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BUCKWHEAT *VS*. SORGHUM FLOUR IN GLUTEN-FREE RICE COOKIES ENHANCED WITH PEA PROTEIN POWDER

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Abstract

Buckwheat (BF), sorghum (SF) and coconut (CF) flours as well as pea protein (PP) are considered alternative raw materials for gluten-free baked products. A cookie formulation based on 100% rice flour was control. Rice flour was substituted with different percentages of BF or SF (20%, 30% and 40%) and 20% PP and 10% CF were added to increase cookies nutritional values. This study showed how the addition of buckwheat and sorghum flour influenced the physico-chemical, texture and colour properties as well as the sensory attributes. Samples with 20% and 30% SF or BF had better scores than control, the highest acceptance scores were 6.44 for cookies with 20% SF and 6.11 for cookies with 20% BF. The colour measurement showed that the samples with the addition of SF were lighter than BF. Also, the samples with BF had similar colour to the control. Moreover, by adding different raw materials to rice flour, the level of protein and fiber increased.

Key words*: buckwheat, gluten-free cookies, pea protein powder, sorghum.*

INTRODUCTION

Nowadays food allergies are growing (Sicherer, 2011). According to Sicherer & Sampson (2010) about 5% of young children and 3- 4% of adults have food allergies. The main allergens are milk and eggs (about 2.5% of young children and 0.3% of adults are allergic to milk and 1.5% of young children and 0.2% of adults are allergic to eggs) followed by wheat and soy. The protein from wheat, gluten affects people which are suffering from celiac disease. This disease is a common autoimmune systemic disorder which affects approximately 1% of the global population.

Considering the fact that the population is growing and at the same time the number of people suffering from celiac disease is increasing, the gluten-free products are a growing demand, thus, the baking industry should expand and diversify this type of products (Rosell & Garzon, 2015). However, the development of gluten-free products remains a technological, sensory and nutritional challenge (da Silva & Conti-Silva, 2016). There are a lot of challenges that make gluten-containing products hard to replace. Gluten is the protein from wheat that plays a key role in dough developing determining the unique baking quality. Gluten provides water absorption ability, cohesiveness, viscosity and elasticity to wheat dough. The lack of gluten leads to the lack of dough cohesiveness, elasticity and baking quality. This fact negatively influences the way of dough handling (Bendera & Schonlechnera, 2019). Moreover, celiac people have various nutrient deficiencies such as significantly lower weight, body mass index, fat and lean body mass than control subjects therefore gluten-free diet should meet several requirements (Hallert et al., 2002). For a proper diet of people who suffer from celiac disease gluten-free products should be a source of nutrients such as: fiber, protein, vitamins and minerals (calcium, iron and zinc) (Martínez-Villaluenga et al., 2020).

Cookies represent a product range with a wide variety of diversity as texture, formulation, taste, flavour, colour, influenced by the addition of different ingredients. Therefore, we can find sweet and salty cookies, with a harder or softer texture, with or without cream or with various additions of fruit, seeds or powders or with

different colours. The global market for cookies was valued at USD 30.6 billion in 2018 and tends to grow with 5.3% each year (Grand View Research, Cookies Market Size, Share & Trends Analysis Report, 2019).

Rice and corn flour are one of the most used ingredients in the world for gluten-free cookies (GFC) development. However, for diversification and for nutritionally enhancement, a long list of ingredients such as pseudo-cereals, seeds, legumes and nuts (e.g. amaranth, quinoa, millet, sorghum, flax and chickpeas) could be integrated (Kupper, 2005).

Sorghum is a gluten-free cereal with a high level of phenolic compounds (phenolic acids, flavonoids and condensed tannins) and high antioxidant capacity which helps in chronic diseases prevention such as cardiovascular disease, obesity, non-fatty liver disease, 2 diabetes mellitus and cancer (Arbex et al., 2018; Lopes et al., 2018)

Buckwheat is a pseudo-cereal, also without gluten, rich in fiber, essential amino acids, vitamins, minerals and polyphenols. Moreover, buckwheat is one of the most researched pseudo-cereals for GF cookies formulation. During thermal treatments, buckwheat flour can maintain its antioxidant capacity (Sakac et al., 2011). The level of starch in buckwheat is similar to many cereal grains, also buckwheat is known for its high levels resistant starch (Xu et al., 2020; Zhang et al., 2020; Skrabanja et al., 2001). Therefore, this study aimed to establish differences between gluten-free cookies with buckwheat addition and cookies with sorghum addition.

