American Journal of Food Science and Technology, 2019, Vol. 7, No. 2, 40-44
Available online at http://pubs.sciepub.com/ajfst/7/2/1
Published by Science and Education Publishing
DOI:10.12691/ajfst-7-2-1

Development of Gluten-free Biscuit from Peanut-Pearl Millet Composite Flour

Martha Wunnam Alhassan*, Theodora Ojangba, Francis Kweku Amagloh

Department of Food Science and Technology, University for Development Studies, Tamale, Ghana
*Corresponding author: mwalhassan@uds.edu.gh

Received December 03, 2018; Revised January 06, 2019; Accepted March 01, 2019

Abstract The consumption of wheat products is increasing in Africa even though the climatic conditions in many African countries do not promote its cultivation. The main objective of the study was to develop a nutritious gluten-free biscuit from peanut-millet composite flour. Three composite flours were prepared from peanut (P) and Pearl millet (M). These include; PMF01 (60% PF: 40% MF), PMF02 (40% PF: 60% MF), and PMF03 (50% PF: 50% MF). The proximate compositions and sensory qualities of the composite biscuits were determined and compared with biscuit prepared from 100% wheat flour as control. There were no significant differences ($p > 0.05$) between the composite biscuits and the 100% wheat biscuit in all the proximate compositions (moisture, crude fat and carbohydrate) except protein and ash contents. The 100% wheat biscuit recorded lower protein and ash contents (7.26 ± 0.35^c and 1.01 ± 0.01^c respectively) compared to the composite biscuits. Fifty (50) untrained sensory judges were used to assess the consumer acceptability of the biscuit products using a 7-point hedonic scale (from 1 = dislike extremely to 7 = like extremely). The sensory attributes that were assessed include color, taste, aroma, crispiness and overall acceptability. The results of the sensory analysis revealed that the composite biscuits were generally liked and accepted. This indicates that peanut-millet composite biscuits when commercialized may be accepted by consumers. Peanut-millet flour formulations can therefore potentially substitute wheat flour in biscuit making.

Keywords: *gluten-free, formulation, composite flour, biscuit, consumer acceptability*

Cite This Article: Martha Wunnam Alhassan, Theodora Ojangba, and Francis Kweku Amagloh, "Development of Gluten-free Biscuit from Peanut-Pearl Millet Composite Flour." *American Journal of Food Science and Technology*, vol. 7, no. 2 (2019): 40-44. doi: 10.12691/ajfst-7-2-1.

1. Introduction

Malnutrition continues to be a major challenge in Sub-Saharan Africa even though she is abounding in foods. This is partly due to the underutilization of locally grown crops. Biscuit is one of the most widely consumed snacks in the world and is fast becoming a popular snack in Ghana due to its good eating quality and long shelf life. Most bakery products including biscuits are made from refined flour. This is because wheat is known to contain a high amount of gluten which is responsible for most of the quality characteristics of pastries. In Ghana, biscuits are among the most widely consumed snacks. However, the climatic conditions do not permit wheat which is the major ingredient in biscuit preparation, to be grown locally. This has resulted in high importation of wheat in Ghana; a situation that has led to the high cost of biscuits in the country.

The protein gluten found in wheat is responsible for severe discomforts in people who suffer from celiac disease; a condition resulting from an intolerance to gluten. Celiac disease is a chronic disease of the gastrointestinal system, in which characteristic damage of the small intestinal mucosa occurs in genetically susceptible people in response to the presence of gluten in food [1]. Wheat is also considered nutritionally poor because it is deficient in essential amino acids such as lysine and threonine [2].

These challenges associated with the use of wheat, has necessitated the search for alternate flour sources to replace wheat in the preparation of bakery products. Most countries are now interested in the possibility of replacing the wheat needed for making baked goods, wholly or partly with flour obtained from home grown products [3]. Composite flour is a new approach to utilize underutilized food products. Peanut serves as a cheap source of high-quality dietary protein and oil. Although millets are nutritionally superior to other cereals, their utilization as food is mostly limited to traditional consumers and population of lower economic standard [4].

