in the same column followed by the same letter are not significantly different at 0.05 level.

The increase in total phenols of the extruded snacks fortified with purslane was directly connected to the increased amount of purslane. The snacks with 10% purslane had the highest percent of phenols (4.84 mg/100gm) compared with control (3.30 mg/100gm). The scavenging activity on DPPH radicals is a way to gather basic information about antiradical activity for different vegetable matrices. Antioxidant activity of the extracts is a combined action of different compounds, some of them with beneficial action and others with antagonistic effect. The antioxidant activity of rice snacks increased by the addition of purslane. The addition of 10% purslane caused an increase in antioxidant to 87.28% compared with 67.44% for control. This may be due to the high antioxidants in purslane. Oliveira *et al.* [35] suggested that purslane may be useful as potential source of antioxidant in food.

The fatty acid composition of rice snacks is shown in Table (4). From the results in table (4), it can be noticed that the addition of purslane had significantly increased the levels of both linolenic (omega 3 fatty acid) and linoleic acid in both extruded snacks and crackers. This increase in linolenic and linoleic acid was a result of the high levels of these fatty acids in purslane (44.29% and 24.03% respectively). Also the increase of both acids were directly proportion to the levels of purslane. The decrease in oleic acid in samples fortified with purslane may be because in these samples no oil was added which contains flavours and artificial colours.

3.3. Physical Properties of Rice Snacks

Bulk density plays a vital role in product appearance and overall acceptability of the product and is an important physical property in designing suitable packaging materials. The physical properties of the extruded rice snacks are shown in Table (5).

It can be noticed from the results in Table (5) that, the increase of purslane additive to rice snacks increased the WAI. The greater WAI values observed in the extruded products fortified with purslane powder could be related to the high water absorption capacity of purslane powder. In fact, the higher water absorption is the characteristic feature of fiber supplemented flours as reported by several researchers [42]. Dietary fiber may interact with water by means of polar and hydrophobic interactions, hydrogen bonding, and enclosure. The results of these interactions vary with the flexibility of the fiber surface. This agree with Hussien *et al.* [25] who pointed out that the addition of 10% purslane to rice snacks gave a significantly lower WSI value compared with samples containing rice flour only. This finding was reported also by Shirani *et al.* [42].

The expansion ratio decreased by 10, 15.67 and 25% after the addition of 2, 5 and 10% purslane respectively. The results agree with work by Hussien *et al.* [25] who revealed that adding purslane traditional starchy snakes reduced the expansion values up to 25% compared to the control. Also, decreasing of expansion ratio (ER) of extruded products may be due to the increase of dietary-fiber content by adding purslane powder.

In all formulations with purslane powder the bulk density of the samples was higher than the control sample. Similar findings were reported by Potter *et al.*, 2013. The findings were attributed to the presence of sugar and soluble fiber that absorb moisture and affect the expansion capability of the extrudates as reported by Shoar *et al.* [43].

All the snacks prepared from rice flour mixed with the purslane had higher a* and b* values and lower L* values than the control this was due to the darker color of purslane (L* = 31.74, a* = -8.94, b* = 12.12 compared to rice flour (L* = 85.14, a* = 1.33, b* = 13.64). Addition of purslane significantly ($P < 0.05$) lowered the lightness (L) compared to the control (Table 5 and 6), increased the a+ (redness) and decreased the b+ value (yellowness) of the products. The results agree with work by Hussien *et al.* [25], also Shirani *et al.* [42] in their study with fenugreek flour.

Table 5. *Physical Properties of Extruded Rice Snacks Fortified with Purslane.*

Property \ Treatment	Control	2%	5%	10%
Water Absorption	323.33±1.52 d	334.00±6.08 c	340.33±0.35 b	350.33±0.57 a
Water Absorption Index (WAI)%	9.69±0.45a	9.45±0.24b	9.20±0.57c	8.59±0.90 d
Water Solubility Index (WSI) %	23.04±0.84 a	21.85±0.77 b	20.75±0.55 c	19.50±0.35 d
Expansion Ratio (ER)	3.19±0.15 a	3.00±0.10 b	2.70±0.08 c	2.40±0.12 d
Bulk Density (BD) (gm/cm^3)	77.21±0.09 d	78.01±0.15 c	78.79±0.17 b	79.25±0.08 a
Colour				
L*	84.70±0.05 a	79.75±0.55 b	77.54±0.84 c	75.12±0.77 d
a*	3.05±0.09 a	2.85±0.04 b	2.18±0.39 c	1.87±0.55 d
b*	12.15±0.25 a	11.90±0.77 b	11.75±0.35 c	10. 95±0.94 d
ΔE	-	4.96±0.55 c	7.22±0.55 b	9.73±0.42 a

Values are means of three replicates ±SD, and numbers in the same raw followed by the same letter are not significantly different at 0.05 level.
*L (lightness with L = 100 for lightness, and L = zero for darkness), a [(chromaticity on a green (-) to red (+)], b [(chromaticity on a blue (-) to yellow (+)].
**Numerical total color difference (ΔE) was calculated by: $\Delta E = [(L-L_0)^2+ (a-a_0)^2 + (b-b_0)^2]^{½}$.

