JAP&T TPA-Timişoara

Available online at http://journal-of-agroalimentary.ro

Journal of Agroalimentary Processes and Technologies 2021, *27*(3), 348-356

Journal of Agroalimentary Processes and Technologies

Evaluation of the nutritional and sensory profile of gluten-free cookies made from rice flour and green banana flour

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Abstract

The present study was performed to evaluate the proximal composition of some mixtures obtained from two gluten-free flours (rice flour - RF and green banana flour - GBF) and to evaluate the nutritional profile of gluten-free cookies obtained from these mixtures. Several samples of cookies were prepared, and the flour mixtures used were: 100%:0%; 85%:15%; 70%:30% and 55%:45%. The determinations made for studied flour, flour mixtures and gluten-free cookies samples were: moisture content, protein content, ash content, fiber content, fat content and total carbohydrate content. The results obtained regarding the proximal composition of the mixtures (M1 ÷ M3) highlight their superior nutritional profile. Thus, the use of these mixtures according to the substitution ratios established in this study, can be considered an interesting alternative for the production of gluten-free cookies to meet the current demand for gluten-free products. The results of the sensory evaluation indicated that partial replacement of rice flour with green banana flour up to 45%, did not affect the overall acceptability of the cookies, however, increasing the percentage of green banana flour resulted in lower acceptance, which may be due to the slightly bitter flavour that green banana flour imparts to the cookies. All cookie assortments were found acceptable on the hedonic scale in terms of appearance, texture, flavor, taste and overall acceptability. The results obtained regarding the chemical composition of the studied cookies samples show the superior nutritional profile (higher ash, fiber, and carbohydrate content but lower moisture and protein) of all three cookies samples (C15GBF, C30GBF and C45GBF) compared to CC.

Keywords: gluten-free cookies, green banana flour, sensory evaluation, nutritional quality

1. Introduction

In recent years, as people's interest in food and health has grown, the importance of nutrition has steadily increased, as has the number of studies on food fortification and the production of functional products [1]. Food fortification is one of the techniques developed and applied to solve health problems encountered in society. Thus, the current food products reflect an increasing volume of the technical-scientific evolution [2].

Currently, both nationally and internationally, special attention is paid to obtaining food products that are in line with consumer trends and requirements, ensuring the improvement of the quality and nutritional value of products [2, 3]. Improving the technological and nutritional characteristics of food is achieved by adding one or more nutrients that are found in small quantities or missing from the product or diet. At present, studies aimed at determining the nutritional, sensory and functional quality of many food products are constantly increasing [4, 5]. The importance of flour products in satisfying the food requirements of the population has been an important factor that has determined that the bakery and pastry industry in Romania, along with the other branches of the national industry, to develop at an accelerated pace [6].

In the flour products industry there are numerous studies on the production of functional products with undeniable nutritional value, made from different types of unconventional flours (almond flour, buckwheat flour, amaranth flour, teff flour,

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arrowroot flour, chickpea flour, coconut flour tapioca flour, green banana flour) [7]. According to these studies, Korea and China, as well as some European countries, mainly Italy, use mainly unconventional flours in the production of cookies, breakfast cereals, muffins, desserts and other flour products. Thus, wheat flour has been substituted in different proportions with various unconventional flours to make products [2, 8]. Therefore, researches on the nutritious alternatives supporting similar features with the wheat based formulations has importance in terms of improving the quality of celiac individuals' lives, as well as supporting nutrient intake, enabling adaptation to gluten-free diet and increasing availability on the market by increasing the variety of gluten-free products.

The flours used in this study for the purpose of obtaining gluten-free cookies with high nutritional potential were rye flour (RF) and green banana flour (GBF). The substitution in different proportions of RF with GBF in the recipe for making gluten-free cookies is justified on the basis of their complex chemical composition, implicit in their nutritional and biological value [9-13].

