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Production and evaluation of gluten free biscuits as functional foods for celiac disease patients

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Abstract

In this study the utilization of Jerusalem artichoke which is the main rich source of inulin. Inulin is polysaccharide composed of fructo-oligosaccharides is of increasing interest as fat-replace, sweetener and clinical especially in reducing blood glucose attenuation as well as functional food additives so that, gluten-free biscuits were prepared for celiac disease with high blood glucose level. Corn flour and starch were used to produce gluten free biscuits with functional properties. In this study the dry Jerusalem artichoke were used to prepare biscuits using Jerusalem artichoke as replacement (25, 50, 75 and 100%) both of sugar and corn oil which were used in the production with the use of Jerusalem artichoke a reduction in flour was 15, 30, 45 and 60% in biscuits formula. Raw materials were analyzed for chemical properties. Also the produced biscuits were evaluated for physical, chemical, minerals content and sensory characteristics. The results indicated that the high level of inulin in Jerusalem artichoke which reached 73% (on dry weight basis). Protein, fiber, ash and minerals such as (Fe, Ca and Mg) contents were increased by increasing the replacing level of either sugar or corn oil by Jerusalem artichoke. Physical properties were no significant difference with control sample and sample which containing 25, 50 and 75% Jerusalem artichoke. There were no significant differences between control and biscuits made by substituting level up to 75% sugar and 75% corn oil. All samples containing Jerusalem artichoke powder were the best in providing recommended daily allowances (RDA) in protein , fiber and minerals such as (Fe, Ca and Mg) for children 7-10 years) and adults (19-24years) for celiac disease.

Keywords: Jerusalem artichoke – Inulin – Biscuits - Functional foods - Celiac disease

1. Introduction

Celiac disease is a chronic disease of the gastrointestinal system, in which characteristics atrophy of the small intestinal mucosa occurs in genetically predisposed people in response to the presence of gluten in food. It is a continuous intolerance of gluten, gliadin and responsive prolamins that are present in wheat, rye and barley. The major characteristics of the disease are intestinal damage due to an immune defect (autoimmune disease) that occurs in people with a genetic background [5]. Celiac disease is a chronic disease of the proximal segment of the small intestine. The most important characteristics of celiac disease are: permanent intolerance of gluten (a constituent of some cereal): typical mucosal findings in jejunely biopsy specimen, typical present (malabsorpton) and subsequent improvement on a gluten –free diet with complete histological and clinical remission and recurrence of the disease when the diet is broken, the disease can clinically manifest at any age most commonly in the first few years of life, a few months of introducing gluten in diet [31]. Offer celiac disease

