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Preparation of some functional bakeries for celiac patients

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The present investigation was carried out to prepare gluten free biscuits with high quality for celiac patients. The chemical analysis as minerals, amino acids of raw materials was estimated. Also, chemical composition for gluten free biscuits blends was determined and results showed that protein, ether extract and fibre contents were higher in all samples prepared using cassava flour, quinoa flour and sweet potato flour than those samples prepared using cassava flour. Volume, length, spread ratio and width of gluten free biscuit blends B2, B3, B4 and B5 decreased but thickness and bulk density increased compared to cassava flour biscuits B1. All sensory characteristics of free gluten biscuits samples B2, B3, B4 and B5 prepared using cassava flour, quinoa flour, and sweet potato flour were somewhat higher than biscuits prepared from cassava flour B1. Finally, blends B2 and B5 had higher scores in sensorial evaluation, chemical analysis, and physical attributes.

Graphical Abstract

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1. Introduction

Celiac disease is an immune-mediated enteropathy caused by dietary gluten, which is found in wheat, rye, and barley. It is one of the most frequent lifelong food-related disorders in the world. In addition to enteropathy, coeliac disease is a systemic condition defined by a variable combination of gluten-related signs and symptoms as well as disease-specific antibodies.

Gluten consumption produces damaging gluten peptides, which can trigger adaptive and innate immune responses in those who are predisposed. Patients may feel with severe gastrointestinal symptoms and malabsorption, extra intestinal symptoms, or no symptoms at all, depending on the clinical presentation. Diagnosis is difficult due to the diverse clinical presentation, and celiac disease is underdiagnosed.

During a gluten-free diet, celiac disease is diagnosed by combining celiac disease serology and small intestine mucosal histology. The only effective treatment for celiac disease is a gluten-free diet that must be followed for the rest of one's life; nevertheless, the diet is restricted and gluten is difficult to avoid. Continuous research and education of both patients and health-care professionals are required to optimize diagnosis and care in celiac disease.[1]

Cassava (*Manihot esculenta* Crantz, often known as manioc or yucca) is a tuber, not a cereal. It comes from the North-East of Brazil in South America. It is now grown in Indonesia, Malaysia, the Philippines, Thailand, and parts of Africa, including Nigeria, which has recently surpassed Brazil as the world's leading cassava producer.[2]

Tropical South America, and Southeast Asia, as well as West Africa and the Congo basin. Cassava is a mostly starchy raw material that has no gluten, making it appropriate for celiac disease sufferers. Celiac disease is characterized by a lifelong intolerance to the prolamins found in wheat and other cereals, and the only effective treatment is lifelong adherence to a gluten-free diet. Many gluten-free items are now available; however there are still some issues with bread production. In fact, many gluten-free bread on the market today are of lower quality than their gluten-containing equivalents.[3]Quinoa, unlike wheat, rye, and barley, is gluten-free, making it a viable alternative to typical cereals for persons with Celiac disease. Quinoa is a pseudo-cereal from the Chenopodium genus (Chenopodiaceae family). It's a perfect grain with a protein profile that's similar to that of milk, plus it's high in vital fatty acids and fibre.[4]Quinoa is high in calcium, magnesium, iron, and zinc, among other nutrients.[5]

Quinoa is being utilized in items such as bread, chips, pancakes, and cookies, and it is gaining popularity around the world.[6] After rice, corn, and cassava, sweet potato (*Ipomoea batatas* L.) is the fourth most important alternative source of carbohydrates. This crop is currently regarded as having a low economic worth, but it has enormous social significance. It's most known as a snack meal, but it's also eaten as a staple food or a rice alternative in many places. Because of its quick maturity time, capacity to grow in a variety of climatic situations, and ability to grow on less fertile soils, sweet potato has a lot of potential for usage as a food in developing countries with limited resources.[7] Sweet potato flesh comes in a variety of colors: white, creamy, yellow, orange, and purple. The most commonly grown and consumed varieties are orange, white, and creamy.[8-9] Sweet potatoes are a high-carbohydrate, low-fat food. A good source of antioxidants, fibre, zinc, potassium, sodium, manganese, calcium, magnesium, iron, and vitamin C. Sweet potatoes with orange flesh are also high in vitamin A.[10-12] There is an increase in the number of people suffering from food intolerances nowadays. Lactose intolerance, gluten intolerance/gluten allergies, and celiac disease are the most common. Buckwheat, amaranth, and quinoa are three gluten-free pseudo-cereals that can be included in gluten-free diets.[13] The prevalence of cardiovascular illnesses and other degenerative diseases such as malignancies is also on the rise, and incorporating whole pseudo-cereals such as quinoa, which possesses functional characteristics, into the diet could help give a safe, easy, and cost-effective strategy to prevent such diseases.[4]