This study is warranted because, composite flour produced from peanut and pearl millet can serve as an alternative to wheat flour in the preparation of biscuit. It will help to reduce the importation of wheat and also reduce the cost of biscuit production thus making it more affordable. Composite biscuit from peanut and millet will serve as an alternate bakery product for celiacs who are allergic to the gluten in wheat. The incorporation of peanut in the composite biscuit will also help to improve the protein content of biscuits since peanuts contain more protein as compared to wheat. The study will ultimately

play a significant role in the prevention of malnutrition in Ghana.

The objectives were to utilize peanut-millet composite flour in the preparation of biscuit, to determine the nutritional composition of the peanut-millet composite biscuit and to assess the consumer acceptability of the peanut-millet composite biscuit.

2. Materials and Methods

2.1. Materials

Peanuts (ACC-ICGV-91324 and ACC-ICGV-93305 cultivars) were purchased from the Center for Scientific and Industrial Research-Savannah Agriculture Research Institute (CSIR-SARI), in the Northern Region of Ghana. Pearl millet, soft wheat flour and all the other ingredients used in the preparation of the peanut-millet composite biscuits and the 100% wheat biscuit were purchased from Tamale Central market, in the Northern Region of Ghana.

2.2. Preparation of Defatted Peanut Flour

The traditional method of peanut oil extraction was used to de-fat the peanut flour. The peanuts were sorted and cleaned to remove dust and foreign materials. They were then dried in sunlight for 5 h after which they were roasted in a preheated homemade drum roaster at a temperature of 120°C for 25 min. After roasting, the peanuts were cooled at room temperature (25°C) and milled into a fine paste with a disc attrition mill. Oil was extracted from the paste manually by mashing the paste in hot water (100°C) until oil appeared on the surface of the paste. The oil was then decanted from the paste to obtain a defatted peanut paste. The defatted paste was then rolled into small balls and allowed to cool at room temperature (25°C) after which they were ground into coarse powder using a mortar and pestle. The coarse powder was then milled with a disc attrition mill to obtain defatted peanut flour.

2.3. Preparation of Millet Flour

Pearl millet grains were sorted and cleaned to remove dust and foreign materials and roasted in a preheated homemade drum roaster at a temperature of 100°C for 25 min. After roasting, the millet was taken out of the roaster and cooled to room temperature (25°C). It was then milled with a disc attrition mill to obtain a fine flour.

2.4. Product Formulation

A single factor with four treatments in a completely randomized design was used in the preparation of the composite biscuits and the 100% wheat biscuit (control). The peanut-millet flour blends were formulated as shown in Table 1.

2.5. Preparation of Biscuits

Three (3) peanut-millet flour blends were formulated by mixing peanut and millet flours together in their respective proportions based on the formulation Table (Table 1). Four (4) biscuit types were prepared using the peanut-millet flour blends and 100% wheat flour which served as a control in the experiment. All the biscuit types were prepared using the same recipe. 300g of margarine was rubbed in 600g of flour. The other ingredients; sugar, milk, egg and baking powder were added to the mixture in the proportions indicated in Table 2. The mixture was then kneaded until it developed into dough. After mixing, the dough was molded and laminated into sheets. It was then cut into a variety of shapes and sizes using a home-made biscuit cutter. The molded biscuits were placed on a baking sheet and baked in a gas oven for 25 min at a temperature of 150°C. After baking, the biscuits were cooled at room temperature (20°C) and packed.

Table 1. Percentage composition of peanut-millet blends for biscuit preparation

Recipe	Peanut flour (%)	Millet flour (%)	Wheat flour (%)
PMF01	60	40	-
PMF02	40	60	-
PMF03	50	50	-
WF01	-	-	100

PMF01 = (60% PF: 40% MF); PMF02 = (40% PF: 60% MF); PMF03 = (50% PF: 50% MF) and WF01 = control (100% WF), PF = peanut flour, MF = millet flour, WF = wheat flour.

Table 2. Ingredients used for biscuit preparation

Ingredient	Quantity
Flour	600g
Margarine	300g
Sugar	150g
Milk	100ml
Egg	25g
Baking powder	5g

2.6. Aflatoxin Concentration

The aflatoxin concentrations of the peanut and millet flours used in the preparation of the biscuit products were determined to ascertain their safety prior to the baking of the biscuits. This was done to ensure the that the aflatoxin contents of the peanut and millet flours were safe for consumption. The Neogen cooperation method was used in the determination of Aflatoxin content in the peanut and millet flours. Ethanol was used to extract the sample by dipping an Aflatoxin test strip in a tube containing the sample and the lines on the test strip were observed (two coloration lines in the middle). After six min, the test strip was fixed into a tablet and the readings were taken. The Reveal Q+ test kit was used to display the results.