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testing in children and adolescents with the following otherwise unexplained symptoms and signs: chronic abdominal pain, cramping or distension, chronic or intermittent diarrhea, growth failure, iron deficiency anemia, weight loss, chronic fatigue, short stature, delayed puberty, osteoporosis and explained abnormal liver biochemistry [23]. Functional food is food similar in appearance to conventional food, which is consumed as a part of the usual diet and has demonstrated physiological benefit and/or reduces the risk of chronic disease beyond basic nutritional functions [20]. Functional foods and beverages are natural products enriched or balanced with biologically active components which offer the potential of enhanced health or reduced risk of disease. The most common functional foods contain specific minerals, vitamins, fatty acids or dietary fiber, or are enriched with biologically active substances such as phytochemicals or other antioxidants and probiotics – live beneficial cultures [32]. The Jerusalem artichoke powder (JAP) made from Jerusalem artichoke roots also is a valuable product, rich in inulin, as well as vitamins and minerals. Powder of dried Jerusalem artichoke tubers is more convenient to store for a longer time and easier to use in technological processes. Jerusalem artichoke powder has lower moisture, protein and fat content in comparison with the high quality wheat flour but the dietary fibre, sugars, vitamins and minerals amount is higher powder of the whole tubers of Jerusalem artichoke with high of inulin may be applied as substitute of cereal flour in cakes [24]. The Jerusalem artichoke tubers are known to be a health-promoting source. They contain inulin instead of starch as a carbohydrate reserve. Inulin and its degraded product oligofructose are the major compounds of interest in the food industry as functional food ingredients and low-calorie food materials. Many scientists have discovered that it has a beneficial effect on the gastro-intestinal activity stimulating reproduction of beneficial bacteria. Jerusalem artichokes have also been promoted as a healthy choice for diabetics. The reason for this being the case is because fructose is better tolerated by people that are diabetic. It has also been reported as a folk remedy for diabetes [25]. Inulin in fortified foods and beverages may improve gastrointestinal health and improve calcium absorption, and may affect the physiological and biochemical processes in rats and human beings, beneficially influencing the lipid metabolism, which results in better health and reduction in the risk of many diseases including cardiovascular diseases [7,11]. The main sources of inulin used in the food industry are chicory and Jerusalem artichoke. Jerusalem artichoke is rich in inulin – a polydisperse carbohydrate consisting mainly of β (2-1) fructosyl-fructose links [19]. Jerusalem artichoke powder with high inulin concentration, which is produced from the local Jerusalem artichoke varieties offered to the market, contains all water soluble components – proteins (15-18% of DM), carbohydrates (62% of DM) including inulin (50-60% of DM), K (400-500 mg 100 g-1), P (70-75 mg 100 g-1), vitamins, and plant-origin cholesterol-free lipids and fiber, thus increasing its functional value [10]. It was reported by [29,30] that inulin could improve the absorption of minerals. Moreover, inulin ingestion had a positive influence on lipid metabolism and blood sugar regulation in diabetics and on large bowel function. It also increase the density and proportion of colonic bifidobacteria. Many hydrocolloid systems have shown good fat mimetic properties in baked systems, which contain relatively high finished product moisture content such as cakes. Starches and hydrocolloid can mimic the rheological sensation of fat in mouth due to the binding and orientation of water in the molecule. Low dextrose equivalent (D.E.) maltodextrin derived from potato, tapioca, corn and rice have shown short texture/fat like qualities when prepared at 20-25% solution [38]. Maltodextrins are carbohydrates ingredients made by hydrolysis of corn starch. Grain Processing Corp. Iowa, sells a number of them especially Maltrin M040, a low-D.E. maltodextrin containing almost 98% penta and higher saccharides, it provides a creamy, fat-like texture due to a combination of good film-forming characteristics and low hygroscopicity while contributing only 4 kcal/g**.** The FDA classifies maltodextrins as products with a D. E. of less than 20 [28]. Maltodextrin is one of the more popular fat replacers that have been introduced as food additives in the last 25 years, partly because of its capacity to reproduce a fat-like mouthfeel, which originates from the three-dimensional network of gelled maltodextrin. However, maltodextrins are also used as general structuring agents and some important functional properties include bulking, gelling, providing resistance to caking, adding texture and body, binding flavour and fat, crystallization prevention, promotion of dispersibility and solubility and freezing control. These properties have resulted in its widespread use in the food industry Chronakis (1998) [12] and Chrystel and William (2006) [13].

The present work is a trial to use Jerusalem artichoke as a source of inulin as sweetener and fat replacer at different levels 25%, 50%, 75% and 100% to study its influence on biscuits properties to give free gluten healthy biscuits with similar characteristics and good consumer acceptance for diabetic celiac patients.

2. Materials and methods

2.1. Materials

- *Yellow corn flour (97% extraction)* was obtained from Egyptian Company for maize products (Maize) 10th of Ramadan City, Egypt.
- *Starch and maltodextrin* (corn maltodextrin) were obtained from (Starch and Glucose Co. Egypt).
- *Jerusalem artichoke* was parched from Moshtohor Faculty of Agric. Banha Uinv., Egypt.
- *Corn oil, sugar, eggs, baking powder and vanilla* were obtained from a local market in Giza, Egypt.

2.2 Methods

Preparation of Jerusalem artichoke: Jerusalem artichoke was dried at 60 ºC in an electric oven drier for over night until constant weight. The dried tubers were ground to particales to pass through 125 m sieve (to be blended).

Biscuits preparing: *Ingredients:* Biscuits were prepared according to the method of Mohamed *et al.,* 2004 [27] with some modifications, The blend consisted of 100 gm corn flour, 30 sugar, 15 gm corn oil, 0.5 gm skimmed milk, 24 gm fresh egg, 0.3 gm vanillin, 1 gm baking powder, 1 gm cinnamon and 135 gm water were added. The replacement of sucrose (by using Jerusalem artichoke natural sweetener replaced sucrose according to the degree of its sweetness compared with sucrose besides Jerusalem artichoke replaced corn oil at 25, 50, 75 and 100% as shown in Table (1).