This search aimed to study the use of the cassava flour, quinoa flour and sweet potato flour for the improvement of gluten-free biscuits for persons suffering from celiac ailment.

2. Materials and Methods

2.1 Materials

Cassava flour (*Manihot esculenta* Crantz), quinoa flour (*Chenopodium Quinoa Willd*), sweet potato flour (*Ipomoea batatas* L.) and other ingredients that used to prepare biscuits like sugar (sucrose), egg, baking powder, salt (sodium chloride) and butter were purchased from the local market, Kafrelsheikh city, Egypt. Chemicals and solvents were purchased from EL- Gomhoria Company, Cairo, Egypt.

2.1.1 Preparation of Biscuits

The biscuit blends are obtainable in **Table 1**. The procedures are as follows: sugar and butter were mixed in (a Kenwood blender) at a medium speed until plumped cream was formed, adjust egg and continue the mixing. Cassava flour, quinoa flour and sweet potato flour were added to the blender then salivated on a flat rolling board. Cut biscuits were placed on creamed baking trays and baked for 15 minutes in an electric oven at 160°C.[14]

Table 1. Blends of biscuits for celiac patients

Ingredients	B1	B2	B3	B4	B5
Cassava flour(g)	100	50	50	50	50
Quinoa flour (g)	---	10	20	30	40
Sweet potato flour(g)		40	30	20	10
Sugar (g)	30	30	30	30	30
Whole egg(g)	24	24	24	24	24
Baking powder (g)	01	01	01	01	01
Butter (g)	15	15	15	15	15
Vanillin (g)	0.3	0.3	0.3	0.3	0.3
Skimmed milk	0.5	0.5	0.5	0.5	0.5
Warm water(ml)	As needed				

B1= 100% Cassava flour.
B2 = 50% Cassava flour+10% Quinoa flour + 40% Sweet potato flour.
B3 = 50% Cassava flour+20% Quinoa flour + 30% Sweet potato flour.
B4 = 50% Cassava flour+30% Quinoa flour + 20% Sweet potato flour.
B5 = 50% Cassava flour+40% Quinoa flour + 10% Sweet potato flour.

2.2 Methods

2.2.1 Proximate analysis of ingredients and biscuits

Cassava flour, quinoa flour, sweet potato flour and biscuit blends were investigated for crude protein, ash, ether extract and crude fiber according to the procedures outlined by AOAC.[15] Available carbohydrates were calculated by difference.

Available carbohydrates = 100 – (crude protein + ash + ether extract + crude fibre) according to the reported method.[16]

Total calories were calculated by according to report papers[17] as follows:

Total calories =Ether extract × 9 + Crude protein × 4 + Available carbohydrate × 4.

2.2.2. Determination of Vitamin C

Vitamin C was assayed as described before.[18]

2.2.3 Determination of total carotenoid

The total carotenoid content was estimated by the procedure described by Chan and Cavaletto using UV/Visible spectrophotometer.[19]

2.2.4 Determination of minerals content

Minerals were determined according to the procedures outlined by AOAC.[15]

2.2.5 Determination of amino acids

Amino acids of cassava flour, quinoa flour, sweet potato flour were determined according the method described in AOAC.[15]

2.2.6 Estimation of tryptophan

Tryptophan content of samples was determined calorimetrically according to the method described before.[20]
Computed protein efficiency ratio (C-PER):
C-PER was determined according to the reported equation[21]:
C-PER = -0.684+0.456 (Leucine) -0.047 (proline).
Computed Biological value (BV): Biological value was determined according to the reported equation[22]:

BV = 49.9+10.53C-PER.