RF is a rich source of minerals (zinc, magnesium, selenium, manganese), antioxidants, fibers, vitamin B complex. Consumption of RF products helps remineralize the body, reduces the risk of heart disease and gives a feeling of satiety [9,10]. The content of insoluble fiber stimulates metabolism, speeds up digestion and helps contributes to lowering cholesterol, the content of antioxidants prevents premature aging, and the content of complex carbohydrates helps to stabilize blood sugar [10].

GBF is made from green bananas and has a mild flavor of raw bananas, but when cooked, GBF loses that fruit flavor and hence, can be used as a healthier alternative to white or processed wheat flours [11]. GBF is prepared by drying, this flour has a high storability and a long shelf life. GBF is prepared and it is used in bakery and confectionery industries [12]. GBF is rich in phenolic compounds such as prebiotic fibers, proteins, carotenoids, flavonoids and vitamins (A, B3, B6, B12, C, and E), mineral salts (phosphorus, magnesium, zinc). Phenolic compounds and natural antioxidants (especially catechin, epicatechin and gallocatechine) in GBF contribute to the storage stability and exerting health benefits [12, 13].

Because of the high starch content, GBF has excellent baking characteristics that allow it to replace wheat and other flours [11-13]. Consumption of GBF helps weight loss, control diabetes, improve bowel transit, lower cholesterol and triglycerides [14]. The use of GBF for baking cookies can help control chronic diseases like obesity and diabetes, by lowering the glycemic index of the products [15, 16]. The physio-chemical and sensory properties information of cookies from RF and GBF are important from stand point of nutrition, production industry and maximum utilization. RF supplemented with GBF might offer a promising nutritious and healthy alternative to consumers due to the high dietary fibers, minerals and vitamins content in GBF. Based on these observations, the purpose of this study was to obtain an assortment of gluten-free cookies with superior nutritional properties conferred by the additions of RF and GBF; establishing the optimal manufacturing recipe and the optimal doses of RF and GBF that can be added to gluten-free cookies without affecting their quality.

2.Materials and Methods

2.1. Materials

The flours (rice flour - RF and green banana flour - GBF) and the other ingredients used in this study have been purchased from hypermarkets and specialized stores.

Steps in the preparation of flour mixtures

In the formation of the three mixtures, RF and GBF were used in variable proportions: *Mixture (M1)*: 85%RF:15%GBF, *Mixture (M2):* 70%RF:30%GBF and *Mixture (M3):* 55%RF:45%GBF respectively.

2.2. Methods

2.2.1. Proximate composition of flours and flour mixtures

The proximate composition was determined using the approved AOAC 2000 standard methods [17]: moisture determined according to standard method AOAC 2000; fat content by extraction with Soxhlet apparatus according to standard method AOAC 2000; protein content by the Kjeldahl method according to standard method AACC 2000; fiber content according to standard method AOAC 2000; carbohydrate content was determined by difference using the equation: 100 – (moisture + fat + ash + protein), by standard method AOAC 1995. All analyses were carried out in triplicate.

2.2.2. Gluten-free cookies preparation

The gluten-free cookies formulations are presented in *Table 1*. Cookies were prepared using GBF combined with RF according to the method proposed by Amarasinghe *et. al.* (2021) and Inyang *et. al.* (2018) [13, 16] with slight modifications. All the ingredients were accurately weighed. Cookie dough was prepared from RF (control – 100%) and GBF combinations (15%, 30%, 45%) using flour (100%), Stevia sugar (60%), butter (75%), egg (60%), vanilla (1%), salt (1.5%) and baking powder (7.5%). Stevia sugar was ground to a fine powder and mixed with butter for 5 min until creamy. Eggs were added while mixing. Salt, vanilla flavor and baking powder were thoroughly mixed to form the dough. The dough was covered with a polyethylene film and kept in the freezer for 30 min to rest. The resulting dough was rolled (thickness of 1 cm) and cut into circular portions by using a round shaped cutter (5 cm). After being baked at 170°C for 20 minutes, the cookies were allowed to cool and packed in high density polyethylene film and stored at room temperature for subsequent analyses. The cookie samples produced from 100% RF served as control [18]. The cookie samples studied in this study were: **CC:** Control cookies with 100% RF:0% GBF; **C15GBF**: Cookies with 85% RF:15% GBF; **C30GBF**: Cookies with 70% RF:30% GBF and **C45GBF**: Cookies with 55% RF:45% GBF.

