Amaranthus Hypochondriacus and *Chenopodium Quinoa*, Ingredients witht High Nutritive Value in Gluten - Free Sweet Products Formulations

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The nutritional quality of proteins in blends of amaranth-rice and quinoa-rice flours, has been determined by amino acid assay and by AOAC Official Method protein pattern. 100% whole rice flour was used as control. Afterwards, the whole rice flour was replaced by 10, 20 and 30% amaranth and quinoa flour, respectively, in order to prepare two sorts of gluten free sweet products (cookies and muffins). The effect of cooking (at 180°C for 20 min) on proteins and amino acid compositions of gluten-free cookies and muffins was studied, also. The amino acid composition of the protein in both flour blends of amaranth and quinoa show similar patterns. The first limiting amino acids were the aromatic amino acids tyrosine + phenylalanine, giving a chemical score of 86 for protein in 30% quinoa flour blends and 85 for protein in amaranth blends, respectively. Threonine was the next limiting amino acid followed by lysine. Based on different solubility in water, saline, and buffer, flour blends proteins were fractionated on as albumin-1 (Albu-1), albumin-2 (Albu-2), globulin (Glob), and glutelin (Glu) and were identified by AOAC Official Method protein pattern. Albu-1 was high in lysine (3.4-6.6 g 100 g^{-1} protein), while Albu-2, had a high leucine content (4.2-6.9 g 100 g^{-1} protein). Glu fractions were well-balanced in their essential amino acids with the exception of methionine. The levels of tyrosine, threonine and tryptophan were in several cases negatively affected by the cooking procedure.

Keywords: amaranth, quinoa, protein, amino acids, gluten-free sweet products

Pseudocereals are part of another family than grasses. They are plants dicotyledons that resemble in function and composition with those of the true cereals, the taxonomic relations being presented in figure 1 [5].

Pseudocereals are dicotyledonous species, as opposed to the monocotyledonous grains, whose name derives from the fact that these plants produce small grains similar to cereal grains, to which resemble in function and composition. Three cultures belong to pseudocereals, namely amaranth, buckwheat and quinoa [6], their taxonomic relations being presented in figure 1. They have rich leaves and their seeds do not grow in spikes, but in inflorescence. Grain structure is different from cereal grains, also. These grains have been increasingly researched as nutritious ingredients in gluten-free formulations and as source of bioactive compounds with health-promoting effects. Among the most attractive features of these seeds it could be included their high quality protein and the presence of abundant amounts of fiber and minerals such as calcium and iron [8, 10, 22].

Celiac disease (gluten enteropathy) or gluten intolerance, is a genetic disorder of the immune system caused by a permanent sensitivity to gluten [17]. In the case of susceptible individuals, ingesting toxic gluten induces an immunological reaction that leads to the damage of the small intestine surface - specifically to the atrophy of intestinal villi covered surface [18].

Despite advances in the diagnosis of the gluten enteropathy, affecting about 1% of the major populations, the disease remains largely unrecognized. Once diagnosed with celiac disease, the patient is directed to a gluten-free diet, throughout life. Gluten-free diet involves excluding the intake of storage proteins, found in grains like wheat, rye and barley and their hybrids. As for bakery products designed for celiac people, an alternative to traditional cereal flours, are flours obtained from pseudograins. As the major storage proteins in amaranth and quinoa seeds are globulins, the enrichment of sweet gluten-free products with nutrient-dense fractions of pseudocereals naturally gluten-free (such as buckwheat, quinoa, amaranth, or millet) can be of interest [15, 16].

The genus *Amaranthus L.* contains more than 60 species, from which three main amaranth species are being cultivated for their seeds and most used for human nutrition, that is *A. caudatus* in Peru and other Andean countries, *A. cruentus* in Guatemala and *A. hypochondriacus* in Mexico [9]. Amaranth proteins consist mainly of albumins and globulins, prolamins being very scarce. The essential amino acids content is high in amaranth seeds and the amino acid composition is better balanced than in most cereals [19, 25, 26].