2.2.7 Chemical score of amino acid:

Chemical score of indispensable amino acids was calculated according to the reported method[23] as follows:

$$\text{Chemical score} = \frac{\text{Essential amino acid / 100 g protein in sample}}{\text{Essential amino acid / 100 g protein in FAO / WHO / UNU}} \times 100$$

- The amino acid that shows the lowest percent value is named limiting amino acid, was the ratio obtained is the score.

2.2.8 Sensorial evaluation of biscuits

According to procedure of AACC,[24] biscuit samples were tested organoleptically for sensory qualities. 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).

2.2.9 Hardness of biscuits

Hardness of biscuits was determined according to the reported method.[24]

2.2.10 Physical characteristics of biscuits

Width and length: a Vernier calliper was used to assess the width of six biscuits when they were placed edge to edge (0.01 mm accuracy). Using the mean value, the average width was kept in check.[25] Similarly, the length of the biscuits was calculated by taking the average of six biscuits.

Thickness

The average thickness was calculated by stacking six biscuits on top of one another and obtaining the average thickness (cm). With the use of an advanced weighted balance, the weight of six biscuits was estimated.

Volume

The length of the biscuits was used to compute the volume. The following formula can be used to calculate width and thickness: Volume (m^3) = $L \times W \times T$

L = average length of biscuits (cm)   W = average width of biscuits (cm)   T = average thickness of biscuits (cm)

Spread ratio

The spread ratio was estimated according to the reported method[26] by using the following equations: The spread ratio is equal to the width divided by the thickness.

2.2.11 Statistical Analysis:

Statistical analysis was prepared using SPSS software (version 16) and Duncan's multiple range tests was used for mean comparison.

3. Results and Discussions

3.1 Chemical composition of raw materials (On dry weight basis)

The chemical analyze of raw materials, revealed in **Table 2**, exposed that cassava flour contained 5 % ash; 7.00% crude protein; 1.50 % ether extract; 4.50% crude fiber; 80 % available carbohydrates and361.50 kcal/100g Caloric value. These results agree with.[27] reported that cassava flour contains 6.70% crude protein. Also, the previous results stated that cassava flour contain 1.28% fat; 5.44% ash, 3.70% crude fiber and 86.29% total carbohydrates.[28]

As for Orange Sweet potato flour, results showed 5.30% crude protein, 1.88%ether extract, 4.50%ash, 5.20% crude fiber, 83.12% available carbohydrates and 370.60 kcal/100g Caloric values. The data were harmony with the reported work.[29] stated that Orange Sweet potato flour had 2.37% crude fiber, 3.04% ash, 3.77% proteins, 387.83 kcal/100g Caloric value and 91.41% total carbohydrates. Results of Quinoa flour analysis showed that crude protein was 16%; ether extract reached 6.30%, while crude fiber was 7.00 %, ash was 4.50 %, and available carbohydrates were 66.20% and385.50 kcal/100g Caloric value. The data are harmony with the work of *El-Hadidy et al*. who stated that quinoa flour had 6.52% crude ether extract, 13.13% crude protein, 75.70% total carbohydrates,4.65% ash, and 414 kcal/100g Caloric value.[30]

Data offered in **Table 2** displayed mineral content of cassava flour, orange sweet potato flour, and quinoa flour as mg/100 g. The results revealed that the mean value of minerals (K, P, Mg, Fe, Mn, and Zn) in quinoa flour was higher than that of cassava or orange sweet potato. On the other hand, Ca and Na levels are higher in cassava flour and orange sweet potato flour than quinoa flour. These results were confirmed with the reported work.[29]stated that cassava flour contain Na, Mg, Ca, Zn, Mn and Fe.Olatunde, *et al.,* who stated that sweet potato flour contain Na Ca, K, P, Zn, Fe, Cu and Mn.[31] El-Hadidy *et al*., who stated that quinoa flour contain K, Ca, P, Fe, Zn and Mn.[31]