Table 1. Formulas for gluten-free cookies with RF and GBF

Ingredients (g)	**Gluten-free cookie samples**			
	CC	**C15GBF**	**C30GBF**	**C45GBF**
Rice flour (RF)	200	170	140	110
Green banana flour (GBF)	0	30	60	90
Stevia sugar	120	120	120	120
Butter	150	150	150	150
Egg	120	120	120	120
Vanilla	2	2	2	2
Salt	3	3	3	3
Baking powder	15	15	15	15

2.2.3. Sensory evaluation of gluten-free cookies

The sensory evaluation consisted of judging the quality of prepared cookies by a panels of 20 semi-trained aged between 18 and 30 years. A hedonic scale rating test was used to measure the degree of pleasurable and un-pleasurable experience of cookies on a 9-point Hedonic scale (*9: Like extremely; 8: Like very much; 7: Like moderately; 6: Like slightly; 5: Neither like nor dislike; 4: Dislike slightly; 3: Dislike moderately; 2: Dislike very much; 1: Dislike extremely*). Each evaluator received three cookie samples identified with random three-digit codes. The panellists were given an evaluation form which listed various sensory parameters (taste, texture, flavour, appearance and overall acceptability) [18, 19].

2.2.4. Chemical evaluation of gluten-free cookies

The gluten-free cookies samples obtained according to the method described in *paragraph 2.2.2.*, were submitted to chemical evaluation aiming: moisture, fat, protein, fiber, carbohydrate, ash according to standard method (*paragraph 2.2.1.*) [17, 20, 21].

2.2.5. Physical parameters of gluten-free cookies

Physical properties of the cookie samples were determined according to AACC (2000) methods [20]. The weight of three cookies from each sample was determined on an electronic weighing balance (Mettler, Germany) and average recorded in grams (g). The diameter of cookies was determined by placing four cookies edge to edge and by measuring it with ruler of mm. All of the cookies were rotated at angles 90° and the new diameter was measured, this was then repeated for angles of 180, 270, and 360°. The average of diameter was recorded. Thickness was measured by stacking three well-formed cookies on top of one another, then restacking in a different order and measuring them to get the average in millimeters. The average of thickness was recorded. The spread ratio of the cookie samples was determined by dividing the average value of the diameter by average value of thickness of same cookie samples. All analyzes were performed in triplicate [21].

3. Results and Discussion

3.1. Proximate composition of flours and flour mixtures

Table 2 summarizes the proximate analysis of flours and flour mixtures. The results obtained indicate that the partial substitution of RF for GBF significantly influenced the chemical composition of the flour mixtures obtained, with a higher content of fats, ash, fibers and carbohydrates. The moisture of GBF was significantly lower (8.68±0.17%) than that of RF (14.06±0.07%). Considering the lower moisture content in GBF (8.68% < 14% the acceptable limits which determines the extension of shelf life of the products) it can be used for the development of bakery and pastry products [13, 19]. The GBF sample showed high levels of fat – 2.18±0.09% compared to 1.65±0.04% in RF, ash – 3.50±0.21% compared to 2.55±0.21% in RF, fiber – 6.82±0.12% compared to 3.44±0.14% in RF and carbohydrates – 72.85±0.11% compared to 65.29±0.02% in RF and lower protein levels – 5.63±0.05% compared to 12.62±0.12% in RF, results that are consistent with those obtained by Inyang U. E. *et. al.* (2018) and Amarasinghe N. *et. al.* (2021) [13, 16].

