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NUTRITIONAL VALUES OF PSEUDOCEREALS FLOUR MIXTURES USED IN GLUTEN-FREE SWEET BAKERY PRODUCTS

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Abstract
Coeliac disease is an autoimmune disorder caused by a reaction of the body's immune system to prolamins found in wheat (gliadin), rye (secalin), barley (hordein) and their crossbreeds. At present, the only effective treatment for coeliac people is a lifelong gluten-free diet, but it is difficult to follow such a diet, due to the many gluten containing products excluded. Starting from these considerations, this study aimed to investigate some nutritional parameters, in order to support the use of pseudocereal gluten-free flour mixtures (amaranth, buckwheat and quinoa, respectively) along with rice flour, for obtaining gluten-free sweet bakery products, with a high nutritional value and acceptability. Thus, each sort of flour was used in various amounts of 10%, 20% and 30%, respectively, along with rice flour, in order to obtain the best gluten-free sweet products (muffins), regarding its nutritional value and acceptability score. Gluten-free sweet products were prepared by the same recipe, in three trials each, in which rice flour and amaranth, buckwheat and quinoa flour, respectively, varied: T1-RF:AF(90:10), T2-RF:AF(80:20), T3-RF:AF(70:30), T4-RF:BWF(90:10), T5-RF:BWF(80:20), T6-RF:BWF(70:30), T7-RF:QF(90:10), T8-RF:QF(80:20), T9-RF:QF(70:30). A blank sample of the sweet gluten-free bakery product was prepared by using rice flour only, as basis.
Key words: Gluten-free sweet bakery products, pseudocereals flours, quality indices.

Introduction

Celiac disease known as gluten sensitive enteropathy, is a chronic disorder of the small intestine caused by the exposure to gluten proteins from wheat, barley, rye and oat (Tye-Din *et al*., 2010), to genetically predisposed individuals, both children and adults (Fasano *et al*., 2013). In susceptible individuals, the ingestion of gluten leads to the damage of the mucosal surface of the small intestine (Catassi C., Fasano A, 2008), which causes the malabsorbtion of nutrients in the human body. Celiac disease remains largely unrecognized, affecting 1% of most populations, in spite of the advances made in it's diagnosis (Rubio-Tapia A., Murray J.A., 2010). Once diagnosed, a celiac patient must follow a life-long gluten-free diet, which prevents morbidity and reduces the incidence of the associated gastrointestinal affections (Kupper C., 2005).

Bakery industry occupies an important place in the framework of consumer goods manufacturing, due to the fact that bread is a daily consumed staple food, which results in an emerging need for the development of new gluten-free bakery products suitable to consumer's needs, in order to increase his dietary choices and improve quality of life in general (Kupper C., 2005).

Manufacturing bakery products without gluten is a great challenge for science people and a major problem for bakers nowadays. In recent years, the interest on gluten-free bakery products has been increasing. Thus, science people have searched an alternative to classic wheat or other gluten containing flours, by using *pseudocereals* or legume flours that are gluten-free and rich in proteins, for the nutritional quality of the product (Alvarez-Jubete *et al*., 2009).

Rice flour is among the most used raw material for gluten-free bakery products manufacturing, low in fat and protein content, it is recommended for soft, doughs for muffins, cakes or biscuits.

Pseudocereals, that is amaranth (*Amaranthus cruentus* L.), buckwheat (*Fagopyrum esculentum* Moench.) and quinoa (*Chenopodium quinoa* Willd.), exhibit a high quality nutritional profile, being an important

source of protein and amino acids, vitamins, starch and fibre (Steadman KJ *et al*, 2001; Alvarez-Jubete *et al*., 2009).
Starting from these considerations, this paper aims to investigate some nutritional parameters, in order to support the use of pseudocereal gluten-free flour mixtures (amaranth, buckwheat and quinoa, respectively) along with rice flour, for obtaining gluten-free sweet bakery products, with a high nutritional value and acceptability.

Materials and methods

Materials
All raw materials used in these experiments have been purchased from specialized stores.

Methods
Analytical methods applied to flours
The analytical methods used in experiments for determinating the quality indices of rice and pseudocereals flours have been the following: Moisture content (%) SR-877-1996; Protein content (%)- STAS 90-2007; Lipids (%) STAS -90-2007; Water absorption (%) and Ash content (%) STAS-90-2007, respectively.