MATERIALS AND METHODS

Rice flour was obtained from the National Institute of Research and Development for Food Bioresources - IBA Bucharest. Pea protein powder, coconut flour and sorghum flour (SF) were bought from Paradisul Verde (Romania) while buckwheat flour (BF) was purchased from Eurokalis.

First of all, the control (C) was made of 100% rice flour, then another 6 samples were developed. Three of them were based on buckwheat flour where the rice flour was substituted with 40%, 30% and 20% BF (B40, B30, B20) and the others three based on SF (S40, S30, S20) instead of buckwheat flour. In addition, BF and SF formulations contained pea protein powder (60 g) and coconut flour (30 g). Cookies were developed as follows: control with rice flour 100%, B40, B30, B20 with rice flour (150, 120, 90 g) and buckwheat flour (60, 90, 120 g) and S40, S30, S20 with rice flour (150, 120, 90 g) and sorghum flour (60, 90, 120 g). The rest of the ingredients which never change in all the cookies formulation were: sugar (40 g) coconut sugar flower (40 g), coconut milk (100 g), butter (100 g), egg (≈ 45 g), lemon juice (20 g), baking powder (3 g) and salt (2 g). Figure 1 shows the process of the gluten-free cookies manufacturing.

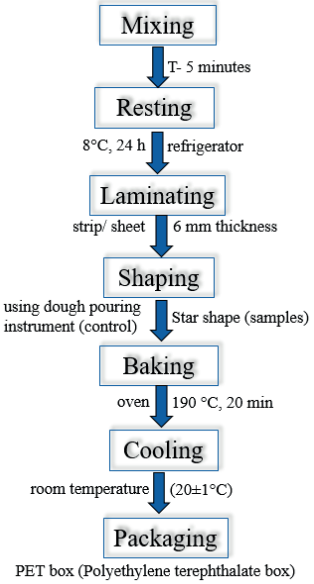

Figure 1. The process of the gluten-free cookies manufacturing

Chemical composition of gluten-free cookies

Chemical composition of gluten-free cookies was determined according to the Association Official of Analytical Chemists (AOAC, 2005) methods for ash (furnace Nabertherm, Lilienthal, Germany), fat (fat extraction system SOXTEC 2055, FOSS, Hillerød, Denmark), protein (Kjeldahl block digestion unit, Behr, Düsseldorf, Germany) and total dietary fibre (Fibertec system, FOSS, Hillerød, Denmark) content. Also, the carbohydrate values were calculated according to Regulation (EU) no. 1169/2011 of the European Parliament and of

the Council of 25 October 2011 using the following equation: 100 - (moisture + ash + proteins + lipids + fibres). These analysis were performed to calculate the energy value which was calculated using the following conversion factors: 9 for fat, 4 for carbohydrates, 4 for protein and 2 for fibre.

Moisture content

Moisture content was determined using Moisture analyzer METTLER TOLEDO, model HE73 at 130°C, sprinkling 5 grams of sample on the entire surface of the tray without pressing.

Colour measurement

Colour was performed using CM-5 Konica Minolta colorimeter on GF cookies sample. determining three parameters: parameter L* which measures the brightness of the sample on a scale from 0 to 100, where value 0 represents black and value 100 represents white; parameter a* which represents the colour of the sample on the scale from pure green to pure red, where the negative values are green, the positive values are red and 0 is neutral and parameter b* which represents the position of the sample on a scale from pure blue to pure yellow, where the negative values are blue, the positive values are yellow and 0 is neutral. Each value was an average of 10 measurements made on different points of the sample.

Texture measurement

Texture analysis was done using an Instron Texture Analyzer (5944, Illinois Tool Works Inc., SUA). The method of analysis included a cycle of compressions in the middle of each cookie up to a distance of 50% from the height of the cookie. The experimental conditions were: compression speed: 3 mm/min; load cell: 50 N. The texture parameter firmness (or hardness) was defined as the maximum force (expressed in N) which a cookie can bear before breaking. This parameter was calculated using the Bluehill 3.13 program.