Producers: For making biscuits: all dry ingredients were mixed together in a dough mixer for 3 minutes, then all liquid ingredients were added to the dry mixture and mixed at low speed for 3 minutes then water was added as require to obtain suitable smooth dough and the resulted dough was let to rest for 5 minutes. Then sheeted to 3 mm. thickness. Circle pieces cut of dough were formed by using of templates with an outer diameter of 50 mm. the biscuits were baked at 180 ºC for 12 minutes. After baking biscuits allowed to cool at room temperature for 1 hr. before sensory evaluation [17].

Chemical analysis:

- Protein, fat, ash and crude fiber were determined according to the method described in (A.O.A.C., 2005) [2].
- Total carbohydrates were calculated by difference according to the following equation: carbohydrates = 100- (protein % +fat %+ ash %).
- Caloric value was calculated according the following equatio [18]. Caloric value = 4 (protein %+ carbohydrates %) + 9 (fat %)
- Minerals i.e. calcium, iron and magnesium were determined using Perkin-Elmer 23865 Atomic absorption spectro-photometer Germany.
- Inulin, glucose and fructose contents in Jerusalem artichoke were determined using HPLC according to the method described by Alistair *et al.,* 1983 [4].

Physical characteristics: Physical characteristics of produced biscuits were determined according to A.A.C.C., 2002 [1]. Cookie diameter (D) and thickness (T) were measured for groups of 10 cookies, loss of weight were measured as difference between raw formed dough and baked cookie. The spread ratio obtained was the ratio between diameter (D) and thickness (T)

***Breaking force and strength*:** Breaking force and strength were calculated by using a struct-o-graph instrument available in Bisco Misr Company Egypt Fig. (1). It is mechanically transmitted a card recorder and the following equation is applied to calculate breaking strength occurring in biscuit samples as described in A.A.C.C., 2002 [1].

Max breaking force= (FB. LS/4) X (1/W)

Where:

- FB= the breaking force
- LS= Supporting width (3.6)
- W= the moment of resistance b.h2/6
- b= width of loaded cross section
- h= height of the loaded cross section.
- (*obtained from struct-o-graph manual)

Sensory evaluation of produced biscuits: Produced biscuits by using suggested blends were evaluated for sensory characteristics by ten panelists from the staff of Bread and PastryResearch Department Agric. Res. Center, Giza. The scoring scheme was established as mentioned by A.A.C.C., 2002 [1]. as follows color of crust (20), taste (20), odor (20), general appearance (20), crunchiness (20) and the overall score 100 degrees.

Statistical analysis:

The obtained data for sensory evaluation was statistically analyzed by the significant difference value (L.S.D.) at 0.05 levels probability by Snedecor and Cochran, 1989 [33].

3.Results and discussion

Chemical composition of raw materials:From data presented in table (2) it could demonstrated that Jerusalem artichokes contained the highest value in crude fiber and ash (6.12 and 7.11% respectively) meanwhile yellow corn flour contained the highest value in protein (7.91%). The fat content for corn flour and starch was the same (2.0%). These results were nearly with that data was found by Doweidar and Kamel, 2011 [16].

Inulin, fructose, glucose and minerals contents of Jerusalem artichoke (on dry weight basis): The content of inulin, fructose, glucose and minerals i.e. Calcium, iron and magnesium are summarized in Table (3). Jerusalem artichoke powder had 73.0% inulin, 3.0% fructose, 1.50% glucose and considerable amounts of calcium, iron and magnesium. These results are in a good agreement with (Add El-Lateef 2000) [3].

Chemical composition of produced biscuits: The food industry is being challenged to redesign traditional food for optimal nutritional value, in response to some population sectors with particular nutritional necessities, and making them as tasty as or better than the original. One way to achieve a healthy food product is to reduce or to omit some of the calorie-laden ingredients- especially sugar and fat for diabetic patients [26]. From the obtained results in Table (4) it could be concluded that, all blends of biscuits which containing Jerusalem artichoke had the highest value of protein, ash and fiber and the lowest value of fat. The protein value was increased by 4.0%-29.40%, meanwhile fiber and ash were increased by 14.29%-317.0% and 20.60%- 12.66% respectively compared with control biscuits. There was a slight reduction in energy; the reduction in calories was ranged from 1.09% to 10.90% in all samples which containing Jerusalem artichoke compared with control sample. These results agreed with those obtained by Doweidar *et al.,* 2010 [17]. The increment of important components such as protein and fiber depend upon the Jerusalem amount.

