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STUDY OF THE NUTRITIONAL QUALITY AND ACCEPTABILITY OF MILLET BISCUITS (*PENNISSETUM GLAUCUM* L.) SUPPLEMENTED WITH COWPEA (*VIGNA UNGUICULATA* L) AND *BAMBARA* GROUNDNUT (*VIGNA SUBTERRANEA* L.)

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ABSTRACT: *The aim of the study was to determine the effect of supplementation of legume flour cowpea and Bambara groundnut from Burkina Faso at different levels 15%, 30% et 50% on the nutritional quality and acceptability of millet biscuits. The macronutrients, iron and zinc contents were determined using standard AOAC methods. The acceptability test of cookies were performed with a panel of 30 tasters. The protein content of cookies increased proportionally with the supplementation. The protein contents of cowpea cookies were higher than Bambara groundnut cookies, 12.82 g / 100 g and 10.47 g / 100 g respectively. Supplemented cookies have low iron and zinc contents, 2.23 mg / 100 g and 1.87 mg / 100 g respectively for cowpea and Bambara groundnut. On the organoleptic level, up to 15% supplementation, there is no significant difference in odor and taste.*

KEY WORDS: legume, biscuit, protein, acceptability, composite flour

INTRODUCTION

Millet is the basic food in many African countries. It is used for various foods and traditional drinks. Many millet varieties have higher protein, energy, mineral and vitamin content than other cereals (Sehgal and Kawatra, 2003, Songré-Ouattara et *al*., 2016). Millet (*Pennissetum glaucum* L.) is rich in methionine and poor in lysine and cysteine, which are essential amino acids (Kumar and Parmeswaran, 1999). However millet and sorghum have the particularity of lacking gluten, a protein which is more and more avoided due to the celiac disease. Nutrition and health have become crucial for consumer choice (Nehir and Simsek, 2012). Many wheat-based products, particularly those from pastry and bakery are increasingly supplemented with millet and sorghum cereals to reduce gluten levels. The use of millet in the bakery and pastry industry does not improve the nutritional value of the products but creates added value (Verma and Patel, 2013).

Significant improvement in protein, lipid and ash content was observed in flours made from millet and wheat (Singh et *al*., 2005). Wheat supplementation with millet at 40% yielded good results in biscuits and cakes (Begum et *al*., 2003, Yenagi et *al*., 2013, Saha et al., 2010). Grain products are high in energy, but poor in nutritional value (Bellisle, 2014, Adeyeye and Akingbala, 2014). Like all cereals, the content of some essential amino acids such as lysine is insufficient to meet the nutritional requirements recommended by the FAO / WHO / UNU (2007) for children aged 2 to 5 years. Ready-

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to-eat foods such as biscuits are important drivers for nutritional enrichment (Honda and Jood, 2005). They represent an important part of the people's diet. The introduction of legumes into the production of biscuits is a way to improve the nutritional status of people.

In developed countries such as France and Australia, nutrition guides recommend adding of legumes (Jeppesen 2011, Ancellin 2011, Australian Dietary Guidelines summary 2013). Legumes are characterized by high levels of protein (18-34%) (Evans and Boulter, 1974, Hama-Ba et *al*., 2017) compared to cereals. They are rich in essential amino acids such as lysine, tryptophan, and methionine (Frota et *al*., 2017; Vasconcelos et *al*., 2010). In addition, legumes have the advantage of being traditionally produced and consumed in many developing countries where nutritional deficiencies are a public health problem. According to the ICRISAT report (2015), over 80% of cowpea production comes from sub-Saharan Africa. Many studies on the enrichment of biscuits with legumes have yielded interesting nutritional and technological results (Aaron et *al*., 2013, Aziah et *al*., 2012). In Burkina Faso, cowpeas and *Bambara* groundnut (voandzou) are two legumes that are traditionally eaten and of good nutritional value (Hama-Ba et *al*., 2017). In 2016, annual production amounted to 571,304 tons for cowpea and 46,876 tons for voandzou (MARHASA, 2015).

The purpose of this study is to determine the effect of the use of flours made from millet and cowpea and *Bambara* groundnut called "voandzou" legumes on the nutritional quality and acceptability of biscuits. This study will be of great interest for the agri-food industries working for the promotion of local products and in the fight against the nutritional deficiencies of the people.