Table 6. *Physical Properties of Rice Crackers Fortified with Purslane.*

	Control	5%	10%	15%
Diameter (mm)	57.9±0.40 a	56.3±0.32 b	55.1±0.21 c	53.0±0.45 d
Thickness (mm)	3.85±0.03 d	4.08±0.05 c	4.31±0.12 b	4.71±0.09 a
Weight (gm)	6.15±0.27 a	5.97±0.18 b	5.67±0.45 c	5.07±0.05 d
Spread Ratio	15.04±0.21 a	13.79±0.12 b	12.78±0.05 c	11.25±0.18 d
Density (gm/cm^3)	0.52±0.12 a	0.48±0.15 b	0.45±0.16 c	0.41±0.12 d
Colour				
L	81.7±0.05 a	77.85±0.55 b	76.44±0.84 c	74.32±0.77 d
A	2.95±0.09 a	2.55±0.04 b	2.08±0.39 c	1.67±0.55 d
B	12.00±0.25 a	11.70±0.77 b	10.85±0.35 c	9. 98±0.94 d
ΔE	-	3.88±0.06 c	5.45±0.42 b	7.76±0.55 a

Values are means of three replicates ±SD, and numbers in the same raw followed by the same letter are not significantly different at 0.05 level.
*L (lightness with L = 100 for lightness, and L = zero for darkness), a [(chromaticity on a green (-) to red (+)], b [(chromaticity on a blue (-) to yellow (+)].
**Numerical total color difference (ΔE) was calculated by: $\Delta E = [(L-L_0)^2+(a-a_0)^2 +(b-b_0)^2]^{½}$.

Physical properties of crackers are important for both manufacturers and consumers. Results in Table 6 indicate that crackers prepared by the addition of different levels of purslane showed a decrease in the diameter of crackers from 57.9 mm to 53.0 mm. The decreasing trend was directly proportional with increasing level of purslane substitution. It is clear that the significant decrease in the diameter of crackers may be attributed to the increase in fiber contents due to addition of purslane, which is a rich source of dietary fiber. These results agree with results of Almasoud and Salem [6] reported similar results in there study on wheat fortified crackers. The thickness of crackers increased significantly from 3.85 to 4.71 mm among treatments, with increasing percentage of purslane. The spread ratio, which is the ratio of diameter and thickness, decreased from 15.04 to 11.25 indicating undesirable effect of purslane on diameter and thickness of crackers. Vieira *et al.* (2007) has established that the spread ratio is strongly correlated to the water absorption capacities of the flour. Therefore, it can be concluded that addition of purslane powder limits the spreading of crackers. Table 6 shows that, with increasing purslane powder levels, causes an increase in the density of crackers.

Sensory Evaluation of Rice Snacks:

Nowadays, consumers have increased for consuming high amounts of safe and ready to use products but with high sensory attributes, nutritional and health qualities of foods [48].

One of the limiting factors for consumer acceptability is the sensory evaluation of the different attributes. Therefore, the organolyptic test of the samples attributes were estimated to measure the acceptability of such products and revealed a final judge on the preferences of the newest products in relation to the control sample (Table 7)