Also, according to the results presented in *Table 2*, the studied mixtures (M1 ÷ M3) can be considered important "sources of proteins, mineral substances, fibers and fats", thus, the protein content varied between 9.48±0.19% in M3 and 11.58±0.11% in M1, the ash content varied between 2.69±0.15% in M1 and 2.96±0.24% in M3, the fibers content varied between 3.95±0.02% in M1 and 4.96±0.33% in M3 and fat content varied between 1.73±0.02% in M1 and 1.88±0.04% in M3, results that are comparable with those in the literature [13, 19]. Regarding the carbohydrate content of the analysed mixtures (M1 ÷ M3), it can be observed that it increases linearly from M1 (65.98±0.01%) to M3 (69.03±0.14%) proportional to the increase in the percentage of GBF [19, 21]. As for the moisture of the three mixtures, it can be observed that it decreases proportionally with the increase of the percentage of GBF added, from 13.71±0.12% in M1 to 11.66±0.13% in M3, which makes the use of M1÷ M3 mixtures in the manufacturing technology of gluten-free cookies to cause a decrease in their freshness period [13, 19, 20].

Table 2. Proximate composition of flours and flour mixtures studied

Mixtures	Moisture (%)	Fat (%)	Protein (%)	Ash (%)	Crude fiber (%)	Carbohydrates (%)
RF	14.06±0.07	1.65±0.04	12.62±0.12	2.55±0.21	3.44±0.14	65.29±0.02
GBF	8.68±0.17	2.18±0.09	5.63±0.05	3.50±0.21	6.82±0.12	72.85±0.11
M1	13.71±0.12	1.73±0.02	11.58±0.11	2.69±0.15	3.95±0.02	65.98±0.01
M2	12.42±0.06	1.80±0.08	10.43±0.21	2.82±0.08	4.45±0.24	67.87±0.33
M3	11.66±0.13	1.88±0.04	9.48±0.19	2.96±0.24	4.96±0.33	69.03±0.14

All determinations were done in triplicate and the results were reported as average value ± standard deviation (SD).

Table 3. Quality attributes scored in sensory assessment of gluten-free cookie samples

Parameter	Gluten-free cookie samples evaluated			
	CC	**C15GBF**	**C30GBF**	**C45GBF**
Taste	8.32±0.12	7.87±0.08	7.42±0.01	7.04±0.22
Flavor	8.69±0.22	8.22±0.24	8.02±0.11	7.83±0.06
Texture	7.23±0.33	6.89±0.24	6.67±0.08	6.52±0.33
Appearance	7.34±0.09	7.03±0.34	6.85±0.22	6.56±0.11
Overall acceptability	8.24±0.14	7.96±0.09	7.64±0.13	7.44±0.22

All determinations were done in triplicate and the results were reported as average value ± standard deviation (SD).