Data obtainable in **Table 2** presented ascorbic acid and β-carotene content of cassava flour, orange sweet potato flour, and quinoa flour as mg/100 g. The results revealed that the mean value of vitamin C content of Cassava flour, orange sweet potato flour and quinoa flour was (12.80, 27.50 and 14.50 mg/100g), respectively, while β-carotene content of Cassava flour, orange sweet potato flour and quinoa flour was (1.30, 9.07 and 1.5 mg/100g), respectively. These results were confirmed with the reported work.[32] stated that orange sweet potato flour contain ascorbic acid (2.10 mg/100g) and β carotene (8109μg/100g). *Abdellatif*, stated that quinoa flour contain Ascorbic acid (15.5 mg/100g).[33] *Koziol.*, indicated that quinoa flour contain Ascorbic acid (4 mg/100g) and ß carotene (0.39 mg/100g).[34]

Table 2. Chemical composition of raw materials

Components	**Cassava flour (g /100 g)**	**Orange Sweet potato flour (g /100 g)**	**Quinoa flour (g/100 g)**
Crude protein%	$7.00^{b}\pm0.05$	$5.30^{c}\pm0.04$	$16.00^{a}\pm0.05$
Ether extract%	$1.50^{c}\pm0.02$	$1.88^{b}\pm0.01$	$6.30^{a}\pm0.03$
Ash%	$5.00^{a}\pm0.01$	$4.50^{b}\pm0.02$	$4.50^{b}\pm00.05$
Crude fibre%	$4.50^{c}\pm0.03$	$5.20^{b}\pm0.03$	$7.00^{a}\pm0.06$
***Available carbohydrates%**	$80.00^{b}\pm 0.50$	$83.12^{a}\pm0.80$	$66.2^{c}\pm0.50$
Caloric value (kcal/100g)	$361.50^{c}\pm0.60$	$370.60^{b}\pm0.50$	$385.50^{a}\pm0.80$
Minerals (m g /100 g)			
K	$450^{c}\pm3.50$	$850^{b}\pm2.5$	$1550^{a}\pm 3.50$
Ca	$280^{a}\pm5.00$	$156^{b}\pm0.55$	$125^{c}\pm0.70$
P	$250^{b}\pm2.40$	$145^{c}\pm0.65$	$406^{a}\pm0.80$
Na	$125.38^{a}\pm6.50$	$115^{b}\pm1.00$	$55^{c}\pm0.09$
Mg	$170^{b}\pm0.70$	$150^{c}\pm0.95$	$540^{a}\pm2.0b$
Fe	$3.50^{c}\pm0.03$	$3.80^{b}\pm0.03$	$12^{a}\pm0.04$
Mn	$5.60^{a}\pm0.07$	$1.80^{c}\pm0.01$	$4.40^{b}\pm0.03$
Zn	$1.83^{c}\pm0.02$	$3.50^{b}\pm0.01$	$3.80^{a}\pm0.02$
Vitamins (mg /100g)			
Vitamin C	$12.80^{c}\pm0.07$	$27.05^{a}\pm0.05$	$14.50^{b}\pm0.40$
B-carotene	$1.30^{c}\pm0.01$	$9.07^{a}\pm0.04$	$1.50^{b}\pm0.03$

-Each value was an average of three determinations ± standard deviation.
- a, b and c different superscript letters in the same rows are significantly different at LSD at ($p \leq 0.05$).
*Available carbohydrates = 100 – (crude protein + ash + ether extract + crude fibre).

3.2 Amino acids composition of cassava flour, orange sweet potatoes flour and quinoa flour (g. amino acid /100g protein)

Amino acid contents of cassava flour, orange sweet potato and quinoa flour were determined as g/100g protein and the obtained results of amino acids are shown in **Table 3**.