2.7. Proximate Composition

The peanut-millet composite biscuits as well as the 100% wheat flour biscuit were analyzed for their proximate compositions. The ash, moisture, fat, carbohydrate and protein contents of all the biscuit types were determined according to [5] procedures.

2.8. Sensory Evaluation

Sensory analysis was conducted on the peanut-millet composite biscuit as well as the 100% wheat flour biscuit to determine their sensory characteristics and consumer acceptability. The biscuit products were evaluated by 50 untrained sensory judges comprising students from the Nyankpala Campus of the University for Development Studies (UDS), Ghana. The judges assessed each of the biscuit products based on a 7-point hedonic scale (1 = dislike extremely, 2 = dislike moderately, 3 = dislike, 4 = neither like nor dislike, 5 = like, 6= like moderately and 7 = like extremely) described by [6] (Each of the composite biscuits and the 100% wheat flour biscuit (control) were assigned three-digit codes and the judges were given questionnaires to evaluate them based on the following sensory attributes; color, taste, aroma, crispiness and overall acceptability.

2.9. Statistical Analysis

The results of the proximate analyses were subjected to analysis of variance (ANOVA) in SPSS (Version 2016) and the means were compared using Post Hoc Tukey Test at $p<0.05$. Sensory data were analyzed using Kruskal Wallis Test in XLSTAT 2016 at 95% confidence level.

3. Results and Discussion

3.1. Aflatoxin Concentration in Peanut and Millet

The results of the aflatoxin concentration of the peanut and millet flours that were used to prepare the composite biscuit are shown in Table 3. The Aflatoxin concentration in peanut flour was 1.025 ppb while that of millet flour was 2.50 ppb. These Aflatoxin concentrations were found to be below the maximum allowable limit of 20 ppb recommended by Ghana Standard Authority (GSA).

Table 3 Aflatoxin concentration of peanut and millet flours

Samples	Mean(ppb)
Peanut (ACC-ICGV-91324)	1.00
Peanut (ACC-ICGV-93305)	1.05
Millet (Pearl millet)	2.50

3.2. Proximate Composition

3.2.1. Fat

The crude fat content of the biscuit products ranged from 26.30% to 30.02%. There was no significant difference ($p> 0.05$) between the peanut-millet biscuits and the 100% wheat flour biscuit (product WF01). Product PMF03 recorded the highest value (30.02%) for fat content while the 100% wheat flour biscuit (product WF01) recorded a fat content of 28.44%. The highest fat content was recorded by the biscuit which was prepared from equal compositions of peanut and millet flours. According to [7], high amount of fat could hasten spoilage by promoting rancidity which could lead to the development of off flavors and odors.

3.2.2. Protein

The protein content of biscuit products ranged from 7.26% to 22.44%. The protein content of the 100% wheat biscuit (product WF01) was 7.26% which was significantly different ($p< 0.05$) from the peanut-millet composite biscuits. The protein contents of all the peanut-millet biscuits were higher than the control which was 100% wheat biscuit. This may be due to the inclusion of peanut which is a legume in the formulation of the composite biscuit. This is because; legumes in nature have more protein than cereals [8].

3.2.3. Ash

The ash content of food material could be used as an indicator of mineral constituents, [9]. Statistically, there was significant difference between the biscuit products ($p<0.05$). The ash content ranged from 1.01% and 2.32%. The lowest value was recorded by the 100% wheat biscuit (product WF01) while the highest (2.32%) was recorded by product PMF01. The high protein contents observed in the composite biscuits could be due to the higher proportion of peanut, because, peanuts are rich sources of minerals such as calcium, magnesium and phosphorus. The high ash content of the peanut-millet biscuits could result from the combined effect of the peanut and millet used in the biscuit preparation. This is because according to [10], ash content is not affected by baking temperature and time, but rather dependent on the blends.

