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Preparation of Gluten Free Biscuits from Quinoa, Rice and Chickpeas for Celiac Disease Patients

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ABSTRACT

This study aimed to prepare gluten-free high quality biscuits for patients suffer from celiac. used flour instead of wheat flour, were quinoa, rice and chickpeas flours as well as basic other ingredients of biscuits. used blends were rice (B1), (B2 = Rice 50% + Quinoa 40% + Chickpea 10%), (B3 = Rice 50%+ Quinoa 30%+ Chickpea 20%), (B4=Rice 50%+ Quinoa 20%+ Chickpea 30%), (B3=Rice 50%+ Quinoa 10%+ Chickpea 40%), chemical analysis, minerals content, amino acids content of raw materials were determined. Chemical composition of biscuit blends showed that crude protein, ether extract, ash and fiber contents were higher in all samples prepared using quinoa flour, rice flour and chickpeas flour than those of rice flour only. Quinoa flour had higher percentage of leucine (8.60%), and phenylalanine (6.30%). chickpeas flour had higher percentage of lysine (7.80%), valine (5.50%). rice flour was higher in alanine, glycine and tryptophan content. Caloric values of biscuit blends B3, B4 and B5 contained quinoa flour, rice flour, chickpeas flour was lower than B1. Appearance, taste, odor and color of biscuits contained quinoa flour; rice flour and chickpeas flour have higher scores than biscuits from rice flour B1. While, all sensory properties of free gluten biscuits samples B2, B3, B4 and B5 prepared using quinoa flour, rice, and chickpeas flour (87.4%, 90.2%. 91.1% and 92.8%, respectively) were higher than biscuit prepared from rice flour B1(85.3%) overall. The biscuits are nutritionally convenient for celiac disease patients.

Keywords: Quinoa, chickpeas, rice, biscuits, celiac, gluten-free

INTRODUCTION

Gluten-free foods are those that have fewer than 20 parts per million of gluten, according to the international Codex Alimentarius (Fasano and Catassi, 2012).

Celiac disease is an autoimmune illness caused by gluten consumption in the diet, which damages the small intestine. When you eat gluten-containing foods over time, your immune system reacts to a protein found in wheat, rye, and barley, causing inflammation that damages the small intestine lining, limiting nutrient absorption, especially iron, folate, vitamin D, and calcium, and can lead to serious medical complications if left untreated or undiagnosed (Caio *et al*., 2019) .Celiac disease (CD), non-celiac wheat sensitivity (NCWS), and wheat allergy (WA) are examples of "gluten associated disorders" in which gluten is the primary external cause. Celiac disease can strike anyone at any age. The prevalence is substantially higher in western countries, as seen and reported. Symptoms vary from person to person, as evidenced by the fact that even while eating a gluten-free diet, patients experience shortages in calcium, iron, fibre, and folic acid (Gupta and Awasthi , 2021). As a result, the only approach to treat celiac disease is to avoid gluten-containing foods like wheat for the rest of one's life. As a result, a large range of gluten-free items are available on the market that patients can ingest, causing the market to expand and develop (Sarabhai and Prabhasankar, 2017). Gluten sensitivity is becoming more common in the population. As a result, in order to supply celiac patients with a wheat replacement, their nutritional needs must be taken into account. As a result, a study was conducted to make gluten-free snacks using broken rice as a main ingredient in combination with quinoa and chickpea, which would provide a nutritionally dense snack to celiac patients.

Rice has a low prolamin content, hypoallergenic activity, bland flavour, low sodium, and high digestible carbohydrate content, making it acceptable for celiac diets (Phimolsiripol, *et al.*, 2012). For around 65 percent of the country's population, rice is a major staple meal. Rice is gluten-free by nature and provides protein as well. Rice protein is beneficial since it is among the cereal proteins with the highest nutritional quality (high in the necessary amino acid lysine). It contains a good amount of additional nutrients, such as phosphorus, calcium, magnesium, potassium, iron, zinc, copper, manganese, thiamin, niacin, and riboflavin, in addition to carbohydrate and protein. Rice has a low prolamin content, hypoallergenic activity, bland flavour, low sodium, and high digestible carbohydrate content, making it acceptable for celiac diets (Mona *et al*., 2015)