Technological process for obtaining gluten-free muffins
The common technological process was used for gluten-free muffins manufacture. The recipe used was the following one: gluten free flour blend 400 g, corn starch 100 g, xanthan gum 10 g, milk 450 mL, oil 350 mL, eggs 300 g, sugar 250 g, baking powder 10 g and salt 5 g.
Three trials were performed, for each sort of pseudocereal flour, in which various blends of gluten-free flours were used, that is: (RF:AF): T1-90:10, T2-80:20, T3-70:30; (RF:BWF) : T4-90:10, T5-80:20, T6-70:30; (RF:QF): T7-90:10, T8-80:20, T9-70:30. Similarly, control gluten-free muffins samples were prepared from rice flour only.
After being kneaded, the dough was placed in small paper cups for baking. The optimum parameters of the technological process were: kneading – 15 minutes at high speed, baking for 20 minutes/180ºC. After baking, the muffins were cooled at room temperature, and put into paper bags.
Sensory and physical-chemical evaluation of gluten-free muffins
Gluten-free muffins samples prepared according to the protocol described in paragraph 2.2.2. were subjected to sensory and physico-chemical evaluation, aiming: aspect and shape, colour, taste, flavour and softness (according to STAS 91-2007: "Bread, loaf products and bakery specialities. Analysis methods"). The sensory analysis was performed by using the Romanian scoring scheme.

Results and discussion

Quality of rice flour, pseudocereals flours and their blends
The nutritional parameters of gluten-free flours and their mixtures, used in the experiments, are shown in Table 1.

Table 1. Quality indices of gluten-free flours and their blends used in gluten-free muffins manufacture

Experimental values	Quality indices				
	Moisture (%)	Lipids (%)	Protein (%)	Ash (%)	Water absorption (%)
RF100%	12.88	2.46	5.29	1.47	50.55
AF100%	9.94	4.98	13.92	3.14	48.44
BWF100%	11.77	2.40	11.21	1.89	49.20
QF100%	11.90	6.22	14.19	2.35	48.05
RF90%AF10%	12.91	2.50	6.21	2.13	49.35
RF80%AF20%	12.22	3.05	6.23	2.64	49.09
RF70%AF30%	11.96	3.57	7.46	1.82	48.82
RF90%BWF10%	12.36	2.24	6.05	1.58	50.25
RF80%BWF20%	12.46	2.39	6.11	1.59	50.02
RF705BWF30%	12.50	2.45	7.4	1.71	49.22
RF90%QF10%	12.69	2.12	6.17	1.62	49.45
RF80%QF20%	12.60	3.07	6.22	1.69	49.12
RF70%QF30%	12.44	3.61	7.49	1.73	48.62

By comparing the values obtained for the analysed samples (RF 100%, AF 100%, BWF 100%, QF 100%, RF90%AF10%, RF80%AF20%, RF70%AF30% RF90%BWF10%, RF80%BWF20%, RF70%BWF30%, RF90%QF10%, RF80%QF20%, RF70%QF30%) it can be stated that these flours can be used in gluten-free baking, due to the fact that they are gluten-free mainly, but also for their nutritional value.

Summarizing the data presented in Table 1, regarding the quality indices and chemical composition of rice and buckwheat flour and their blends, the following assessments can be made:

- The water absorption of the flour blends increased with increasing protein contents;
- The moisture content of flour blends decreased with rice flour proportion increasing;
- Amaranth flour is rich in protein (13.92%) exhibiting the highest ash content (3.14%) among the gluten-free flour blends;
- Buckwheat flour, with a low lipids content (2.40%) comes second regarding it's protein content (11.21%);
- Quinoa flour may be characterized with having the highest protein content (14.19%) and lipids content (6.22%), respectively;
- Rice flour exhibits the highest water absorption (50.55%) and the lowest ash content (1.47%) amongst the gluten-free flours.

Sensory evaluation of gluten-free muffins

The use of well-proportioned blends of gluten-free flours (rice flour and pseudocereals flours, respectively) led to the obtaining of final products with optimum sensory characteristics, in accordance with STAS 1227-3/1990. Sensory evaluation of the assortments of gluten-free muffins obtained in the "Milling and Baking Technology" Laboratory of Faculty of Food Processing Technology of Banat's University of Agricultural Sciences and Veterinary Medicine "King Michael I of Romania" from Timisoara, Romania, was performed using the points scale method, which accordingly, they have obtained the following qualifications, presented in Tables 2, 3, and 4, respectively. The evaluation was carried out by 10 tasters, untrained and not celiac people.