3.2.4. Moisture

The moisture content of the biscuit product ranged from 2.78% to 3.86%. There was no significant difference ($p>0.05$) between the biscuit products. However, product PMF03 recorded the lowest moisture content of 2.78% compared to the 100% wheat biscuit (2.99%). A similar observation was made by [11] in the developed biscuit made from OFSP-wheat composite biscuit with the control (100% wheat biscuit) recording higher moisture content than OFSP- wheat composite biscuit. According to [9] the lower the moisture contents of a product, the longer the shelf stability of the product. Low moisture content in biscuits is helpful. It can lead to a reduction in microbial proliferation and extend storage life if stored inside suitable packaging materials under good environmental state [7].

Table 4. Proximate composition of biscuit products

Biscuit product	Fat %	Protein %	Ash %	Moisture %	Carbohydrate %
PMF01	26.30 ± 10.79^{a}	22.44 ± 0.51^{a}	2.32 ± 0.01^{a}	2.86 ± 1.42^{a}	46.07 ± 12.70^{a}
PMF02	27.83 ± 6.67^{a}	13.46 ± 0.76^{b}	1.90 ± 0.09^{b}	3.86 ± 0.53^{a}	52.95 ± 8.06^{a}
PMF03	30.02 ± 3.01^{a}	13.57 ± 0.00^{b}	1.76 ± 0.00^{b}	2.78 ± 1.27^{a}	51.86 ± 4.28^{a}
WF01	28.44 ± 0.98^{a}	7.26 ± 0.35^{c}	1.01 ± 0.01^{c}	2.99 ± 0.60^{a}	60.30 ± 1.25^{a}

*The superscripts denoted by different letters in the same column are significantly different ($p<0.05$). PMF01= (60% PF:40% MF), PMF02= (40% PF:60% MF), PMF03= (50% PF: 50% MF) and WF01= (100% WF). PF = peanut flour, MF = millet flour, WF = wheat flour.

3.2.5. Carbohydrate

The carbohydrate content of the biscuit product ranged from 46.07% to 60.30%. The results show that there was no significant difference ($p > 0.05$) between the composite biscuits and the 100% wheat biscuit (product WF01). The 100% wheat biscuit recorded the highest value of carbohydrate content (60.30%). This could be due to the higher carbohydrate content present in wheat flour compared to composite flour.

3.3. Sensory Evaluation

Results of sensory attributes of the biscuit products such as color, taste, aroma, crispiness and overall acceptance are presented in Table 5.

3.3.1. Color

The mean scores for color of all the biscuit products ranged between 4.46 and 6.16. The score for the control was significantly different ($p<0.05$) from the composite biscuit products. The control (100% wheat biscuit) was the most preferred in terms of color with a mean score of 6.16 which indicates 'like moderately'. Products PMF01 and PMF03 were however fairly liked since their mean scores were between 4.46 to 4.98 indicating 'like' on the hedonic scale. The least preferred was product PMF02 with mean score of 4.46 which from the hedonic scale represents 'neither like nor dislike'. According to [12], color is known as the only quality that consumers can base their purchasing decisions. The low score for color observed for the composite biscuit may be due to the dark brown color of the biscuits. This may have given an impression of 'over-baked' products; thus, affecting their preference. The browning of the composite biscuits could be due to caramelization of the sugars in biscuits. It could also be due to maillard reactions as the protein contributed by peanut might have reacted with sugar during the baking process.

3.3.2. Taste

The preference scores of tastes ranged between 4.36 and 5.62. The 100% wheat biscuit (product WF01) was most preferred and significantly different ($p<0.05$) from the composite biscuits. It recorded a taste preference of 5.62 which indicate 'like moderately'. Product PMF02 was the least preferred with a mean score of 4.36 indicating 'neither like nor dislike'. The low taste score for product PMF02 could be attributed to the high formulation of millet in that composition since millets contains high amounts of antioxidants and nutraceuticals [[13]; 4]**.** Products PMF01 and PMF03 recorded higher mean scores of 4.76 and 4.64 indicating 'like' while product PMF02 recorded a score of 4.36 which indicates 'neither like nor dislike' on the hedonic scale. The lower preference scores for the composite biscuits could be due to the inclusion of peanut which gave it a nutty taste. These could be attributed to the high peanut combination in product PMF01which gave it a nutty taste.