Table 7. *Sensory Evaluation of Rice Snacks Fortified with Purslane Powder.*

	Colour	Taste	Odour	Crispness	After taste	Appearance	Overall Acceptance
Extruded Snacks							
Control	9.60±0.63 a	9.70±0.59 a	9.46±0.83a	9.46±0.91 a	9.63±0.61a	9.66±0.48 a	9.53±0.83 a
2%	9.33±0.72 a	8.90±1.01 a	8.93±0.79 a	9.33±0.72 a	8.89±0.83 b	8.93±0.77 b	9.25±0.73 a
5%	8.96±0.86 b	8.46±1.41 b	8.40±0.82 b	9.07±0.96 b	8.50±1.20 c	8.03±1.47 b	8.66±1.09 b
10%	8.40±1.50 c	7.83±1.79 c	8.20±1.56 c	8.75±1.14 c	8.13±1.90 d	7.73±1.68 c	8.20±1.97 c
Crackers							
Control	9.60±0.02 a	9.70±0.01 a	9.46±0.02 a	9.56±0.91 a	9.73±0.61a	9.84±0.02 a	9.53±0.08 a
5%	9.33±0.02 a	9.65±0.03 a	9.29±0.02 a	9.43±0.72 a	8.99±0.83 b	9.04±0.01 b	9.37±0.02 a
10%	8.76±0.03 b	8.92±0.02 b	8.95±0.02 b	9.27±0.96 b	8.60±1.20 c	8.93±0.05 b	8.66±0.03 b
15%	8.36±0.01 c	7.83±0.05 c	8.20±0.03 c	8.75±1.14 c	8.13±1.90 d	7.70±0.20 c	8.20±0.04 c

*Values, within the same raw, with different letters are significantly different ($p \leq 5.05$)

Results mentioned in table (7) indicated that snacks with purslane had high sensory scores, except in after taste, in comparison with control. There was no significant difference between the control and 2% fortified samples, except in after taste. With respect to the color preference, a significant difference could be detected among 5% and 10% snack products. The most preferable fortified extruded sample, was the 2% fortified samples. As for crackers, 5% purslane fortification showed the most sensory preferable cracker fortified sample.

Similar results were obtained by Tarkergari *et al.*[48] who found significant differences in a few of the recipes fortified with purslane that of control. Also, Ward *et al.* [49] based on selective chemical and physical properties studied patties containing 5 and 10% purslane for sensory evaluation for colour, juiciness tenderness texture and flavor and rated 5% incorporation to be significantly better than 10% incorporation. Hussien *et al.* [25] reported snacks fortified with purslane to be accepted by panelists up to 10% with 2% preferred.

Almasoud and Salem [6] reported similar results in their study on wheat fortified crackers, showing the 5% fortified crackers to be the most preferred. While Renu and Waghray [39] reported that papads with 15% of incorporated purslane leaves were preferred more over control, in terms of taste and flavor. While all samples were sensory accepted for their color, texture, and appearance compared to control.

Percentages of the recommended dietary allowances (% RDA) provided from Rice Snacks Fortified with Purslane Powder for Children (4-8 years)

Dietary Guidelines for Americans (2005) emphasize the need for a variety of vegetables and fruits in diets as well as grains to ensure an adequate intake of micronutrients. Almasoud and Salem [6], emphasized that the nutritional quality of the gluten-free diet, particularly the iron, calcium and fiber contents, should be concerned.

The percentages of the recommended dietary allowances (% RDA) are provided from 100g of snacks and crackers for children are showed in table (8), it could be observed that all values of %RDA for protein, minerals (i.e., iron, zinc and calcium) and omega 3 content were high in all samples of fortified with purslane compared with control.

Table 8. *Percentage of RDA for some nutrients provided by 100gm Rice Snacks Fortified with Purslane Powder for children (4-8 years).*

	% RDA						
Sample	**Protein (19 g/d)**	**Carbohydrate (130 g/d)**	**Dietary Fiber (25 g/d)**	**Zn (5 mg/d)**	**Ca (1000 mg/d)**	**Fe (10 mg/d)**	**Linoleic Acid (Omega 3) (10 g/d)**
Extruded Snacks							
Control	39.68	69.68	6.00	10.40	2.01	16.70	1.08
2%	41.58	69.23	13.64	18.20	2.98	22.50	2.03
5%	43.42	68.65	16.32	28.20	3.72	36.70	2.30
10%	47.47	67.7	20.00	32.00	5.05	41.60	2.70
Crackers							
Control	44.05	53.44	13.4	19.00	15.07	14.50	1.1
5%	46.42	52.96	17.84	21.80	20.26	21.90	2.20
10%	48.89	52.43	26.48	31.00	23.20	27.30	2.56
15%	51.37	51.81	28.48	38.60	25.38	54.10	2.97

4. Conclusion

The results of our study revealed that broken rice, the by-product of rice milling industry, can be used as an ingredient for many gluten-free snacks. The produced snacks can be used for celiac disease patients. According to the results, purslane could be used as an alternative source of some nutrients (especially omega 3-fatty acid) for human consumption. The addition of purslane increased the nutritional quality of extruded snacks and crackers. The most preferable fortified extruded sample, was the 2% fortified samples. As for crackers, 5% purslane fortification showed the most sensory preferable cracker fortified sample. Addition of some herbs, such as cumin or chili, can be used to improve the after-taste of both snacks.

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