The nutritional value of amaranth as pseudograin (like buckwheat and quinoa) is related mostly with its protein content. According to the literature, amaranth exhibits a protein content of 14 to 16.5%, is rich in lysine and has acceptable levels of cysteine and methionine [1].

Amaranth comprises insignificant or zero amounts of prolamins, which are the major storage protein in cereals and the toxic component to people suffering of celiac disease [1]. Amaranth contains 40% albumins, 20% globulins, 25-30% glutelins and 2-3% prolamins.

Quinoa (*Chenopodium quinoa Willd.*) is a plant native from Andes Mountains, which belongs to the *Caryophyllales* order, *Chenopodiaceae* family, genus *Chenopodium*.

Quinoa is one of the most nutritious plants in the diet, appearing on the list of crops to provide food security in

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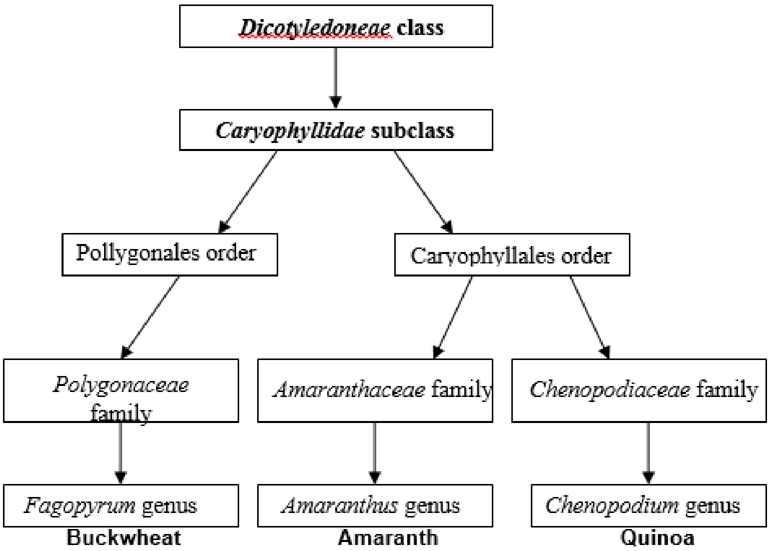

Fig. 1. Botanical classification of amarant, buckwheat and quinoa [5]

this century, list compiled by the Food and Agriculture Organization (FAO, 1998). Due to its the protein content, quinoa can successfully replace animal protein in the diet. Previous studies show that protein from quinoa can be equal to casein. Since the nutritional quality of proteins is determined by the proportion of essential amino acids, quinoa occupies a leading position, showing high levels of histidine, isoleucine, phenylalanine, tyrosine, tryptophan and leucine.

Determining the appropriate functional properties related to protein structure and amino acids composition and their changes during cooking are of major importance for the use of quinoa and amaranth flours in the baking industry. Therefore, if hypothesized that blending rice with amaranth/quinoa flours, in different ratio, and using these blends in gluten-free sweet bakery recipies, it is possible to obtain high quality products (cookies and muffins), two of the most common items in the occidental diet.

Thus the objective of this research was to evaluate the changes in amino acid composition and protein pattern in blended flours of amaranth, quinoa and rice, before and after baking at 180^0 C for 20 min in two gluten-free assortments formulations.

Experiemntal part

Materials and methods

Sample materials

White rice flour, along with amaranth and quinoa flour, respectively, were purchased from a local supermarket specialised in free gluten products. Whole rice flour was used as control flour and, afterwards, replaced with amaranth and quinoa flour as nutrient-dense fractions of naturally gluten-free pseudocereals. Following the control recipe, rice flour was replaced by 10, 20 and 30%, respectively, amaranth and quinoa flours to prepare cookies and muffins, respectively. Therefore, a total of 13 formulations resulted in to be tried, in terms of flour blends, as follows: R1 (100% rice flour), Q1 (90% Rice flour + 10% Quinoa flour), Q2 (80% Rice flour + 20% Quinoa flour), Q3 (70% Rice flour + 30% Quinoa flour), A1 (90% Rice flour + 10% Amaranth flour), A2 (80% Rice flour + 20% Amaranth flour), A3 (70% Rice flour + 30% Amaranth flour). In order to analyse these flour samples, they were defatted for 24 h with hexane in a 10% (w/v) suspension under continuous stirring, air-dried at room temperature, and finally stored at 4°C until use.