3.3.3. Aroma

According to [14], aroma is the main decisive factor that makes a product to be liked or disliked. The mean scores for aroma ranged from 4.48 and 5.36. The 100% wheat biscuit was the most preferred in terms of aroma. There was a significant difference ($p< 0.05$) between the control and the composite biscuits. Among the peanut-millet biscuits, the highest mean score of 4.58 was recorded by product PMF01, followed by product PMF03 with a mean score of 4.88. Both products (products PMF01 and PMF02) scored 'like' on the hedonic scale. Product PMF03 was however the least preferred biscuit and differed significantly ($p>0.05$) from the rest of the composite biscuits. With respect to the aroma, all the composite biscuits were accepted with the exception of product PMF02. Panelists accepted all the peanut-millet composite biscuits with the exception of product PMF02 since their mean indicated 'like' on the hedonic scale. Increased sourness resulting from the inclusion of millet in the composite biscuits may have contributed to the low preference for the composite biscuit compared to the control.

3.3.4. Crispiness

Crispiness represents the key textural attributes of dry snacks products; denoting freshness and high quality [15]. Crispiness mean scores ranged between 4.76 and 5.78. The control (100% wheat) was significantly different ($p<0.05$) from the peanut-millet composite biscuits. With reference to the 7-point hedonic scale used for the sensory analysis, the peanut-millet biscuits were 'liked' by the panelists. However, product PMF02 was the least preferred. The control (100% wheat) was the most preferred representing 'liked moderately' on the hedonic scale. From the result of this study, the crispness of the biscuits decreased with increasing proportion of millet flour. The 100% wheat flour (product WF01) was however crispier than the composite biscuits.

3.3.5. Overall Acceptability

The overall acceptability means scores recorded by the biscuit products ranged between 4.98 and 6.20 with product PMF02 recording the lowest mean of 4.98 which indicates 'like' on the hedonic scale. There was a significant difference ($p<0.05$) in terms of overall acceptability between the composite biscuit and the 100% wheat biscuit. However, there was no significant difference ($p> 0.05$) among the peanut-millet composite biscuit. This could be attributed to dissimilar characteristics of the peanut-millet composite biscuits types in terms of color, crispiness, taste and aroma to the control (100% wheat). The 100% wheat biscuit was the most preferred indicating 'like moderately'. All the peanut-millet composite biscuits were 'liked' by the panelists since their mean scores was 5 even though the least preferred was product PMF02. The lower ratings for the peanut-millet biscuits could be due to the unattractive color and taste of the biscuits. The biscuits made from ratio 60:40 (PF: MF) and 50:50 (PF: MF) were more acceptable indicating likeness for the products. The overall acceptability shows how much or less the products are globally accepted. According to [16], acceptability may not often depend solely on the sensory attributes of the product but also on other determinants such as physiological, behavioral and cognitive factors, related to the consumer.

Table 5. Sensory evaluation of biscuit products

Product	Color	Taste	Aroma	Crispiness	Overall acceptability
PMF01	4.98±1.13[a]	4.76±1.44[a]	4.58±1.39[a]	4.90±1.36[a]	5.16±1.13[a]
PMF02	4.46±1.27[a]	4.36±1.38[a]	4.48±2.00[a]	4.76±1.45[a]	4.98±1.27[a]
PMF03	4.56±1.37[a]	4.64±1.52[a]	4.88±1.24[ab]	4.90±1.36[a]	5.14±1.11[a]
WF01	6.16±0.87[b]	5.62±1.19[b]	5.36±1.38[b]	5.78±1.02[b]	6.20±0.99[b]

*The superscripts denoted by different letters in the same column are significantly different ($p<0.05$). PMF01= (60% PF and 40% MF), PMF01= (40% PF and 60% MF), PMF01= (50% PF and 50% MF) and WF= control (100% WF).

4. Conclusion

Peanut-millet composite flour was used to substitute wheat flour in the preparation of biscuit. 100% wheat biscuit was compared with the formulated composite biscuits. The biscuit products were evaluated for their proximate composition and sensory attributes as well as their overall acceptability.

There was no significant difference ($P>0.05$) between the biscuit products in all the proximate determinations except protein and ash where a significant difference was observed between the composite biscuits and the 100% wheat biscuit. It was observed that peanut-millet composite biscuits recorded significantly higher protein content than the 100% wheat biscuit.