Consumer acceptance

Consumer acceptance of the 7 types of cookies was performed by 18 people (12 females and 6 males from National Institute of Research and Development for Food Bioresources - IBA Bucharest using a 9-point hedonic scale. Scores were given based on the scale from 1 “I dislike it extremely” to 9 “I like it extremely”. Between each sample water was provided to people for mouth cleaning. 20-60 years old was the age group of the sensory panelists who performed sensory analysis of gluten-free cookies.

RESULTS AND DISCUSSIONS

Chemical composition of gluten-free cookies

Analyzing the protein content of each sample, the samples with pea protein as well as BF and SF addition, had a remarkable increase of the protein content up to 3.3 times more compared to the control (Table 1).

Moreover, differences of protein content can be seen between the samples with the buckwheat addition (B40, B30 and B20), which had a higher protein content when higher BF addition percentages were used.

Table 1. Chemical composition (%) of gluten- free cookies

	P	**F**	**Ch** of which sugar		**CF**	**A**	**M**	**EV**
C	3.73	13.99	49.38	12.35	1.1	0.80	12.16	350/1429
B40	12.51	15.20	38.11	13.53	3.21	1.76	10.83	355/1449
B30	12.20	15.17	38.79	13.62	3.03	1.70	9.22	356/1452
B20	11.95	15.07	39.46	13.40	2.84	1.65	11.29	357/1454
S40	11.89	15.05	40.25	13,57	2.21	1.43	15.76	358/1461
S30	11.77	15.04	40.38	13.39	2.28	1.37	16.3	358/1461
S20	11.66	14.99	40.80	13.36	2.35	1.36	13.93	359/1465

***S** - name of the sample; **P** - protein content; **F** - fat content; **Ch** - Carbohydrates of which sugar; **CF** - Crude fiber; **A** - Ash; **M** - cookie moisture. All of them are expressed as percentage (%) ***EV** - Energy Value expressed as kcal/kJ

The same trend was noticed for the sorghum cookies. The fat content increased from ≈ 14% for the control cookie to ≈ 15% for the enriched samples. Control had lower values of fat content because it was made from 100% rice, the fat content in the other formulations was influenced by the addition of coconut flour. Coconut dishes are rich in fats, proteins and some vitamins, they counterbalance some of the deficiencies (Palaniappan & Subramaniam, 2010). Coconut flour also has a high fiber content. The fiber content was higher in buckwheat and sorghum cookies compared to control. Moreover, the buckwheat cookies had a higher content of 3.21% compared to 2.35% for sorghum cookies due to the fact that buckwheat is richer in fiber than sorghum. Alvarez-Jubete, 2009 analyzed buckwheat seeds and showed the following results 12.5 ± 0.3% protein, 2.1 ± 0.1% fat, and 29.5 ± 1.2% dietary fiber.

Moisture content

The moisture content varies between samples. The lowest value was recorded for B30- 9.22% and the highest for S30- 16.3%. The other values were: 10.83% for B40, 11.29% for B20, 12.16% for C, 13.93% for S20, 15.76% for S40. The different values for the moisture content may be because of the cookies position in the oven.

Colour measurement

The colour analysis results showed similar values between the control and buckwheat samples. On the other side, the gluten-free cookies with the addition of sorghum showed a lighter colour than those with the addition of buckwheat. Although the percentages of buckwheat and sorghum varied, there were no significant changes in the colour parameters (Table 2). Some differences can be seen but there is no tendency. These differences may be due to the cookies position in the oven.

Table 2. Colour of gluten-free cookies

Sample	L*(D65)	a*(D65)	b*(D65)
C	72.82±0.12	7.06±0.06	25.07±0.03
B40	72.21±0.02	7.16±0.02	23.61±0.03
B30	69.18±0.05	9.19±0.03	24.96±0.04
B20	71.90±0.05	7.69±0.01	24.67±0.05
S40	74.49±0.07	5.95±0.02	22.53±0.06
S30	74.02±0.07	6.15±0.02	23.67±0.06
S20	74.29±0.03	6.39±0.02	23.46±0.05

Texture measurement

For consumers besides taste and appearance, the product texture is an important factor when they choose to buy a product.