Gluten free sweet products preparation

Tables 1 and 2, respectively, show the ingredients used for the gluten-free formulations (cookies and muffins). In cookies case, the gluten-free flour (control sample) or amaranth and quinoa flour blends with rice flour, respectively, were previously mixed with potato starch, the xanthan gum, along with the baking powder, and let to rest for 15 minutes. The egg white was foamed with salt, added the yolk, sugar and melted butter, until reaching a creamy consistency. The gluten-free flour (blends) were added along, in each case, with sodium bicarbonate, to obtain uniform dough and the kneaded resulted dough was kept cold for 15 min in fridge, to rest before rolling it out. Afterwards, the cooled dough was rolled to an uniform thickness of 5 mm. The cookies were cut out with 3.5 cm diameter round shaped cutter. The cut out cookies were placed on a greased or paper lined pan, about 0.5 inch apart and baked at 180 ^{0}C for 15-20 min, cooled to ambient temperature and packed in paper bags.

For the muffin preparation, the gluten-free flour (control sample) or amaranth and quinoa flour blends with rice flour, respectively, were previously mixed with potato starch, xanthan gum along with baking powder, and rest for 15 min. Same, the egg white was foamed and put into fridge. The yolk was mixed with sugar, and after reaching a creamy consistency, the milk, vegetable oil, egg white and sodium bicarbonate were added and mixed. The resulted dough was placed in small paper cups for baking. The optimum parameters of the technological process were: kneading 15 min at high speed, baking for 20 min at 180^{0}C in preheated oven. After baking, following a five-minute setting period, muffins were removed from the pans and allowed to cool for one hour after which, analyses were performed.

Chemical analysis

The Kjeldhal method [16] was used for the protein analysis. The amino acid composition determination was performed following the technique established by the AOAC Official Method [16]. The samples were defatted for 6 h with hot petroleum ether and then hydrolyzed under vacuum for 24 h with 6 mol L^{-1} HCl solution. Methionine and cysteine and/or cystine determination was performed by acid oxidation, followed by acid hydrolysis. Tryptophan was determined after alkaline hydrolysis with 6.0 mol L^{-1} NaOH solution and subsequent neutralization with 6 mol

Ingredients (%) in relation to flour and starch	Control cookies C1	Amaranth cookies			Quinoa cookies		
		A1	A2	A3	Q1	Q2	Q3
Amaranth flour	-	9	18	27	-	-	-
Rice flour	90	81	72	63	81	72	63
Quinoa flour	-	-	-	-	9	18	27
Potatoes starch	10	10					
Salt	0.5	0.5					
White Sugar	22.5	22.5					
Xanthan gum	5	5					
Baking powder	2.5	2.5					
Sodium bicarbonate	2.5	2.5					
Vegetable oil	60	60					
Water	20	20					

Table 1
INGREDIENTS OF AMARANTH, QUINOA AND CONTROL COOKIES USED FOR EXPERIMENT

Ingredients (%) in relation to flour and starch	Control muffins M1	Amaranth muffins			Quinoa muffins		
		A1	A2	A3	Q1	Q2	Q3
Amaranth flour	-	7.5	15	22.5	-	-	-
Rice flour	75	67.5	60	52.5	67.5	60	52.5
Quinoa flour	-	-	-	-	7.5	15	22.5
Potatoes starch	25	25					
Salt	0.5	0.5					
White Sugar	60	60					
Xanthan gum	5	5					
Baking powder	2.5	2.5					
Sodium bicarbonate	2.5	2.5					
Vegetable oil	100	100					
Water	40	40					

Table 2
INGREDIENTS OF AMARANTH, QUINOA AND CONTROL MUFFINS USED FOR EXPERIMENT

L^{-1} HCl solution. The quantification of three hydrolysates was performed with a Beckman amino acid analyzer. Amino acids standard solutions were provided by Sigma (St. Louis, MO). In all cases, analyses were performed by triplicate.