Results offered that the total dispensable amino acids and total indispensable amino acids content of the cassava flour were 53.84and 43.61 g /100 g of protein, respectively. The content of essential amino acids shows that cassava flour had a higher percentage of leucine (8.73%), phenylalanine (8.25%), and lysine (5.43%). while dispensable amino acids contained glutamic and aspartic were 15.20 % and 9.42% followed by arginine 7.42%, while alanine, serine, glycine and proline was 6.74, 5.36,5.16 and 4.54 %, respectively. These results are consistent with the reported work before.[35]

Also, the total non-essential amino acids and total indispensable amino acids content of the orange sweet potato flour were 48.40and 51.6 g /100 g of protein, respectively. The content of essential amino acids shows that orange sweet potato flour had a higher percentage of leucine (7.40%), phenylalanine (7.00%), and lysine (6.80%). dispensable amino acids containing glutamic and aspartic were 8.50 % and 19.90% followed by serine 6.00%, while arginine, glycine, alanine and proline was 5.00, 5.00,4.50 and 4.50 %, respectively. These results are in agreement with the reported work.[36]

The total dispensable amino acids and total indispensable amino acids content of the quinoa flour were 46.80and 44.33g /100 g of protein, respectively. The content of essential amino acids shows that orange sweet potato flour had a higher percentage of lysine (7.00%), phenylalanine (6.50%), and leucine (8.50%). dispensable amino acids containing glutamic and aspartic were 13.00 % and 7.50% followed by glycine 9.00%, while alanine ,serine , proline and arginine was 5.00, 4.55,4.00 and 1.80 %, respectively. Quinoa is considered a good source of some indispensable amino acids like methionine and lysine. These results are in agreement with the reported work.[30]

Computed protein efficiency ratio C- PER and biological value BV of cassava flour, orange sweet potato and quinoa flour were obtainable in **Table 3**. The C-PER of cassava flour, orange sweet potato and quinoa flour were (3.08, 2.47 and 3.00). Meanwhile, BV of cassava flour, orange sweet potato and quinoa flour were (82.37, 75.93 and 81.53), respectively.

The bioavailability or digestibility of a protein is determined by its amino acid composition as well as its bioavailability or digestibility. Protein digestibility, accessible lysine, net protein utilization (NPU), and protein efficiency ratio (PER) are all commonly employed as nutritional quality markers. In this regard, pseudo-cereal proteins have significantly greater values than cereal proteins, and they are comparable to casein proteins.[36] When compared to cereal proteins, the values for pseudo-cereal proteins are significantly greater and are comparable to casein.[39] The final findings show that quinoa flour protein is of excellent grade. Various amino acids cause hypocholesterolemic influence like arginine, lysine, methionine and glycine and hence they are of great significance.[40]

Table 3. Amino acids composition of cassava flour, orange sweet potatoes flour and quinoa flour (g. amino acid /100g protein)

Amino acids	Cassava flour	Orange Sweet potatoes flour	Quinoa flour	FAO/WHO/UNU (1985) pattern
Lysine	5.43	6.80	7.00	5.80
Isoleucine	4.75	5.60	4.7	2.80
Leucine	8.73	7.40	8.5	6.60
Phenylalanine	8.25	7.00	6.5	
Tyrosine	---	5.80	2.80	6.30
Histidine	2.48	2.4	3.50	1.90
Valine	7.70	6.90	4.40	3.5
Threonine	4.55	6.40	4.00	3.40
Methionine	2.55	2.20	3.8	2.20
Tryptophan	ND	1.10	1.13	1.00
Cysteine	1.72	ND	ND	
Total (EAA)	43.61	51.6	46.33	
Aspartic acid	9.42	14.90	7.50	
Glutamic acid	15.20	8.50	13.0	
Serine	5.36	6.00	4.55	
Proline	4.54	4.50	4.00	
Glycine	5.16	5.00	9.00	
Alanine	6.74	4.50	5.00	
Arginine	7.42	5.00	1.80	
Total (NEAA)	53.84	48.40	44.80	
C-PER	3.08	2.47	3.00	
BV	82.37	75.93	81.53	

Total (EAA) = Total Essential Amino Acids Total (NEAA) = Total Non-Essential Amino Acids
C-PER = Computed protein efficiency ratio BV = Biological Value ND= Not Detect

3.3 The chemical scores of cassava flour, orange sweet potato and quinoa flour

Data from **Table 4** display the first, second and third limiting amino acids of cassava flour, orange sweet potato flour and quinoa flour.