Quinoa (*Chenopodium quinoa*) is a seed-producing crop that has been grown for thousands of years in the Andes. Quinoa protein has a low prolamin content (0.5-7.0%), indicating that it is gluten-free and thus non-allergenic. Quinoa contains 13.4 percent total dietary fibre, with 11.0 percent insoluble fiber and 2.4 percent soluble fiber. Quinoa has a lipid-lowering impact and contains 4.4-8.8% crude fat, with the important fatty acids linoleic and linolenic acid accounting for 55 to 63 percent of total fatty acids (Alvarez *et al*., 2010). quinoa flour (QF) is regarded a super food since it

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has a higher protein content and a more balanced amino acid composition than grain flours. QF has roughly 16.4 percent protein, 75.82 percent carbohydrate, 12.4 percent fat, and 3.38 percent fiber, respectively (Jan *et al*., 2018). Vitamins (riboflavin, tocopherol, and ascorbic acid), minerals (calcium, magnesium, iron, potassium, and zinc), and antioxidant molecules (calcium, magnesium, iron, potassium, and zinc) are all abundant in it (Conte *et al*.,2019). Quinoa flour can also be used as a nutritious and nutrient-dense alternative ingredient in the development of functional Gluten-free products because it is naturally gluten-free.

Chickpea (*Cicer arietinum*), popularly known as Garbanzo beans, is a legume in the Fabaceae family. Chickpeas are high in dietary proteins, unsaturated fatty acids, minerals, and beta-carotene (Arooj *et al*., 2021). Chickpeas include soluble fiber, which aids in the reduction of low-density lipoprotein, or bad cholesterol. Manganese, magnesium, zinc, iron, copper, and vitamins including thiamine and vitamin B6 are all found in it. Chickpeas are high in essential amino acids like leucine, aspartic acid, lysine, glutamic acid, and arginine, and when combined with cereals, they give well-balanced essential amino acid profiles. Chickpeas flour is used to make gluten-free bread (Mohammed *et al*., 2014).

Even though, Adding nutritious and functional ingredients like chickpea can have a negative impact on the processing, textural, and sensory aspects of the final product, owing to the diluting influence of gluten forming proteins in the system (Jia *et al*.,2019).

Gluten-free Biscuits are often round bread cakes leavened with baking powder, baking soda, or yeast. It could also be described as cookies or crackers. They're mostly sweet, and they've been used by travelers in the past since they're long-lasting and easy to transport (Mehta *et al*., 2014). This investigation aimed to study the use of the quinoa flour, rice flour and chickpeas flour to produce high-protein, gluten-free biscuits for people suffering from celiac disease.

MATERIALS AND METHODS

Materials

Rice flour (*Oryza Sativa*), Quinoa seeds (*Chenopodium quinoa* Willd.), Chickpeas (*Cicer arietinum*), and other biscuit-making ingredients such as sugar (sucrose), baking powder, vanilla, and butter were purchased from a local market in Dakahlia, Egypt. Chemicals and solvents were purchased from El-Gomhoria Company- Cairo, Egypt.

Preparation of Raw Materials

Preparation of raw materials

Sorting of chickpeas grains and rice to remove extraneous contaminants such as stones, damaged and discolored grains, sticks (particle size 250 m)., the rice and chickpeas were crushed for flour in a small Quadrumat mill (Brabender made in Germany) and sieved flour through a 60-mesh stainless steel sieve, each type of flour was packed into nylon bags for future use according to (Prasad *et al*., 2012).

Quinoa seeds were cleaned to eliminate undesired materials such as mud, dirt, stone, dust, leaf, then soaked in water for 2 hours at room temperature to remove saponins materials. Quinoa seeds were washed with tap water until there was not froth in the water, then dried at 50°C for 12h to eliminate saponins. To make the full meal, the quinoa seeds were ground to a fine powder in a commercial electric blender (More Blender plant, Model Type No: MB-355, China). Flour made from quinoa (Rosell *et al*., 2009).