The amino acid score (AAS) was calculated for essential amino acids using the World Health Organization/ Food and Agriculture Organization of the United Nations/ United Nations University 2007 (WHO/FAO/UNU 2007) protein as pattern.

The chemical score (CS) is given by the limiting amino acid, which is found in greater deficit in relation to the reference protein [18, 20].

Protein extraction and determination

Protein fractions were extracted stepwise using water, saline, and different buffers, and then, the protein contents in each fraction were determined according to the methods described in [2, 4, 8, 9, 21, 27].

Statistical analysis

Statistical analyses were carried out to test whether the addition of amaranth/quinoa flour to the rice flour in various amounts (percents) had a significant effect on amino acid composition and protein fractions in gluten-free assortments formulations. Also, means of the parameters evaluated in amaranth/quinoa and control gluten-free assortments formulations were compared by Tukey test using NCSS, version 2001 [23].

Results and discussions

Characterisation of amaranth and quinoa flour blends

The amaranth/quinoa- rice flour blends contained between 9.0 and 8.8% moisture, 8.5 and 10.1% total protein as it is shown in table 3, with no significant differences ($p>0.05$) between both type of flours. Proximal analysis was similar to that of A. Cruentus [13].

Aminoacid composition of the flour blends and gluten-free assortments

Amaranth and quinoa flours were comparable to soybean in lysine content and could serve as excellent protein suplements to cereal (table 4).

Other investigators have reported similar values for lysine in amaranth and in quinoa, respectively [14]. In the case of amaranth, valine was the limiting amino acid, while in quinoa were the two aromatic amino acids, tyrosine + phenylalanine. The second limiting amino acid was threonine which was followed by methionine. Methionine in quinoa flour tested was 2.17 g per 100 g protein. Thus it provides only 38% (methionine alone) of an adult's need for methionine. In general, the essential amino acids of these pseudocereals varieties exceed the requirements established by the WHO/FAO/ONU [17], so that the balance of essential amino acids results better than that of many vegetable proteins. Regarding the amino acid compositions, amaranth proteins show some remarkable differences from those of rice flour. It should be noted that all flour blends exhibited a high proportion of essential amino acids. In general, the six flour formulations containe

Type of flour	Total protein (Mean + SD)	Moisture (Mean + SD)	Ash (Mean + SD)	Lipids (Mean + SD)
Rice (100%)	8.19 ± 0.043	8.78 ± 0.013	1.48 ± 0.028	2.46± 0.056
Amaranth (100%)	14.19 ± 0.056	9.11 ± 0.027	3.14 ± 0.042	4.98 ± 0.021
Quinoa (100%)	13.92 ± 0.028	8.90 ± 0.032	2.35 ± 0.077	6.22 ± 0.070
A1	8.51 ± 0.089	8.81 ± 0.012	2.13 ± 0.049	2.50 ± 0.035
A2	9.23 ± 0.123	8.91 ± 0.045	2.64 ± 0.075	3.05 ± 0.028
A3	10.09 ± 0.023	9.03 ± 0.051	2.96 ± 0.056	3.57 ± 0.046
Q1	8.47 ± 0.053	8.79 ± 0.076	1.62 ± 0.047	2.12± 0.041
Q2	9.22 ± 0.090	8.83 ± 0.031	1.69 ± 0.072	3.07 ± 0.054
Q3	9.86 ± 0.110	8.87 ± 0.078	1.73 ± 0.035	3.61 ± 0.063

Table 3
PROXIMATE ANALYSIS OF RICE, AMARANTH, QUINOA AND THEIR MIXED FLOURS (gr/100 g DRY BASIS)