Table 2. Scores assigned to gluten free amaranth flour added muffins

Sample	Maximum score	Scores obtained			
		Control muffins	AF10% Muffins	AF20% Muffins	AF30% Muffins
Aspect and shape	6	6	5.80	5.50	5.75
Colour	2	2	2	1.80	1.70
Taste	7	6.50	6.75	6.60	6.40
Flavour	3	3	3	2.70	2.60
Softness	2	2	2	1.90	1.80
Maximum score average	20	19.50	19.60	19.20	19.00

Table 3. Scores assigned to gluten free buckwheat flour added muffins

Sample	Maximum score	Scores obtained			
		Control muffins	BWF10% Muffins	BWF20% Muffins	BWF30% Muffins
Aspect and shape	6	6	5.5	5.80	5.70
Colour	2	2	1.70	2	1.70
Taste	7	6.50	6.15	6.70	6.40
Flavour	3	3	2.60	2.70	2.60
Softness	2	2	1.70	1.80	1.90
Maximum score average	20	19.50	17.90	19.15	18.50

Table 4. Scores assigned to gluten free quinoa flour added muffins

Sample	Maximum score	Scores obtained			
		Control muffins	QF10% Muffins	QF20% Muffins	QF30% Muffins
Aspect and shape	6	6	5	5.70	5.60
Colour	2	2	1.80	2	2
Taste	7	6.50	7	7	6
Flavour	3	3	3	3	2.60
Softness	2	2	2	2	1.90
Maximum score average	20	19.50	18.80	19.7	19.6

Summarizing the data presented in Table 2-4, it can be said that the samples sensory evaluated (the ten assortments of gluten-free muffins) fit in the first two categories of quality (“very good” and “good”), but in terms of sensory analysis, the 20% quinoa flour muffins, 10% amaranth flour muffins and 20% buckwheat flour muffins, respectively, are best, by reaching a score of 19.70, 19.60 and 19.15 points, respectively.

Among the studied samples, the 10% and 20% quinoa flour added muffins reached maxium score regarding taste, flavour and colour (Table 4), while 10% amaranth gluten-free muffins reached the highest score (of 2 points) for their softness (Table 2) and the 20% buckwheat flour added muffins gained maximum score for their colour - 2 points out of 2 (Table 3) .

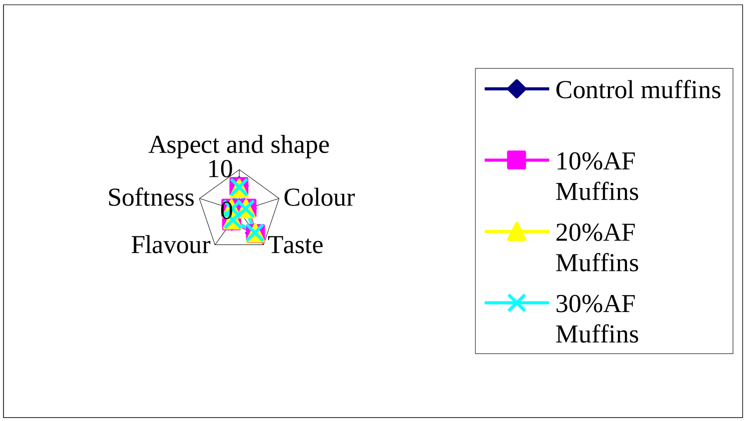

Figure 1. Spider diagram for sensory evaluation of gluten-free amaranth flour added muffins

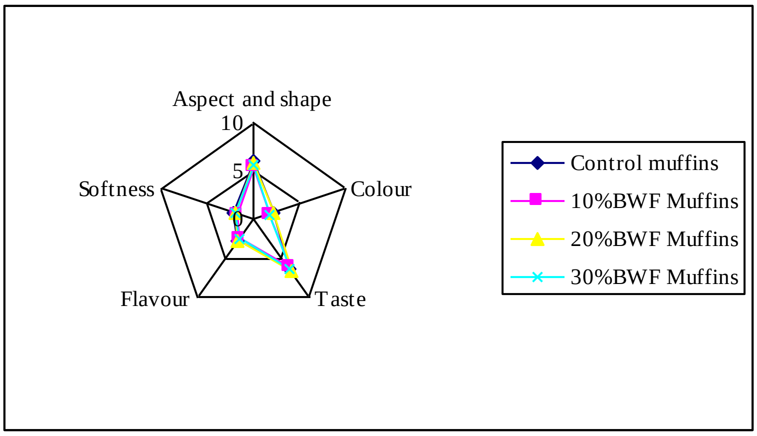

Figure 2. Spider diagram for sensory evaluation of gluten-free buckwheat flour added muffins