It was also observed that the 100% wheat biscuit was significantly different from the composite biscuits in terms of their sensory attributes. There was however no significant difference between the composite biscuit products in terms of sensory attributes. The results from the study indicate that the composite biscuits were accepted even though the 100% wheat biscuit were the most preferred. Formulated blends of peanut and millet flours can potentially serve as a good alternative to wheat flour in the preparation of biscuit.

Acknowledgements

The authors wish to thank the laboratory technicians at KNUST who analysed the samples and all the students who volunteered to take part in the sensory evaluation.

References

[1] Sharoba, A. M., Abd El-Salam, A. M. and Hoda, H. H. (2014). Production and evaluation of gluten free biscuits as functional foods for celiac disease patients. Journal of Agroalimentary Processes and Technologies. 20(3), 203-214.

[2] Jideani, V. and Onwubali, F. (2009). Optimisation of wheat-sprouted soybean flour bread using response surface methodology. African Journal of Biotechnology, 8(22), 6364-6373.

[3] Giwa, E. O. and Ikujenlola, A. V. (2010). Quality characteristics of biscuits produced from composite flours of wheat and quality protein maize. African Journal of Food Science and Technology, 1(5), 116-119.

[4] Jaybhaye, R.V., Pardeshi, I. L., Vengaiah, P.C. and Srivastav P.P. (2014). Processing and technology for millet-based food products: A review. Journal of Ready to Eat Food, 1(2), 32-48.

[5] Association of Official Analytical Chemists (2005). Latimer, J.W. and Horwitz, W. Official methods of analysis.

[6] Stone, H. and Sidel, J. L. (2004). Sensory evaluation practices. Academic press Inc., Tragon corporation, Redwood City, 408 P.

[7] Mohammed, A. R. H.A., Abdelmoneim, I. M., Hayat, A. R. H. and Ahmed, E. E. (2016). Proximate composition, protein digestibility, starch digestibility, physical properties and sensory evaluation of decorticated sorghum and maize biscuits supplemented with chickpea flour. International Journal of Current Research and Academic Review, 4(5), 1-11, May.

[8] Nwosu, J. N. (2013). Production and evaluation of biscuits from blends of bambara groundnut (Vigna Subterranae) and wheat (Triticum Eastrum) flours. International Journal of Food and Nutrition Science, 2(1). http://www.researchpub.org/ journal/ ijfns /ijfns.html.

[9] Sanni, S.A., Adebowale, A.R.A., Olayiwola, I.O. and Maziya-Dixon, B. (2008). Chemical composition and pasting properties of iron fortified maize flour. J. Food, Agri. Environ., 6: 172-175.

[10] Kalekristos, Y. (2010). Influence of baking time and temperature on the quality of Kocho biscuit enriched with faba bean and wheat. M.Sc. Thesis, School of Graduate Studies Institute of Technology, Department of Chemical Engineering, Addis Ababa University, Ethiopia,pp. 112.

[11] Andualem, A., Kebede, A. and Abadi, G. M. (2016). Development of pro-vitamin A and energy rich biscuits: Blending of orange-fleshed sweet potato (Ipomea batatas L.) with wheat (Triticum vulgare) flour and altering baking temperature and time. African Journal of Food Science, 10(6), 79-86.

[12] Surkan, S., Albani, O. and Ramallo, L. (2009). Influence of storage conditions on sensory shelf-life of yerba mate. Journal of Food Quality, 32, 58-72.

[13] Vanisha, S., Nambiar, J. J., Dhaduk, N. S., Tosha, S. and Rujuta, D. (2011). Potential Functional Implications of Pearl millet (Pennisetum glaucum) in Health and Disease. Journal of Applied Pharmaceutical Science, 1(10), 2011, 62-67.

[14] Ferial, M. A. S. and Azza, A. A. A. (2011). Effect of supplementation of Bambara groundnut (Vigna subterranean L.) flour on the quality of biscuits. African Journal of Food Science, 5(7), 376-383.

[15] Dueik, V., Robert, P. and Bouchon, P. (2010). Vacuum frying reduces oil uptake and improves the quality parameters of carrot crisps. Journal of Food Chemistry, 119, 1143-1149.

[16] Nasser, A., Dine E. l. and Olabi A. (2009). Effect of reference foods in repeated acceptability tests: Testing familiar and novel foods using two acceptability scales. Journal of Food Science, 74(20), 97-106.