Minerals contents of produced biscuits: (mg/100g): Table (5) represents the minerals contents of biscuits which containing Jerusalem artichoke (mg/100g). The results showed that all blends of biscuits by using Jerusalem artichoke as sugar replacer had the highest values of minerals (Ca, Fe and Mg) followed by biscuits blends which containing Jerusalem artichoke as fat replacer. Meanwhile, control biscuits had the lowest values of the previous minerals, the increment of important minerals in biscuits depend upon theamount of Jerusalem artichoke [3].

Sensory evaluation of produced biscuits: The sugar content is significant for the organic characteristics of biscuits as the dough can absorb water and depending on temperature can get the desired brown color through the Millard reaction [8]. Fat has a great influence on mouth feel in biscuits, therefore, it is used to give particular smell and taste to the biscuit. In addition a low amount of fat or alternately high water content makes the dough hard and can be used to produce crackers or middle sweet biscuit [17].

The data in Table (6) indicated that the color of samples No. 5, 6 and 7 were lighter and less brown compared with samples No. 2, 3 and 4, that result may be due to the less amount of Jerusalem artichoke. The test sweeteners produced biscuits similar taste with control sample except sample No 4 and 8. it could be observed that all samples of biscuits were very good in appearance expect samples No. 4 and 8 (which made from Jerusalem artichoke at level substitution of

100% from sugar and fat) had good in appearance. It was noticed that samples No.1, 2, 3 and 4 were softer than samples 5, 6, 7 and 8 because of the fat influence which improve the biscuit texture. Jerusalem artichokes addition had not undesirable effects on appearance, crumb color, texture, odor and taste until 75%., this undesirable effect for Jerusalem artichoke at high level due to the darkness color of Jerusalem artichoke.

Physical properties of different types of biscuits: Biscuits are products made of flour, sugar, fat and other minor ingredients having moisture content less than 4% and shelf life more than 6 months [22]. The succercive phase is baking which ensure (a) reduction in biscuit density and development of a porous structure; (b) good thickness ; (c) moisture content reduction and (d) surface color changing [14].

From data in Table (7) it show that moisture content of biscuits samples (as indicated by crispy) ranged from 3.25% to 3.98% compared with 3.21 % for control sample and this due to the difference in water holding capacity to the composition of difference in water holding capacity to the composition of different formulas of these samples. Such increment in moisture may be due to the levels of substituted fiber and protein which absorb more water than starch [6]. Also, data in the same Table showed that biscuit diameter and loss of weight were decreased by increasing both of fat or sugar substitution from 25-100%. While biscuit thickness was slight increased by comparing with control sample. Thus, the spread ratio was decreased when Jerusalem artichoke was used.

Breaking force of biscuits:Increasing in breaking force during storage may be due to the gradual loss of biscuit crispness which tended to be softer as a result of the absorption of sufficient amount of water. As storage period advanced, a softening of biscuit was noted as the moisture content increased which caused the high breaking force values [17]. From the obtained results of Table (8). It was clearly noticed that the highest bending strength for biscuit sample was control then sample No. 5 having values 980-960 P/Cm respectively at zero time while breaking force was decreased by using Jerusalem artichoke after 6 months of storage at room temperature the breaking force was increased to1250-1220 P/Cm.This result was agreement with Bedeir, 2004 [9].

Table 1. Formula of free-gluten biscuits.