The chemical score of the first, second and third limiting amino acids of cassava flour were lysine, methionine and histidine, respectively. Also, the chemical scores of the first, second and third limiting amino acids of orange sweet potato flour were methionine, tryptophan and leucine, respectively. As for the chemical score of the first, second and third limiting amino acids of quinoa flour were leucine, tryptophan and threonine.

The high content of arginine and histidine, both essential for infants and children, makes amaranth and quinoa interesting for the nutrition of Celiac Disease children. Moreover, pseudo-cereals and minor cereals contain amino acids like methionine and cysteine which are essential to human health.[41] This observation is in agreement with Millward who emphasized that leucine and lysine are the most abundant amino acids in growth requirement while sulfuric is one of AA required for maintenance.[42]

Table 4. The chemical scores of cassava flour, orange sweet potato and quinoa flour compared with the required pattern control recommended by FAO/WHO/UNU (1985).

Essential amino acids	FAO/WHO/UNU (1985)pattern	Amino acids score cassava flour	Amino acids score sweet potatoes flour	Amino acids score quinoa flour
Lysine	5.80	093.62*	117.24	120.69
Isoleucine	2.80	169.64	200	167.86
Leucine	6.60	132.27	112.12***	98.48*
Phenylalanine+ Tyrosine	6.30	130.95	203.17	147.62
Histidine	1.90	130.53***	126.32	184.21
Valine	3.5	220.00	197.14	125.71
Threonine	3.40	133.82	188.24	117.65***
Methionine	2.20	115.91**	100*	172.73
Tryptophan	1.00	Nd	110**	113**

Chemical score was calculated as a percentage of the FAO/WHO/UNU (1985) indispensable amino acid.
* First limiting amino acid. ** Second limiting amino acid. ***Third limiting amino acid. nd = not detect

3.4 The chemical analysis of biscuits

The data in **Table 5** exposed the chemical composition of biscuits. There were significant differences in all parameters considered ($P < 0.05$). The highest value for crude protein content was found in blend No. 5 (9.09%) while the lowest content found in blend No. 1 (6.80%). Furthermore the same blend No. 5 characterized by high ether extract, crude fiber ,Caloric value except for available carbohydrates which was the lowest (12.30%, 5.57%, 425.66 kcal/100g) and (52.47%), respectively. This may be due to the high addition level of quinoa flour to an extent (40%). These results are in agreement with the reported work[30] that showed the addition of quinoa flour to prepare biscuits enhances crude protein, crude fiber, ether extract and ash.

Table 5. The chemical composition of gluten free biscuits

Components	B1	B2	B3	B4	B5
Crude protein%	6.80^{a} ±0.02	6.94^{b} ±0.01	7.66^{c} ±0.02	8.57^{d} ±0.04	9.09^{e} ±0.01
Ether extract	11.22^{e} ±0.05	11.42^{d} ±0.01	11.72^{c} ±0.07	12.01^{b} ±0.02	12.30^{a} ±0.06
Ash%	3.55^{a} ±0.03	3.39^{b} ±0.04	3.39^{b} ±0.02	3.39^{b} ±0.04	3.39^{b} ±0.03
Crude fibre%	4.50^{e} ±0.02	5.03^{d} ±0.01	5.21^{c} ±0.02	5.39^{b} ±0.04	5.57^{a} ±0.01
Available carbohydrates%	73.93^{a} ±0.02	73.22^{b} ±0.01	72.02^{c} ±0.02	70.64^{d} ±0.04	69.65^{e} ±0.01
Caloric value (kcal/100g)	423.72^{c} ±0.08	423.42^{d} ±0.05	424.20^{b} ±0.09	425.65^{a} ±0.08	425.66^{a} ±0.13

- a, b, c and d different superscript letters in the same columns are significantly different at LSD at ($p \leq 0.05$).
-Each value was an average of three determinations ± standard deviation.