The textural analysis showed that the values of sample hardness are similar (Table 3). The softest cookies were S40 and B20 with the addition of 40% sorghum and 20% buckwheat, respectively. The hardest sample is the one with 30% buckwheat (B30) and 20% sorghum (S20). It can be seen that the cookie hardness increased with the decrease of the percentage addition of sorghum. According to Naseer et al. (2021) who developed gluten-free cookies with 100% rice flour hardness registered values from 31.00 to 48.90 N. Hadnađev et al. (2013) claimed that cookie dough based on rice had lower water content, was strong and elastic which led to a harder cookie (36 N).

Table 3. Hardness of developed gluten-free cookies

Sample	Hardness (N)
C	12.30±1.24
B40	13.54± 3.18
B30	15.19±2.55
B20	10.94±2.57
S40	10.73±1.71
S30	12.83±0.86
S20	15.05±1.45

Consumer acceptance

The consumer acceptance test was conducted using eighteen untrained panellists. The most popular cookies were S20 (20% sorghum) followed by B20 (20% buckwheat) and B30 (30% buckwheat). The most disliked samples were those with 40% buckwheat and 40% sorghum, respectively (Table 4).

However, looking on the average values, almost all the sample obtained were higher than 5, so these were considered acceptable according to Lazaridou et al. (2007). Only one sample recorded a score below 5.

Table 4. Hedonic scale by consumer acceptance

Sample	Average score
C	5.67±2.28
B40	4.39±2.09
B30	6.00±1.41
B20	6.11±1.57
S40	5.28±2.08
S30	5.56±1.89
S20	6.44±1.25

CONCLUSIONS

The addition of pea protein powder had a major impact on increasing the protein content of cookies. In addition, it was observed that buckwheat GFC were richer in protein content than those with sorghum.

Comparing the fiber content of the 2 types of GFC, it was observed that by adding buckwheat flour in cookies formulation, higher values for the fiber content were obtained in buckwheat-based cookies than in those with sorghum flour.

The formulation of gluten-free cookies with addition of sorghum showed a lighter colour than those with the addition of buckwheat.

As expected, based on the ingredients used in the cookies formulations, the energy values for buckwheat and sorghum cookies was higher than the control.

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REFERENCES

Alvarez-Jubete, L., Arendt, E.K. Gallagher E. (2009). Nutritive value and chemical composition of pseudocereals as gluten-free ingredients. *International Journal of Food Science and Nutrition*, 60(1), 240-257.

Arbex, P. M., de Castro Moreira, M. E., Toledo, R. C. L., de Morais Cardoso, Pinheiro-Sant'ana, H. M., dos Anjos Benjamin, L., Martino, H. S. D., Licursi, L., Carvalho, C.W.P., Queiroz, V.A.V., & Martino, H.S.D. (2018). Extruded sorghum flour (Sorghum bicolor L.) modulate adiposity and inflammation in high fat diet-induced obese rats. *Journal of Functional Foods*, *42*, 346–355. https://doi.org/10.1016/j.jff.2018.01.010.

Barak, S., Mudgil, D., & Khatkar, B.S. (2015). Biochemical and functional properties of wheat gliadins: a review. *Critical Reviews in Food Science and Nutrition* 55, 357-368, https://doi.org/10.1080/10408398.2012.654863.

Bendera, D., & Schonlechnera, R. (2019). Innovative approaches towards improved gluten-free bread properties. *Journal of Cereal Science*, DOI: 10.1016/j.jcs.2019.102904.

Cookies Market Size, Share & Trends Analysis Report By Product (Bar, Molded, Rolled, Drop), By Distribution Channel (Offline, Online), By Region (North America, APAC, MEA, Europe, CSA), And Segment Forecasts, 2019-2025 (2019).

da Silva, T.F., Conti-Silva, A.C. (2016). Preference mappings for gluten-free chocolate cookies: Sensory and physical characteristics. *Nutrition & Food Science*, 46(3):374-387 DOI: 10.1108/NFS-11-2015-0139.