Ingredients	Con.	1	2	3	4	5	6	7	8
Sugar substitution %	-	25	50	75	100	-	-	-	-
Fat substitution %	-	-	-	-	-	25	50	75	100
Corn flour	100	90	90	90	90	90	90	90	90
Starch	-	10	10	10	10	10	10	10	10
Sucrose (gm)	30	22.5	15	7.5	-	30	30	30	30
Jerusalem artichokes powder (as sugar substitution (gm)	-	7.5	15	22.5	30	-	-	-	-
Corn oil (gm)	15	15	15	15	15	11.5	7.5	4	-
Maltodextrin (gel)	-	7.5	15	22.5	30	3.5	7.5	11	15
Jerusalem artichokes as fat substitution gm	-	-	-	-	-	3.5	7.5	11	15

Note: pretest experiment has been carried out to determine the best mixture ratio of suggested materials for this study

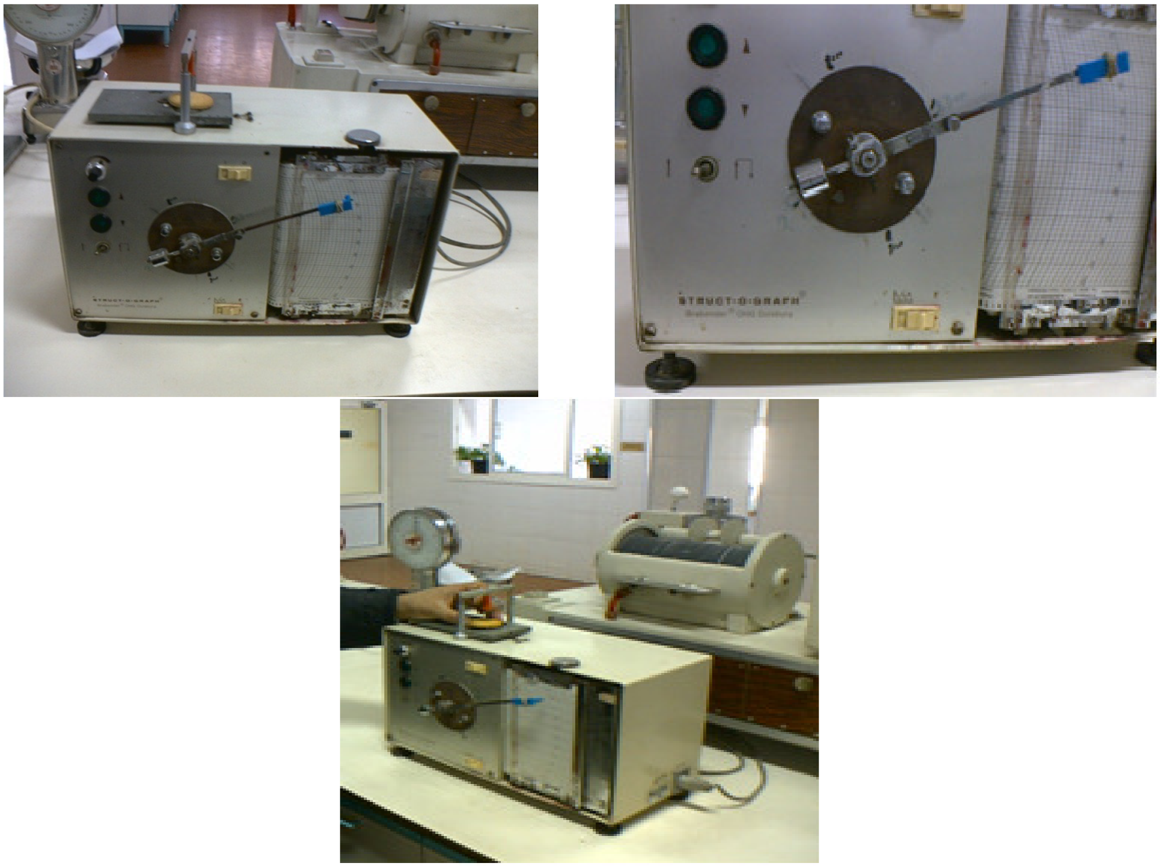

Figura 1. Struct-o-graph instrument in Bisco Misr Company Egypt.

Table 2. Chemical composition of raw materials (on dry weight basis).

Sample	Protein %	Fat %	Ash %	Fiber %	Total Carbohydrates %	Calories kcal\100g
Yellow corn flour 97%	7.91± 0.13	2.0± 0.09	1.50± 0.07	1.20± 0.23	88.59	404.0
Starch	6.50± 0.11	2.0± 0.14	2.35± 0.08	5.50± 0.18	89.15	400.60
Jerusalem artichokes	7.22± 0.14	0.67± 0.01	7.11± 0.05	6.12± 0.25	85.0	374.91

Table 3. Inulin, fructose, glucose and minerals contents of Jerusalem artichoke (on dry weight basis).