Preparation of biscuits:

The biscuits were modified to the process reported by Abd El-Hady (2002) and Man *et al.,* (2014). A laboratory dough mixer was used to make the dough. Shortening and ground sugar were combined for 10 minutes at high speed in a mixer with a flat beater until the mixture became light. While continually mixing, the eggs were added. The flour, leavening agents, and vanilla were mixed together in a dough mixer bowl for 10 minutes to make a solid dough, which was then prepared with the required amount of water. After mixing, the dough was transported to the biscuit-making machine (thickness 5.28 mm, diameter 35.82 mm). The dough pieces were transformed onto a baking tray lined with aluminum foil. After that, Biscuit dough were baked at 220°C for 10 min. Biscuits were allowed to cool for 40 min at room temperature (29±2°C) and packaged in polyethylene bags, then held at room temperature for evaluation.

Table 1. Proximate Analysis of Quinoa, Rice and chickpeas flour:

Ingredients	Blend 1	Blend 2	Blend 3	Blend4	Blend 5
broken rice flour (g)	100	50	50	50	50
chickpea flour(g)	-	10	20	30	40
quinoa flour (g)	-	40	30	20	10
Sugar(g)	33	33	33	33	33
Ammonium bicarbonate(g)	0.35	0.35	0.35	0.35	0.35
Vanilla(g)	0.25	0.25	0.25	0.25	0.25
Sodium bicarbonate(g)	0.45	0.45	0.45	0.45	0.45
Egg (fresh)(g)	20	20	20	20	20
Butter(g)	28	28	28	28	28
Water	30-35 ml	30-35 ml	30-35 ml	30-35 ml	30-35 ml

Quinoa flour, Rice flour and chickpeas flour were analyzed for crude protein, ash, ether extract and crude fiber according to the methods of AOAC (2005).

Available carbohydrates were calculated by difference.

Available carbohydrates = 100 – (protein + ash + ether extract + crude fiber)

Total calories were calculated by the formula of James (1995) as follows:

Total calories = Fat x 9 + Protein x 4 + Available carbohydrate x 4.

Determination of minerals content:

Minerals were analyzed according to the methods of AOAC (2005).

Determination of Amino Acids

Amino acids were calculated according the method described in AOAC (2005).

Estimation of Tryptophan

Tryptophan content of samples was determined calorimetrically according to the method described by Miller (1967).

Computed protein efficiency ratio (C-PER):

C-PER was estimated as described by Alsmeyer, *et al*., (1974) following the equation:

C-PER = -0.684+0.456 (Leucine) -0.047 (proline).

Computed Biological value (BV):

Biological value was estimated as described by Farag, *et al*., (1996) according following equation: -

BV =49.9+10.53C-PER.

Sensory Evaluation of Biscuits:

According to method of Smith, (1972) Biscuit blends were examined for sensory properties. Twenty trained panelists from the Food Technology Research Institute judged the samples for appearance, color, odor, texture, taste, and overall acceptability. For sensorial evaluation, a numerical decadent scale ranging from 1 to 20 was used (1 being very bad and 20 being excellent).

Statistical Analysis

The SPSS version 16.0 software was used to evaluate the analytical data. Descriptive statistics were used to calculate the means and standard deviations. Analysis of one-way variance (ANOVA) and multiple range tests were used to make comparisons between samples. P≤ 0.05 was used to determine statistical

RESULTS AND DISCUSSION

Chemical Compositions of Quinoa Flour, Rice Flour and Chickpeas:

The chemical composition of raw materials, revealed in Table 2, Quinoa flour analysis showed that ether extract reached 5.60%, while crude fiber was 6.80 %, crude protein was 15.50%; ash was 4.30 %, and available carbohydrates were 67.80% and383.600 kcal/100g caloric value. The data are in agreement with the work of El-Hadidy *et al.* (2020) who reported that quinoa flour had 13.13% crude protein, 75.70% total carbohydrates,4.65% ash and 6.52% crude ether extract.

As for rice flour, data exposed 0.70%ether extract, 7.80% crude protein, 0.85%ash, 0.45% fiber and 90.20% available carbohydrates. Results were harmony with Omran and Hussien(2015) reported that rice flour had 7.78%proteins, 0.66% ash and 91.36% carbohydrates. Roushdi *et al.*, (2016) studied that rice flour had 6.65% proteins, 0.38% crude fiber, 0.54% ash and 91.37% available carbohydrates.

Results of chickpeas flour analysis showed that crude protein was 25.40%, ether extract reached 10.50%, While crude fibre was 12.50%, ash was 4.50 % and available carbohydrates were 47.10%. These results are consistent with the work of Elhadidy (2009) who reported that chickpeas flour had 25.58% protein, 12.76% fat, 2.75% ash, 6.6%fibre and 52.31% carbohydrates.