Table 4
AMINO ACID COMPOSITION OF THE FLOURS (g/100 g PROTEIN)

Amino acid	FAO*	Rice	Amaranth	Quinoa	A1	A2	A3	Q1	Q2	Q3
Aspartic acid		8.10 ± 0.2	6.80 ± 0.2	10.54 ± 0.2	8.05 ± 0.4	7.84 ± 0.3	7.71 ± 0.1	8.23 ± 0.3	8.58 ± 0.4	8.83 ± 0.2
Threonine	2.7	3.10 ± 0.1	4.95 ± 0.4	4.41 ± 0.2	3.21 ± 0.1	3.47 ± 0.1	3.65 ± 0.1	3.20 ± 0.2	3.36 ± 0.1	3.49 ± 0.4
Serine		4.20 ± 0.2	5.05 ± 0.2	5.45 ± 0.2	4.24 ± 0.2	4.37 ± 0.1	4.45 ± 0.3	4.23 ± 0.3	4.45 ± 0.3	4.57 ± 0.4
Glutamic acid		17.91 ± 0.3	15.78 ± 0.2	17.40 ± 0.2	17.49 ± 0.1	17.48 ± 0.2	17.27 ± 0.1	17.89 ± 0.1	17.80 ± 0.2	17.75 ± 0.3
Proline		4.32 ± 0.1	4.10 ± 0.4	3.37 ± 0.6	4.21 ± 0.5	4.28 ± 0.3	4.26 ± 0.6	4.11 ± 0.3	4.13 ± 0.1	4.03 ± 0.3
Glycine		4.03 ± 0.1	5.46 ± 0.2	6.12 ± 0.1	4.10 ± 0.4	4.31 ± 0.4	4.45 ± 0.4	4.18 ± 0.1	4.48 ± 0.1	4.65 ± 0.2
Alanine		5.24 ± 0.3	4.35 ± 0.2	5.34 ± 0.3	5.03 ± 0.5	5.06 ± 0.5	4.97 ± 0.5	5.25 ± 0.1	5.27 ± 0.2	5.27 ± 0.1
Valine	4.2	5.57 ± 0.3	2.45 ± 0.1	3.67 ± 0.7	5.20 ± 0.3	4.94 ± 0.3	4.63 ± 0.2	5.34 ± 0.2	5.19 ± 0.3	5.00 ± 0.1
Isoleucine	3.1	4.21 ± 0.2	4.10 ± 0.2	3.09 ± 0.1	4.17 ± 0.1	4.18 ± 0.6	4.17 ± 0.1	4.06 ± 0.5	3.86 ± 0.3	3.78 ± 0.4
Leucine	6.3	7.25 ± 0.1	7.10± 0.2	6.78 ± 0.4	7.17 ± 0.5	7.22 ± 0.4	7.20 ± 0.3	7.23 ± 0.3	7.16 ± 0.4	7.10 ± 0.1
Tyrosine		4.56 ± 0.2	3.85 ± 0.1	3.56 ± 0.1	4.41 ± 0.3	4.41 ± 0.3	4.37 ± 0.4	4.44 ± 0.3	4.36 ± 0.2	4.26 ± 0.3
Phenylalanine		4.72 ± 0.3	6.45 ± 0.3	4.50 ± 0.2	4.89 ± 0.1	5.06 ± 0.1	5.29 ± 0.1	4.68 ± 0.4	4.67 ± 0.4	4.64 ± 0.2
Lysine	5.2	3.11 ± 0.1	8.71 ± 0.2	6.30 ± 0.3	3.67 ± 0.1	4.23 ± 0.3	4.79 ± 0.5	3.39 ± 0.1	3.74 ± 0.4	4.07 ± 0.1
Histidine	1.8	1.91 ± 0.2	2.50 ± 0.3	3.89 ± 0.5	1.93 ± 0.2	2.02 ± 0.4	2.07 ± 0.2	2.08 ± 0.2	2.30 ± 0.3	2.50 ± 0.2
Arginine		7.92 ± 0.3	7.32 ± 0.2	9.45 ± 0.3	7.80 ± 0.4	7.80 ± 0.4	7.74 ± 0.3	7.98 ± 0.5	8.22 ± 0.1	8.37 ± 0.3
Cystine		2.91 ± 0.2	5.60 ± 0.1	3.98 ± 0.4	3.12 ± 0.4	3.44 ± 0.3	3.77 ± 0.4	2.98 ± 0.3	3.12 ± 0.2	3.21 ± 0.4
Methionine		1.90 ± 0.3	4.25 ± 0.1	2.23 ± 0.1	2.11 ± 0.3	2.37 ± 0.1	2.65 ± 0.1	1.91 ± 0.1	1.96 ± 0.1	1.99 ± 0.2
Tryptophan	0.74	1.00 ± 0.1	1.21 ± 0.2	1.91 ± 0.2	1.01 ± 0.1	1.04 ± 0.2	1.06 ± 0.1	1.08 ± 0.3	1.18 ± 0.6	1.27 ± 0.1