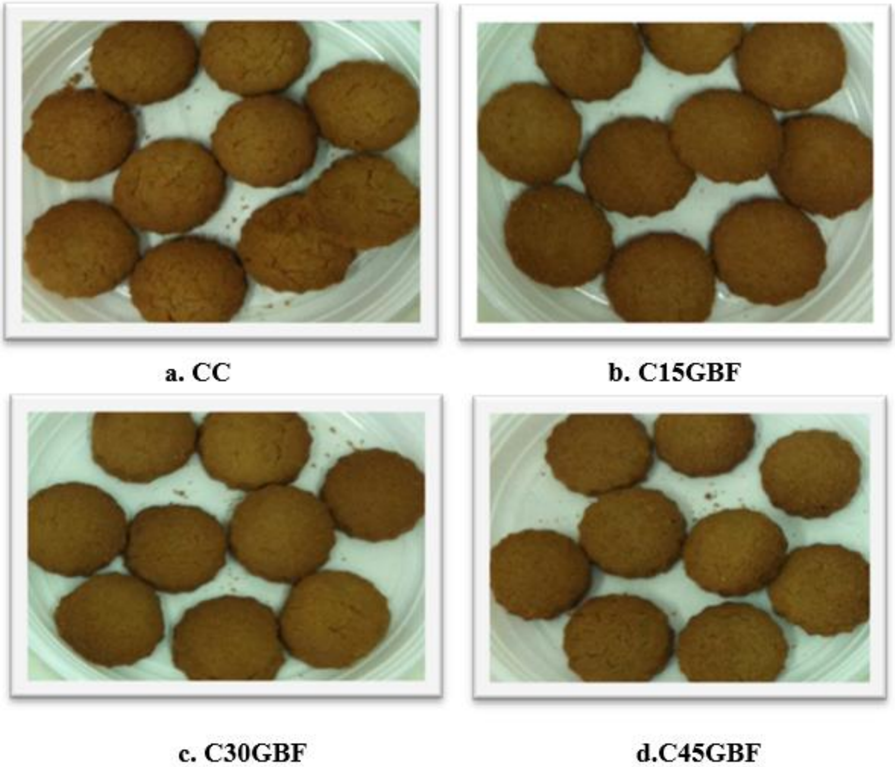

Figure 1. The assortments of gluten-free cookies:
a. Control cookies **(CC)**; **b.** Cookies with 85% RF:15% GBF **(C15GBF)**; **c.** Cookies with 70% RF:30% GBF **(C30GBF)**; **d.** Cookies with 55% RF:45% GBF **(C45GBF)**

3.2. Sensory evaluation of gluten-free cookies

Sensory analysis of cookie samples was carried out using the 9-point Hedonic scale, a method generally used to determine the acceptability of new or existing products on the food market.

Sensory quality attributes (taste, texture, flavour, appearance and overall acceptability) were evaluated by a sensory panel of 20 semi-trained members. Partial substitution of RF with GBF causes significant changes in terms of taste, flavor, texture, appearance and overall acceptability between CC and cookie samples with the addition of 15%, 30% and 45% GBF. From the average sensory scores, it can be observed that none of the studied cookie samples were rejected, since all hedonic values are within the acceptance range of the hedonic scale, i.e., all samples received a score higher than 6.5 (*Table 3*), results that are consistent with those obtained by Asif-Ul-Alam S. M. *et. al.* (2014), Adeola A. A. *et. al.* (2018), Stoin D. *et. al.* (2020) and Parente M. Y. *et. al.* (2021) [18, 19, 22, 23].

From the analysis of the data presented in *Table 3*, it can be seen that, the best scores were obtained by the control sample (CC) in all sensory attributes, and in the case of cookies with added GBF the mean sensory scores decreased proportionally to the percentage of GBF added. This is because RF has a mild flavor and texture [24].

Sensory rating of cookies for taste shows that sample CC was rated highest (8.32±0.12), being followed by sample C15GBF (7.87±0.08) and sample C30GBF (7.42±0.01) while C45GBF was rated lowest (7.04±0.22). According to studies by Drenownoski and Carneros (2000) [25], GBF gives foods a bitter taste, which justifies their lower acceptance by evaluators. The cookie samples showed changes in the flavor depending on the proportion of GBF added, thus, the lowest score was obtained by the C45GBF sample (7.83±0.06) and the highest score by the C15GBF sample (8.22±0.24) followed by sample C30GBF (8.02±0.11). The score assigned by the evaluators to the CC sample in terms of flavor was 8.32±0.12.

The taste and flavor of the cookie samples with added GBF were rated by the evaluators with lower scores than the control sample due to the bitter taste imparted by GBF, which is obtained from unripe fruit [25, 26].

The texture of cookie samples was well accepted by the panelists, as sample CC had a mean value of 7.23±0.33 closely followed by sample C15GBF (6.89±0.24), C30GBF (6.67±0.08) and C45GBF (6.52±0.33) respectively. The decline in texture of cookies may be attributed to the high crude fiber content of GBF, which makes the texture less tender, similar observation was reported by Makinde F.M. and Eyitayo A.O. (2019) [27].