Table 2. Chemical Compositions of Quinoa Flour, Rice Flour and Chickpeas Flour on Dry Weight Basis.

Components	Quinoa flour	Rice flour	Chickpeas flour
Crude protein%	15.50±0.24^{b}	7.80±0.33^{c}	25.40±0.24^{a}
Ether extract%	5.60±0.35^{b}	0.70±0.45^{c}	10.50±0.26^{a}
Ash%	4.30±0.25^{b}	0.85±0.26^{c}	04.50±0.43^{a}
Crude fibre%	6.80±0.27^{b}	0.45±0.24^{c}	12.50±0.32^{a}
*Available carbohydrates%	67.80±0.33^{b}	90.20±0.53^{a}	47.10±0.23^{c}
Caloric value (kcal/100g)	383.60^{b}	398.30^{a}	384.30^{c}

***Available carbohydrates = 100 – (protein + ash + ether extract + crude fiber)**

3. Minerals Content of Quinoa Flour, Rice Flour and Chickpeas Flour (On Dry Weight Basis).

Table 3. presents the mineral content of quinoa flour, rice flour and chickpea flour. The results indicate a higher mineral content of quinoa flour compared to chickpea flour and rice flour. Thus, mixing these different types of flour, we get integration in the quantity and quality of the mineral elements needed by the body. These results are in agreement with El-Hadidy *et al.* (2020) who stated that quinoa flour contain K,Na, Ca, P, Fe, Zn and Mn. El-Dreny and El-Hadidy (2020) reported that rice flour contains Ca, K, P, Fe, Mn and Zn

Table 3. Minerals content of quinoa flour, rice flour and chickpeas flour on dry weight basis.

Macro minerals (mg /100g)	Quinoa flour	Rice flour	Chickpeas flour
K	1490	380	160
Ca	290	18.50	135
P	410	128	230
Na	110	5.60	24
Mg	160	150	170
Micro minerals (mg /100g)			
Mn	11.50	1.90	7.80
Zn	4.20	2.90	2.20
Fe	3.60	0.95	3.50

3. Amino Acids Composition of Quinoa, Rice F and Chickpeas Flour (G. Amino Acid /100g Protein)

Amino acid content of quinoa flour, rice flour and chickpeas flour were determined as g/100g protein and the found results of amino acids are shown in Table 4.

Results showed that, the total essential amino acids and total non-essential amino acids content of the quinoa flour were 46.90 and 46 g /100 g of protein, respectively. The content of indispensable amino acids shows that quinoa flour had higher percentage of leucine (8.60%), lysine (6.80%), and phenylalanine (6.30%). while dispensable amino acids contained glutamic and aspartic were 14 % and 8.50% followed by glycine 8.50%, while alanine, serine, proline and arginine was 4.80, 4.20, 4.00 and 2.00%, respectively. These results are parallel with the study of Elhadidy *et al.*, (2020).

Also, the total essential amino acids and total non-essential amino acids content of the rice flour were 47.10and 48.80 g /100 g of protein, respectively. The content of indispensable amino acids shows that rice flour had higher percentage of leucine (7.60%), phenylalanine (6.90%), and tyrosine (4.80%). while non-essential amino acids contained glutamic and aspartic were 16.50 % and 9.00% followed by arginine 8.00%, while glycine, alanine and serine was 5.00, 4.90 and 4.20 %, respectively. These results are matching with the investigate of El- Derny and El- hadidy (2020).

Table 4. Amino acids composition of quinoa, rice and chickpeas flour (g. amino acid /100g protein)