Jerusalem artichoke	Components
Inulin%	73.0
Fructose %	3.0
Glucose %	1.50
Calcium (mg/100g)	70.0
Iron (mg/100gm)	16.22
Magnesium (mg/100g)	82.0

Table 4. Chemical composition of biscuits as affected by Jerusalem artichokes (on dry weight basis).

Sample*	Protein %	Fat %	Ash %	Fiber %	Total Carbohydrates %	Calories kcal\100g
Control	8.00±0.24	11.00±0.16	1.50±0.02	0.70±0.01	79.50	449.0
Sample 1	8.50±0.28	10.50±0.11	2.10±0.03	1.20±0.01	78.90	444.10
Sample 2	9.20±0.17	10.30±0.08	2.81±0.01	1.81±0.02	77.69	440.26
Sample 3	9.81±0.22	9.50±0.17	3.40±0.03	2.31±0.02	77.29	433.90
Sample 4	10.35±0.14	9.50±0.14	4.20±0.04	2.92±0.04	75.95	430.70
Sample 5	8.31±0.25	8.12±0.09	1.81±0.01	0.80±0.01	81.76	433.36
Sample 6	8.63±0.27	6.32±0.14	2.12±0.02	1.22±0.01	82.93	423.12
Sample 7	9.14±0.13	4.14±0.13	2.41±0.01	1.55±0.02	84.31	411.06
Sample 8	9.55±0.18	2.13±0.02	2.75±0.01	1.81±0.01	85.57	399.65

Table 5. Minerals contents of produced biscuits (mg/100g).

Samples	Ca (mg/100g)	Fe (mg/100g)	Mg (mg/100g)
Control	79.10	2.11	53.51
Sample 1	84.21	3.52	60.42
Sammple2	89.32	4.81	68.11
Sample 3	94.51	5.92	75.33
Sample 4	99.82	7.11	82.45
Sample 5	82.20	2.82	56.52
Sample 6	85.31	3.91	59.81
Sample 7	88.51	4.95	62.91
Sample 8	91.61	6.0	65.95

Table 6. Sensory evaluation of produced biscuits samples.

Sample*	Color (20)	Taste (20)	Odor (20)	Appeara nce (20)	Crunchin ess (20)	Total score (100)	Acceptan ce
Control	19.0^{a}	20.0^{a}	20.0^{a}	19.0^{a}	19.0^{a}	97.0^{a}	V
Sample 1	18.0^{b}	20.0^{a}	20.0^{a}	19.0^{a}	19.0^{a}	96.0^{a}	V
Sample 2	19.0^{a}	20.0^{a}	20.0^{a}	19.0^{a}	19.0^{a}	97.0^{a}	V
Sample 3	19.5^{a}	20.0^{a}	19.5^{a}	19.0^{a}	19.0^{a}	97.0^{a}	V
Sample 4	17.0^{b}	18.0^{b}	18.0^{b}	17.0^{b}	18.0^{b}	88.0^{b}	G
Sample 5	20.0^{a}	20.0^{a}	19.5^{a}	19.0^{a}	19.0^{a}	97.5^{a}	V
Sample 6	19.0^{a}	20.0^{a}	20.0^{a}	19.0^{a}	20.0^{a}	98.0^{a}	V
Sample 7	18.0^{a}	20.0^{a}	20.0^{a}	19.0^{a}	20.0^{a}	97.0^{a}	V
Sample 8	17.0^{b}	18.0^{b}	18.0^{a}	17.0^{b}	18.0^{b}	89.0^{b}	G

Sample*: Sample formula as mentioned in Table 1
Values in the same column followed by same letter is not significant difference at 0.05 probability.
100-90 very good (V), 89-80 Good (G),79-70Satisfactory(S), Less than 70 Questionable (Q)

Table 7. Physical measurements of produced biscuits.