Significant differences were also registered in the case of appearance, thus, sample CC had the highest attributes 7.34±0.09 while samples C15GBF had 7.03±0.34, samples C30GBF had 6.85±0.22 and C45GBF had the lowest attributes of 6.56±0.11. For the overall acceptability, sample CC was rated highest (8.24±0.14) while sample C45GBF was lowest (7.44±0.22). In earlier studies, Parente et al. (2021) [19] observed similar decrease in the sensory attributes of the cookies when RF was substituted with increasing levels of GBF. The results obtained for the sensory evaluation of cookies based on RF and GBF show that the lower the addition of GBF, the higher the acceptance of the cookies by the evaluators.

3.3. Chemical evaluation of gluten-free cookies

In *Table 4*, the results obtained regarding the nutritional profile of cookie samples are shown. The results obtained regarding the chemical composition of the gluten-free cookie samples analysed in this study (*Table 4*), show that the partial substitution of RF with GBF in the recipe, resulted in an increase in their nutrient content. According to the data presented in *Table 4*, the moisture of all GBF-added cookie samples was lower than that of the CC sample (4.84±0.07%), ranging from 3.22±0.02% in the C45GBF sample to 4.26±0.09% in the C15GBF sample, results that are comparable to those obtained by Amarasinghe N. *et. al.* (2021) [13], who obtained moisture values of GBF-added cookies between 3.62% to 3.79%. The lower moisture content of the GBF-added cookie samples compared to the CC sample means that they can be stored for a longer period of time before microbiological degradation sets in, thus having a longer shelf life.

Table 4. Chemical evaluation of gluten-free cookies

Chemical composition (%)	Gluten-free cookies			
	CC	**C15GBF**	**C30GBF**	**C45GBF**
Moisture	4.84±0.07	4.26±0.09	3.53±0.03	3.22±0.02
Fat	14.28±0.04	14.48±0.12	15.62±0.14	16.44±0.11
Protein	12.28±0.27	12.03±0.20	11.56±0.01	11.23±0.33
Ash	2.06±0.22	3.24±0.13	4.46±0.05	5.58±0.05
Crude fiber	3.64±0.02	4.26±0.08	5.32±0.03	6.26±0.14
Carbohydrates	62.74±0.08	61.49±0.46	59.13±0.23	56.88±0.31

All determinations were done in triplicate and the results were reported as average value ± standard deviation (SD).

The fat content in the cookies with GBF ranged from 14.48±0.12 to 16.44±0.11 compared to CC14.28±0.04, there is significant increase in the fat content as the level of GBF increases and this could have contribute to the high energy values. This finding is also in line with the findings of Amarasinghe N. *et. al.* (2021) and Parente et al. (2021) [13, 19] who work with RF and GBF. The cookies with added GBF obtained in this research proved to be a good source of protein, from 11.23±0.33% to 12.03±0.20% compared to 12.28% in CC. The protein content obtained in this research was higher than the value found in a study [28] conducted with cookies formulated with 50% extruded RF, which presented protein content ranging from 6.36 to 7.56 g/100 g cookie. Another fact that may have contributed to the high protein content of cookie samples was the use of eggs in the preparation of cookies [19]. Ash content represents all the inorganic minerals that consists the sample. From the data presented in *Table 4*, regarding the ash content of the analyzed samples, it can be observed that it was higher in all samples with added GBF, ranging from 3.24% in C15GBF to 5.58% in C45GBF versus 2.06% in CC [19], they can be considered products with high functional potential, being important sources of mineral substances. *Table 4* shows an increase in the fiber content of the cookies proportional to the percentage of GBF added, ranging from 4.26±0.08% in C15GBF to 6.26±0.14 in C45GBF, compared to the CC sample which had a fiber content of 3.64±0.02%, results that were consistent with the results presented by Amarasinghe N. *et. al*. (2021) [13].