* Requirements in essential amino acids (g/ 100g protein) proposed by the WHO/FAO/UNU (2007) for preschoolers of 1 to 3 years old

adequate amounts of several essential amino acids for preschool children and all of those essential for adults, except for lysine. As for the nonessential aminoacids, the flour blends were high in glutamic and aspartic acid but low in proline and glycine, feature exhibited by the rice control flour, too.

The total amino acid composition of gluten-free cookies and muffins is shown in table 5. Comparing data from the two tables (table 4 and table 5), the amino acid composition of gluten-free assortments differed from that of the flours, due to the baking.

The most heat-sensitive amino acid, lysine, was slightly reduced in the case of cookies (1.5%), and 2% in the case of muffins, respectively. The content of threonine decreased with 7% in control sample cookies (made of rice flour only), and only with 1.8-2.2% in cookies samples made of flour blends, A3 and Q3, respectively. The most affected content of amino acid, seemed to be the tryptophan's and decreased by 16-17% in the case of A3, Q3, 20-21%% in the case of A2, Q2 and 28% in rice control cookies, in comparison with the correspondent flour values.

Protein Fractions

The nutritional value of pseudocereals is mainly connected to their proteins that are an important group of biomacromolecules involved in physiological functions [7]. In pseudocereals, most of the protein is located in the embryo [11] and contrarily to common grains such as wheat, the proteins are composed mainly of globulins and albumins, and containing very little or no storage prolamin proteins, which are the main storage proteins in cereals and the toxic proteins in celiac disease. Amaranth proteins consist of about 40 % albumins, 20 % globulins, 25 - 30 % glutelins, and 2 – 3 % prolamins [1]. 7S (conamaranthin) and llS (amaranthin) storage globulins are the two main

Table 5
AMINO ACID COMPOSITION OF THE GLUTEN FREE COOKIES (g/100 g PROTEIN)