3.5 Hedonic sensory evaluation (A) and overall acceptability of blends (B)

The sensorial properties of color, appearance, odor, texture, overall acceptability and taste of biscuits prepared from cassava flour, orange sweet potatoes flour and quinoa flour of different levels and biscuits prepared from 100% of cassava flour were evaluated by twenty panelists. The obtained results were statistically investigated and recorded in **Fig. 1**. From the data presented in **Fig. 1**, 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 cassava flour; orange sweet potatoes flour and quinoa flour were nearly similar with those of B5. *El-Hadidy et al*., stated that adding quinoa flour to prepare high nutritional value biscuits enhances color, taste, texture and taste.[30] Sensory evaluation is seen to be a useful approach for resolving issues with food acceptability. It can be used to improve products, maintain quality and more importantly develop new products.

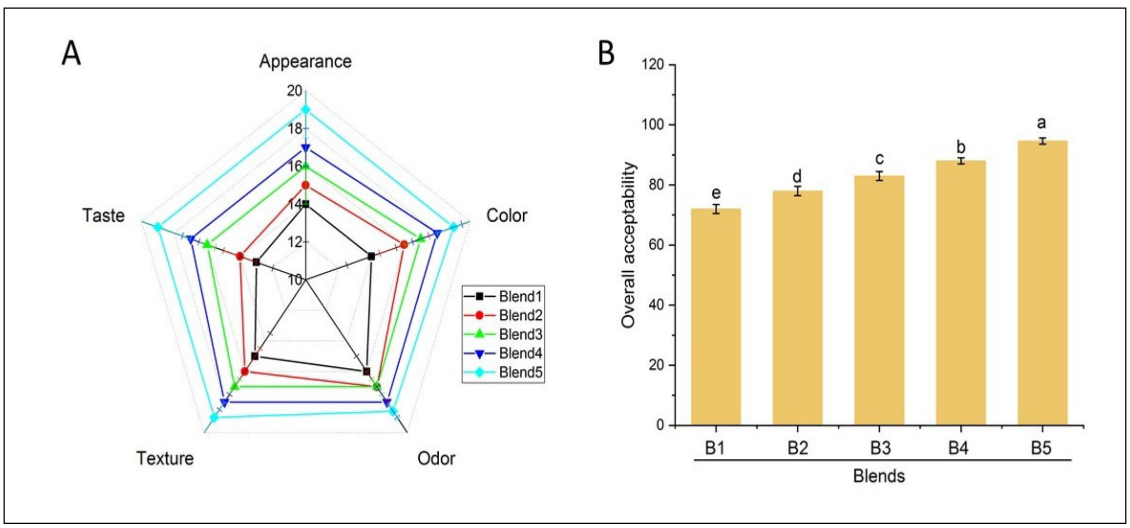

Fig. 1. Hedonic sensory evaluation (A) and overall acceptability of blends (B) and radar graph

3.6 Impact of cassava flour, orange sweet potatoes flour and quinoa flour on the physical characteristics of gluten free biscuits

The results of the physical attributes of gluten free biscuits prepared from cassava flour, orange sweet potatoes flour and quinoa flour blends are exposed in **Table 6**. The length, width, thickness, and weight significantly ($P \geq 0.05$) in all mixtures of gluten free biscuits prepared from different extent of cassava flour, orange sweet potatoes flour and quinoa flour. While biscuits prepared from cassava flour, orange sweet potatoes flour and quinoa flour tended to decrease the length, width, spread ratio and volume, but thickness, bulk density increased in comparison with those biscuits which were prepared from 100% of cassava flour. Such differences in the physical properties could be attributed to properties in the raw materials such as cassava flour, orange sweet potatoes flour and quinoa flour.

Table 6. Physical attributes of gluten free biscuit

Samples	Length (Cm)	Width (Cm)	Thickness (Cm)	Spread ratio	Weight (g)	Volume (cm^3)	Bulk Density (g/cm^3)
B1	08^a	3.5^a	0.75^b	4.67^a	12^a	84^a	0.14^c
B2	06^b	2.5^b	0.80^b	3.13^b	12.5^a	48^e	0.26^a
B3	6.5^b	2.9^{ab}	1.08^a	2.69^d	12.5^a	75.5^b	0.17^b
B4	6.2^b	2.7^b	1.08^a	2.50^e	11.5^a	71.98^c	0.16^b
B5	06^b	2.5^b	0.83^b	3.01^c	12.5^a	49.5^d	0.25^a

- a, b, c and d different superscript letters in the same columns are significantly different at LSD at ($p \leq 0.05$).