Hadnađev, T. R. D., Torbica, A. M., & Hadnađev, M. S. (2013). Influence of buckwheat flour and carboxymethyl cellulose on rheological behaviour and baking performance of gluten-free cookie dough. *Food and Bioprocess Technology*, 6(7), 1770–1781.

Hallert, C., Grant, C., Grehn, S., Granno, C., Hulten, S., & Midhagen, G. (2002). Evidence of poor vitamin status in coeliac patients on a gluten-free diet for 10 years. *Alimentary Pharmacology & Therapeutics*, 16, 1333–1339.

Kupper, C. (2005). Dietary guidelines and implementation for celiac disease. *Gastroenterology*, 128, 121–127.

Lazaridou, A., Duta, D., Papageorgiou, M., Belc, N., & Biliaderis, C.G. (2007). Effects of hydrocolloids on dough rheology and bread quality parameters in gluten-free formulations. *Journal of Food Engineering*, Volume 79, Issue 3, April, Pages 1033–1047.

Lopes, R. de C. S. O., de Lima, S. L. S., da Silva, B. P., Toledo, R. C. L., Moreira, M. E. de C., Anunciação, P. C., & Martino, H. S. D. (2018). Evaluation of the health benefits of consumption of extruded tannin sorghum with unfermented probiotic milk in individuals with chronic kidney disease. *Food Research International*, 107, 629–638. https://doi.org/10.1016/j.foodres. 2018.03.004.

Martínez-Villaluenga, C., Peñas, E., & Hernández-Ledesma, B. (2020). Pseudocereal grains: Nutritional value, health benefits and current applications for the development of gluten-free foods. *Food and Chemical Toxicology*, 137, 111–178.

Naseer, B., Naik, H. R., Hussain, S. Z., Beenish, Z. I., Bhat, T. A., & Nazir, N. (2021). Effect of carboxymethyl cellulose and baking conditions on in-vitro starch digestibility and physico-textural characteristics of low glycemic index gluten-free rice cookies. *Food Science and Technology*, 141 110885.

Palaniappan, G., & Subramaniam, S. (2010). The coconut revival. market survey, lecturers in commerce at Anbu Arts and Science College, Komarapalayam, Namakkal District, Tamilnadu.

Rosell, C. M. & Garzon, R. (2015). Chemical composition of bakery products. *Handbook of Food Chemistry*, 191–224.

Sakac, M., Torbica, A., Sedej, I., & Hadnadev, M. (2011). Influence of breadmaking on antioxidant capacity of gluten free breads based on rice and buckwheat flours. *Food Research International*, 44(9), 2806–2813.

Sakač, M., Pestorić, M., Mišan, A., Nedeljković, N.,

Jambrec, D., Jovanov, P., Banjac, V., Torbica, A., Hadnadev, M., & Mandic, A. (2015). Antioxidant capacity, mineral content and sensory properties of gluten-free rice and buckwheat cookies. *Food Technology and Biotechnology,* 53(1), 38–47.

Sicherer, S. H. (2011). Food allergy. The Mount Sinai. *Journal of Medicine*, 78(5), 683–696.

Sicherer, S. H., & Sampson, H. A. (2010). Food allergy. *The Journal of Allergy and Clinical Immunology*, 125 (Supplement 2), S116–S125 (2).

Skrabanja, V., Liljeberg, E.H.G.M., Kreft, I., & Bjorck, I.M.E. (2001). Nutritional properties of starch in buckwheat products: studies *in vitro* and *in vivo*. *J. Agric. Food Chemistry*. 49, 490–496.

Xu, J., Zhang, Y., Wang, W., & Li, Y., Advanced Properties of Gluten-Free Cookies, Cakes, 2 and Crackers: A Review *Trends in Food Science & Technology*, https://doi.org/10.1016/j.tifs.2020.07.017.

Zhang, Z.-L., Zhou, M.-L., Tang, Y., Li, F.-L., Tang, Y.-X., Shao, J.-R., Xue, W.-T., & Wu, Y.-M. (2012). Bioactive compounds in functional buckwheat food. *Food Research International* 49(1), 389–395.