Amino acid	Rice		A1		A2		A3		Q1		Q2		Q3	
	B	M	B	M	B	M	B	M	B	M	B	M	B	M
Aspartic acid	7.8	7.9	4.92	4.94	4.97	4.95	4.81	4.84	5.26	5.19	5.46	5.42	5.60	5.58
Threonine	3.0	3.1	3.12	3.15	3.40	3.36	3.57	3.60	3.12	3.16	3.29	3.31	3.21	3.16
Serine	4.0	4.1	4.13	4.11	4.28	4.30	4.36	4.40	4.12	4.06	4.36	4.39	4.25	4.20
Glutamic acid	17.91	17.90	17.05	17.15	17.13	17.15	16.92	17.03	17.44	17.34	17.44	17.49	17.00	17.05
Proline	4.21	4.23	4.10	4.05	4.19	4.10	4.17	4.10	4.00	4.07	4.04	4.09	3.94	3.99
Glycine	4.0	3.98	3.99	3.92	4.22	4.18	4.36	4.30	4.07	4.02	4.39	4.31	4.28	4.23
Alanine	5.23	5.23	4.90	4.85	4.95	4.90	4.87	4.91	5.11	5.05	5.16	5.11	5.03	4.95
Valine	5.53	5.57	5.07	5.11	4.84	4.90	4.53	4.58	5.20	5.14	5.08	5.00	4.95	4.90
Isoleucine	4.11	4.15	4.06	4.08	4.09	4.01	4.08	4.11	3.95	3.99	3.78	3.91	3.68	3.62
Leucine	7.15	7.15	6.99	7.05	7.07	7.11	7.05	7.10	7.04	7.10	7.01	7.06	6.84	6.93
Tyrosine	4.56	4.56	4.29	4.29	4.32	4.32	4.28	4.28	4.32	4.32	4.27	4.27	4.16	4.16
Phenylalanine	4.68	4.70	4.76	4.72	4.95	4.90	5.18	5.23	4.56	4,51	4.57	4.60	4.46	4.40
Lysine	3.11	3.10	3.57	3.51	4.14	4.07	4.69	4.64	3.30	3.25	3.66	3.61	3.57	3.50
Histidine	1.91	1.91	1.88	1.81	1.97	1.92	2.02	1.97	2.02	2.02	2.25	2.25	2.19	2.21
Arginine	7.92	8.01	7.60	7.54	7.64	7.60	7.58	7.51	7.78	7.71	8.05	8.01	7.85	7.80
Cystine	2.91	2,97	3.04	3.01	3.37	3.31	3.69	3.63	2.90	2.84	3.05	2.98	2.98	2.98
Methionine	1.90	1.83	2.05	1.99	2.32	2.30	2.59	2.51	1.86	1.80	1.92	1.87	1.87	1.90
Tryptophan	1.00	0.75	0.98	0.96	1.01	0.98	1.03	1.01	1.05	1.01	1.15	1.08	1.12	1.09

classes of globulins that can be differentiated in amaranth, whereas, in quinoa, 11S (chenopodin) with 37 % of total protein, and 2S (highcysteine) with 35 % of total protein [4], are the two major classes of proteins. The importance of proteins in these pseudocereal species is also based on their quality determined by the proportions of essential amino acids, which cannot be synthesized and hence must be provided in the diet [25].

The average ratio of Albu-1:Albu-2:Glob:Glut:rest was 8.9:3.3:53.6:5.7:28.5. The main protein fraction was Glob, followed by Albu-1, which values were higher than those previously reported [3]. Albu-1 significantly decreased after cooking, its content was negatively correlated with the Glob and was affected during the termic proces.

The obtaining of a phenolic-extract of *Amarantul L*, and the characterization was studied in [28].

Conclusions

Pseudocereals flours, through their high quality protein content, enriched the nutritive value of the gluten-free sweet products (muffins and cookies, respectively). The addition of both amaranth flour and quinoa flour, in 10%, 20% and 30%, respectively, leads to an increase in essential amino acids content, in comparison to control rice flour samples. Regarding the amino acid compositions, amaranth proteins show remarkable differences from those of rice flour and therefore all studied flour blends exhibited a high proportion of essential amino acids. As for the nonessential amino acids, the studied flour blends were high in glutamic and aspartic acid but low in proline and glycine, feature exhibited by the rice control flour, too.

Comparing the data obtained from blends and products, the amino acid composition was different due to the baking operation. The most heat-sensitive amino acid, lysine, was slightly reduced in the case of cookies (1.5%), and 2% in the case of muffins, respectively, while the content of threonine decreased with 7% in control sample cookies (made of rice flour only), and only with 1.8-2.2% in cookies samples made of flour blends, A3 and Q3, respectively.

From data collected and by comparing it to amaranth flour, the quinoa flour proves to increase more the amino acid composition in rice based gluten-free sweet products. Thus, this pseudocereal flour is highly recommended to be used in gluten-free products enrichment, as the highest content in amino acids was recorded in the case of 30% quinoa flour addition.

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