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

3.7 Hardness of biscuits

Data in **Fig. 2** presented the textural parameters assessed from texture profile analysis (TPA) test curves results for the biscuits samples. A marked increase in hardness from 70.27 to 117.76 newton was observed. On the contrary, the biscuits use an increasing amount of using cassava flour B1. Data displayed that B1 and B3 had the highest hardness value (117.7 newton) in comparison to other samples. This may be due to the effect of cassava flour, quinoa flour or orange sweet potato formulation. It is well acknowledged that texture has a significant role in customer acceptance. Due to its tight link with human perception of freshness, Karaolu and Kotancilar found that hardness is the most essential factor in evaluating baked items.[43]

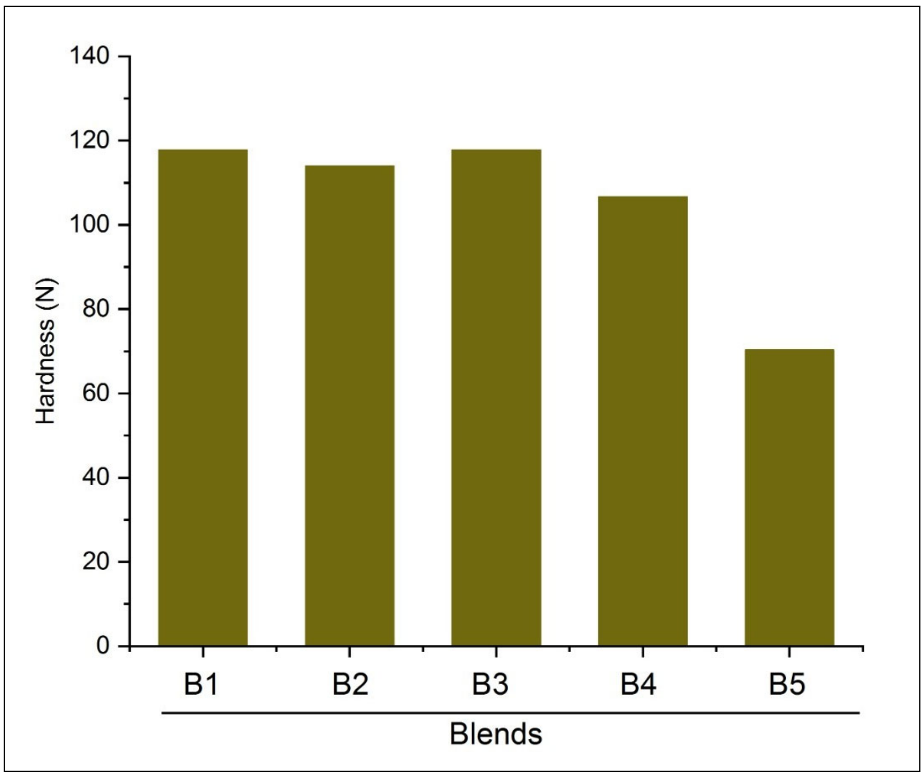

Fig. 2. Hardness of gluten free biscuits blends

4. Conclusion

The obtained results in this investigation exposed that biscuits were prepared from cassava flour, quinoa flour and sweet potato flour at several ratios. The final products were rich in crude protein, crude fiber and ether extract with a high caloric value. These products were a rich source of indispensable amino acids and minerals especially potassium, calcium, magnesium and iron. The sensorial properties of prepared biscuits from cassava flour, quinoa flour and sweet potato flour were nearly similar to products prepared using cassava flour. These products were free of gluten therefore; they are very appropriate for celiac patients. Finally, it could prepare some bakery products using materials free of gluten such as cassava flour, quinoa flour and sweet potato flour flours with high quality that are appropriate for celiac patients.

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