Amino acids	Quinoa flour	Rice flour	Chickpeas flour	FAO/WHO/UNU (1985) pattern
Lysine	6.80	3.90	7.80	5.80
Isoleucine	4.8	4.50	5.30	2.80
Leucine	8.6	7.60	8.20	6.60
Phenylalanine	6.30	6.90	4.80	
Tyrosine	2.50	4.80	3.90	6.30
Histidine	3.60	2.60	3.40	1.90
Valine	4.20	4.60	5.50	3.5
Threonine	5.00	4.80	4.75	3.40
Methionine	4.00	2.50	1.35	2.20
Tryptophan	1.10	1.40	1.35	1.00
Cysteine	ND	3.50	1.70	-
Total (EAA)	46.90	47.10	46.70	-
Aspartic acid	8.50	9.00	10.00	-
Glutamic acid	14.0	16.50	14.50	-
Serine	4.20	4.20	6.00	-
Proline	4.00	1.20	4.00	-
Glycine	8.50	5.00	4.30	-
Alanine	4.80	4.90	4.35	-
Arginine	2.00	8.00	9.80	-
Total (NEAA)	46.00	48.80	52.95	-
C-PER	3.05	2.73	2.87	-
BV	82.01	78.59	80.09	-

EAA: Essential amino acids. NEAA: Nonessential amino acids
C-PER = Computed protein efficiency ratio. BV = Biological value

The total essential amino acids and total non-essential amino acids content of the chickpeas flour were 46.70and 52.95 g /100 g of protein, respectively. The content of indispensable amino acids shows that chickpeas flour had higher percentage of leucine (8.20%) lysine (7.80%),valine (5.50), and phenylalanine (4.80%).while dispensable amino acids contained glutamic and aspartic were 14.50 % and 10% followed by arginine 9.80%, while serine ,glycine, alanine and proline was 6.00, 4.30, 4.35, and 4.00 %, respectively. Chickpeas flour is considered a good source of some essential amino acids such as leucine and lysine El-Hadidy (2009).

Computed protein efficiency ratio C- PER and biological value BV) of quinoa flour, rice flour and chickpeas flour were obtainable in Table 3.The C-PER of quinoa flour, rice flour and chickpeas flour were (3.05, 2.73 and 2.87). Meanwhile, BV of quinoa flour, rice flour and chickpeas flour were (82.01, 78.59 and 80.09), respectively as shown in table 4

The chemical parameters of biscuits

Table (5) shows the chemical composition of gluten-free biscuits. There were significant differences in all parameters considered ($P < 0.05$). The highest value for crude protein content was found in blend 5 (10.84%) while, the lowest content found in blend 1 (6.14%). Furthermore the same blend 5 was characterized by high crude protein, ether extract, crude fibre, except for available carbohydrates which was the lowest (10.84%, 21.33%, 3.55%, 1,77 and 62.51%), respectively. This may be due to the high addition level of quinoa flour and chickpeas flour.

Table 5. Chemical Analysis of Gluten–Free Biscuits

Components	B1	B2	B3	B4	B5
Crude Protein%	6.14 ±0.02	9.06 ±0.01	9.66 ±0.02	10.25 ±0.04	10.84 ±0.01
Ether Extract	18.67 ±0.05	20.44 ±0.01	20.74 ±0.07	21.08 ±0.02	21.33 ±0.06
Ash%	0.67 ±0.03	1.60 ±0.04	1.74 ±0.02	1.75 ±0.04	1.77 ±0.03
Crude Fiber %	0.27 ±0.02	2.52 ±0.01	2.86 ±0.02	3.21 ±0.04	3.55 ±0.01
Available Carbohydrates%*	74.25 ±0.02	66.38 ±0.01	64.99 ±0.02	63.71 ±0.04	62.51 ±0.01
Caloric Value (kcal/100g)	489.59 ±0.08	485.72 ±0.05	485.26 ±0.09	485.56 ±0.08	485.37 ±0.13

Sensory Properties of Biscuits:

The sensorial possessions appearance, color, odor, texture, taste and overall acceptability of biscuits made from quinoa flour, rice flour and chickpeas flour of different levels and biscuits prepared from 100% of rice flour were evaluated by twenty panelists. The results were statistically investigated and noted in Table 6. From the data presented in Table 6, it could be noticed that Appearance, color, odor, texture and overall acceptability B5 have higher scores than B1.The other blends sensorial properties of gluten free biscuit blends contained quinoa flour; rice flour and chickpeas flour were nearly similar with those of B5. El-Hadidy *et al.* (2020) detailed that addition quinoa flour to prepare biscuits for celiac patients enhance of color, taste, texture and taste. Sensory evaluation is seen to be a useful approach for resolving issues with food suitability. It can be used to improve products, maintain quality, and, more significantly, improve new products.