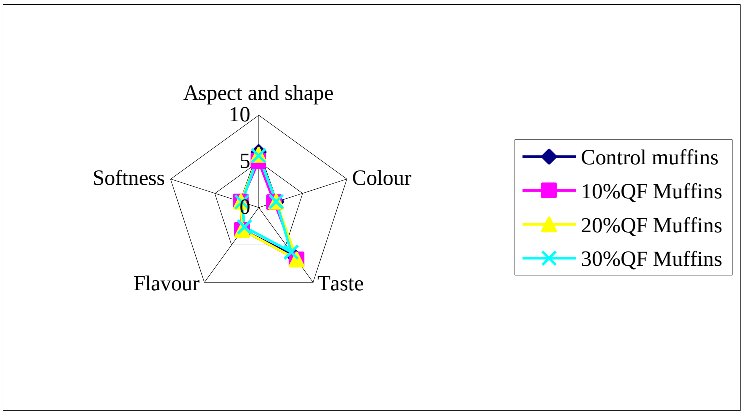

Figure 3. Spider diagram for sensory evaluation of gluten-free quinoa flour added muffins

Physical-chemical evaluation of gluten-free muffins with pseudocereals flour added

After the sensory evaluation, the gluten free muffins with pseudocereals flour added samples were subjected to physico-chemical analysis. The experimental results obtained in this study, are given in figure 4.

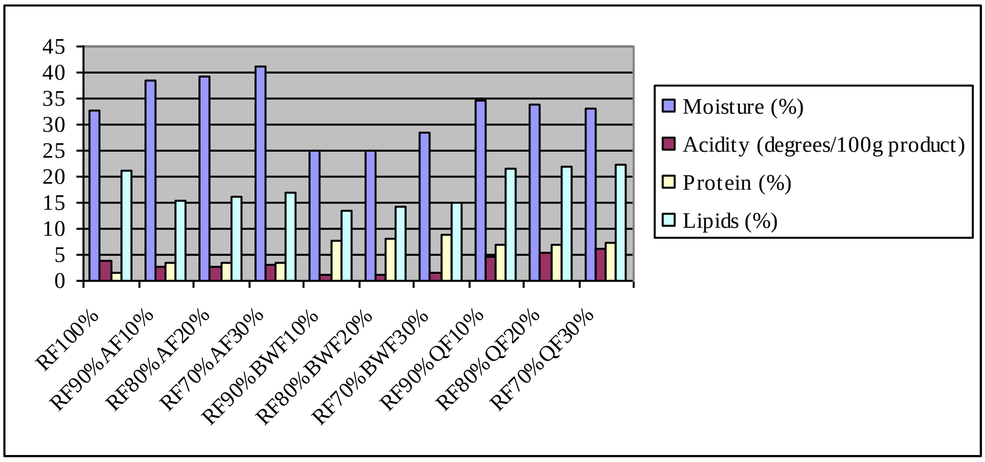

Figure 4. Gluten-free muffins with pseudocereals flour added physical-chemical features variation

From data presented in Figure 4, it can be seen that gluten-free muffins moist is lowest in the buckwheat flour added samples (24.85% - RF90%BWF10%), increasing gradually in control samples (32.61%), quinoa flour added muffins (33% - RF70%QF30%) and reaching the maximum score in amaranth flour added muffins (41.06% - RF70%AF30%).

The protein content of the gluten-free pseudocereals flour added muffins increases with the acidity decreasing, reaching it's maximum score in RF70%BWF30% sample (8.89%), while the minimum acidity of 1grades was recorded in RF90%BWF10%. This increased acidity in gluten free QF added muffins, leads to a higher instability to storage comparative to the other assortments of gluten free muffins (Figure 4).

Figure 4 reveals that sample RF70%QF30% muffins exhibited the highest lipids content (22.14%), while RF90%BWF10% sample had the lowest lipids content (13.42%).

Conclusions

The results obtained in this study indicate that the addition of pseudocereals flours can be successfully used in gluten free baking, in order to obtain an end product – gluten free muffins in this case, with an enhanced nutritional value and a high acceptance by the consumer. Thus, according to this study obtained data, the optimum amount to be added in order to obtain good gluten-free muffins, is: 20% quinoa flour, 10% amaranth flour and 20% buckwheat flour, respectively.

The recommended recipe, following the results obtained in this study, is: gluten-free flour blends 400 g, corn starch 100 g, xanthan gum 10 g, milk 450 mL, oil 350 mL, eggs 300 g, sugar 250 g, baking powder 10 g and salt 5 g; kneading – 15 minutes at high speed, baking for 20 minutes/180ºC.

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