Fibers aid lowering the blood cholesterol level and slows down the process of absorption of glucose, thereby helping in keeping blood glucose level in control [29]. It also ensures smooth bowel transit and this helps in easy flushing out waste product from the body, increase safety and hence impacts some degree of weight management [30]. The carbohydrate content of the samples analyzed in this study decreased proportionally to the percentage of GBF thus added, from 61.49±0.46% (C15GBF) to 56.88±0.31% (C45GBF), compared to the CC sample which had a carbohydrate content of 62.74±0.08%. According to Asif-Ul-Alam S.M. *et. al.* (2014) [31], the carbohydrate content of 20 : 80 (banana flour : wheat flour) cookie formulation was recorded as 71.64%. The results obtained regarding the chemical composition of the GBF-added cookie samples analyzed in this study are comparable with those in the literature [13, 19, 20].

3.4. Physical parameters of gluten-free cookies

The experimental results obtained in this study, are given in *Table 5:*

Table 5. Physical properties of gluten-free cookie samples

Parameter	Cookies samples evaluated			
	CC	**C15GBF**	**C30CF**	**C45CF**
Weight (g)	6.44±0.09	6.12±0.24	5.84±0.09	5.56±0.14
Diameter (mm)	40.55±0.11	40.43±0.03	40.22±0.06	40.04±0.08
Thickness (mm)	5.35±0.02	4.86±0.12	4.62±0.23	4.21±0.22
Spread ratio	5.23±0.11	5.13±0.09	4.92±0.32	4.74±0.19
Water absorption capacity (g)	28.26±0.14	26.24±0.09	24.34±0.12	22.52±0.08

All determinations were done in triplicate and the results were reported as average value ± standard deviation (SD).

According to studies carried out by Poonam *et.al.* (2013) [32], cookies spread ratio is an important quality parameter, the higher the spread ratio, the higher the product yield will be. The spread ratio of the formulated cookies followed the decreasing trend with the increased level of replacement of RF, thus the spread ratio in the case of CC was 5.23±0.11 and decreased to 4.74±0.19 in the case of the B45GBF sample, therefore showing a decrease of this ratio proportional to the increase of the percentage of added GBF. The results are comparable with other studies, according to which, the cookies thickness, diameter and spread ratio decreased proportionally with the ratio of RF and GBF [32]. The quick binding of free water molecules by the hydrophilic sites of non-wheat flours or other ingredients can increase the viscosity of the batter thus resulting in cookies which spread less [27]. The water absorption capacity of the cookie samples analyzed in this study, decreases from 26.24±0.09 g (C15GBF) to 22.52±0.08 g (C45GBF) compared to CC which showed a water absorption capacity value of 28.26±0.14 g, which demonstrates that the addition of GBF favors the absorption of a smaller amount of water in the product.

4. Conclusions

The results of this study confirm that these flour blends (green banana flour and rice flour) are important sources of nutrients that can have positive effects on human health and could be used to produce flour products with improved functionality. The RF and GBF gluten-free cookies obtained according to this study, can be consumed both by people suffering from certain conditions such as celiac disease and non-celiac gluten sensitivity and by people who want to adopt a healthy, nutrient-rich lifestyle and diet. This study emphasizes the potential of commercialization of the studied cookies since all are gluten-free, and if they are commercialized can be consumed by celiac people. The results obtained for the sensory evaluation of cookies based on RF and GBF, demonstrate that the use of a lower proportion of GBF in the cookie formulation leads to an increase in consumer acceptance.

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 / or animal subjects (if exist) respect the specific regulation and standards.

Acknowledgements: The present paper was funded by the Research Project "Research on the use of biologically active substances in order to obtain high-nutrition foods", No 1545/28.02.2019.

This work was supported by proving the equipment's of the Faculty of Food Engineering Timişoara – "*Food Science*"- Research Center.

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