Table 6. Sensory evaluation of biscuits

Samples	Appearance 20	Color 20	Texture 20	Odor 20	Taste 20	Over acceptability 100
B_1	17.68^{c} ±0.48	16.68^{d} ±0.38	17.66^{b} ±0.38	16.32^{d} ±0.48	17.00^{c} ±0.35	85.34^{e} ±0.33
B_2	17.60^{c} ±0.31	17.40^{c} ±0.48	17.60^{b} ±0.44	17.40^{c} ±0.45	17.40^{bc} ±0.45	87.40^{d} ±0.06
B_3	18.20^{bc} ±0.37	18.30^{b} ±0.37	18.00^{b} ±0.51	17.80^{bc} ±0.45	18.20^{ab} ±0.37	90.26^{c} ±0.16
B_4	18.60^{b} ±0.45	18.80^{ab} ±0.47	18.30^{b} ±0.47	18.10^{ab} ±0.32	18.40^{a} ±0.49	91.10^{b} ±0.01
B_5	19.50^{a} ±0.53	19.40^{a} ±0.55	19.20^{a} ±0.37	18.60^{a} ±0.44	19.00^{a} ±0.43	92.80^{a} ±0.05

- Values followed by the same letter in columns are not significantly different at LSD at ($p \leq 0.05$).

- Each value was an average of twenty determinations ± standard deviation.

CONCLUSION

The data in this study showed that biscuits formulated from quinoa flour, rice flour and chickpeas flour at different proportions. The final products were rich of crude protein, crude fiber and ether extract with a high caloric value. These products were a rich source of essential amino acids and minerals especially calcium, potassium, magnesium and iron. The sensorial properties of prepared biscuits from quinoa flour, rice flour and chickpeas flour were nearly similar of products prepared using rice flour. These products were free of gluten therefore; they are very suitable for celiac patients. Finally, it could prepare some bakery products using materials free of gluten such quinoa flour, rice flour and chickpeas flour flours with high quality that are suitable for celiac disease patients.

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تحضير أنواع بسكويت خالي من الجلوتين باستخدام دقيق الأرز و الكينوا و الحمص مخصص لمرضي حساسية الجلوتين

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تهدف الدراسة إلى تحضير بسكويت عالي الجودة وخالي من الغلوتين للمرضى الذين يعانون من حساسية الجلوتين. الدقيق المستخدم كان دقيق الكينوا و الأرز والحمص كبديل عن دقيق القمح بالإضافة إلى المكونات الأساسية الأخرى للبسكويت .تم نجهيز ثلاث خلطات هي الأرز فقط (B1) ، = B2 أرز50 ٪ + كينوا40 ٪ + حمص10 ٪ ، = B3 أرز50 ٪ +كينوا30 ٪ + حمص20 ٪ ، = B4 أرز50 ٪ + كينوا20 ٪ + الحمص30 ٪ ، = B3 أرز50 ٪ + كينوا10 ٪ + حمص40 ٪. تم تقدير التحليل الكيميائي ، محتوى المعادن و الأحماض الأمينية للمواد الخام. أظهر التركيب الكيميائي لخلطات البسكويت الخالية من الجلوتين أن محتوى البروتين الخام ومستخلص الأثير والرماد والألياف كانت أعلى في جميع العينات المحضرة باستخدام دقيق الكينوا ودقيق الأرز ودقيق الحمص مقارنة بالعينة المحضرة باستخدام دقيق الأرز فقط .. و سجل دقيق الكينوا اعلي محتوى في الاحماض الامينية الليوسين 8.6% و الفينيل الانين 6.3% بينما كان دقيق الحمص اعلي في الليسين و الفالين و دقيق الارز اعلي في الالانين و التربتوفان. احتوت الخلطةB1 علي اعلي قيمة لسعرات الحرارية مقارنة بخلطات البسكويت B3 و B4 و B5 التقييم الحسي اظهر ان التقبل الكلي لعينات المحضرة باستخدام دقيق الكينوا و الأرز و الحمص كانت(92.8% , 91.1% .90.2% ,87.4%) أعلى إلى حد ما من البسكويت المحضر من دقيق الأرز (85.3%). كل خلطات البسكويت مناسب من الناحية التغذوية لمرضى سيلياك.

الكلمات الدالة: بسكويت ، خالى الجلوتين ، الحمص ، الأرز ، الكينوا ، السيلياك