Sample	Moisture %	Diameter D(mm)	Thickness(T) (mm)	Spread ratio (D/T)	Loss of weight(g)
Control	3.21	3.50	0.65	5.34	1.52
Sample 1	3.31	3.50	0.66	5.30	1.52
Sample 2	3.54	3.30	0.71	4.65	1.41
Sample 3	3.70	3.20	0.81	3.95	1.30
Sample 4	3.91	3.0	0.90	3.33	1.20
Sample 5	3.25	3.40	0.65	5.20	1.51
Sample 6	3.49	3.30	0.68	4.85	1.51
Sample 7	3.62	3.30	0.70	4.71	1.40
Sample 8	3.84	3.10	0.75	4.13	1.30

Sample*: Sample formula as mentioned in Table1

Table 8. Breaking force of biscuits:

Breaking strength (P/Cm)			
Sample	Zero	3 months	6 months
Control	980	1200	1250
Sample 1	950	1180	1200
Sample 2	930	1150	1180
Sample 3	900	1120	1150
Sample 4	850	1100	1120
Sample 5	960	1190	1220
Sample 6	940	1160	1200
Sample 7	920	1140	1170
Sample 8	900	1100	1140

Sample*: Sample formula as mentioned in Table1

Table 9. Percentages of the recommended dietary allowances (RDA %) are provided from 100gm biscuit for some nutrients for children (7-10) years

RDA*%					
Sample*	RDA** Protein (28g)	RDA** Energy (2000 kcal)	RDA** Fe (10mg)	RDA** Ca (800mg)	RDA** Mg (170mg)
Control	28.57	22.45	21.10	9.89	31.48
Sample 1	30.40	22.20	35.20	11.0	35.54
Sample 2	32.90	22.01	84.10	11.20	40.07
Sample 3	35.04	21.70	59.20	11.80	44.31
Sample 4	37.0	21.50	71.1	12.50	48.50
Sample 5	29.70	21.67	28.20	10.30	33.25
Sample 6	30.82	21.16	39.10	10.66	35.18
Sample 7	32.64	20.55	49.50	11.06	37.0
Sample 8	34.11	19.98	60.0	11.50	39.0

Sample*: Sample formula as mentioned in Table 1
RDA%*= value of nutrient in sample x 100 / RDA for the same nutrient in reference.
RDA**= value of nutrient in reference

Table 10. Percentages of the recommended dietary allowances (RDA%) are provided from 100gm biscuits samples for some nutrients for adult (19-24)years

RDA%					
Sample*	RDA** Protein (58g)	RDA** Energy (2900kcal)	RDA** Fe(10mg)	RDA**Ca (1200 mg)	RDA**Mg (350mg)
Control	13.79	15.48	21.10	6.59	15.30
Sample 1	14.66	15.31	35.20	7.02	17.30
Sample 2	15.90	15.18	84.10	7.44	19.50
Sample 3	16.91	14.96	59.20	7.90	21.52
Sample 4	18.0	14.85	71.1	8.32	23.60
Sample 5	14.32	14.94	28.20	6.90	16.15
Sample 6	15.0	14.59	39.10	7.11	17.11
Sample 7	15.76	14.17	49.50	7.40	18.0
Sample 8	16.47	13.78	60.0	7.60	18.84

Sample*: Sample formula as mentioned in Table 1
RDA%*= value of nutrient in sample x 100 / RDA for the same nutrient in reference. RDA**= value of nutrient in reference

Percentages of the recommended dietary allowances (RDA%) are provided from produced products: Recent studies have shown some nutritional inadequacies associated with the gluten-free diet [15,21,34, 35]. As the only treatment for celiac disease remains the gluten-free diet, this raises a concern over the long-term health of individuals with celiac disease. In one study [35] it was demonstrated that many of the gluten-free products were not enriched, fortified or naturally rich sources of folate, iron or fiber. In another study [36], it was demonstrated that 37 % of males and 79 % of females did not meet the recommended amount of grain servings per day. The USDA through the food. Guide Pyramid [37] recommends six to 11 servings from the grain/bread/starch group per day to meet the daily recommended intake for B complex vitamins and fiber. In the same study, most of the female participants did not meet recommended nutrient intakes. Of the female participants, only 44% met their recommended intake for iron, 46% for fiber and only 31% met their recommended intake of calcium.

The percentages of the recommended dietary allowances (RDA%) are provided from 100g of biscuits for children and adults are shown in Tables (9 and 10) it could be observed that all values of RDA% for protein, minerals i.e. Fe, Ca and Mg were high in biscuits which containing different levels of Jerusalem artichoke compared with the control sample.

Compliance with Ethics Requirements: Authors declare that they respect the journal's ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human and/or animal subjects (if exists) respect the specific regulations and standards.

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