MATERIALS AND METHODS

Biological material

Cereal and legume varieties

The cereal used are millet (*Pennissetum glaucum* L.) with the *Misari 1* variety. The legumes used are cowpea (*Vigna unguiculata* L.) with the improved *Tiligré* variety and the voandzou (*Vigna subteranea* L.) with a local white variety of Nobéré. Nobéré is located in the south center region of Burkina Faso. Cereal and legume varieties were obtained from seed researchers at the Institute for Environment and Agricultural Research of Burkina Faso (INERA).

Ingredients

Ingredients added during biscuit production are: sugar, vegetable oil, eggs, milk, corn starch, baking powder and bicarbonate. The same amount has been added in the different formulations.

Biscuit production

Formulations

The biscuits were produced from the formulations shown in Table 1. The control formulas consisted solely of millet (FM). The other formulas are composed of millet and legumes with different proportions with respectively 15%, 30% and 50% addition of cowpea (FN) and voandzou (FV) flour.

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Tableau 1: Composition of different flours for biscuits production (%)

Ingredients	Control Flour (FM)	Millet-Cowpea flour (FN)			Millet-Voandzou flour (FV)		
		15%	30%	50%	15%	30%	50%
Millet flour (%)	50	42.5	35	25	42.5	35	25
Cowpea/Voandzou flour (%)	0	7.5	15	25	7.5	15	25
Sugar (%)	12.5	12.5	12.5	12.5	12.5	12.5	12.5
Vegetable (%) oil	12.5	12.5	12.5	12.5	12.5	12.5	12.5
Eggs (%)	9	9	9	9	9	9	9
Milk powder (%)	10	10	10	10	10	10	10
Starch Maize (%)	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Baking Powder (%)	2	2	2	2	2	2	2
Bicarbonate (%)	0.5	0.5	0.5	0.5	0.5	0.5	0.5

For the millet flour production, the millet was washed very well and dried before grounded. The cowpea and voandzou seeds were soaked overnight, then dried and grounded.

Biscuit production

The ingredients were weighed according to the table 1. The dry products were mixed well then the eggs were added. The paste were cut into small squares. The dough pieces were baked at 150°C for 30 minutes. The biscuits obtained were cooled for 10 minutes before packaged in plastic bags for physico-chemical analyzes.

Biochemical composition

Biochemical tests were made on the raw materials and the biscuit samples from the formulations. They consisted of determining the water content, macronutrient contents and those of iron, zinc minerals.

The water content of the samples was determined by differential weighing of 5 g sample before and after putting it in an oven at 130 ° C for 2 h according to the French standard NF V 03-707, 2000.

The protein content was determined according to the Kjeldahl method of the AFNOR standard NF V03-050 (1970). The conversion factor considered is 6.25.

The lipid content was determined according to ISO-659 (June 1998) with the Soxhlet extraction method.

The ash was determined by incineration in a muffle furnace at 550 ° C according to ISO 2171, 2007.

The carbohydrate content was calculated (Egan et al. 1981**)**.

Total Carbohydrate Content (%) = 100- [protein (%) + lipid (%) + ash (%) + water (%)]..

Iron contents were determined by flame atomic absorption spectrometry digestion of biscuit flours by ashing according to the AOAC method**.**

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The energy value was calculated using the Atwater and Benedict coefficients (1899) according to the following formula: Energy (Kcal / 100g) =% carbohydrates × 4 (Kcal) +% proteins × 4 (Kcal) +% lipids × 9 (Kcal).

Acceptability tests

A panel of 30 adults (15 women and 15 men) assessed the biscuits. A profile test and a hedonic test were performed. The profile test focused on the color (1: very nice, 2: nice, 3: poor), the smell (1: very pleasant, 2: pleasant, 3: fair, 4: bad, 5: very bad) and the texture (1: very soft, 2: soft, 3: neither soft nor hard, 4: hard, 5: very hard). The hedonic test was performed on a hedonic scale of 5 points (1: very pleasant, 2: pleasant, 3: neither pleasant nor unpleasant, 4: unpleasant, 5: very unpleasant). The plate of each taster is composed of biscuits of the 3 formulations of the same legume and a millet-based control biscuit.

Statistical analysis

Averages and standard deviations were calculated on Excel. Analysis of variance (ANOVA) was performed using the Statgraphics Plus 5.1 software. Each analysis was performed three times per sample and an average was determined

RESULTS

Nutritional composition of raw materials

The nutritional composition of millet and legumes varieties were presented in the table 2. There is a significant difference in protein, lipids, ash, iron and zinc contents. The protein content of legume varieties is about 1.5 times higher than that of the millet variety. Lipid levels are low for both millet and legumes, less than 7%. Iron and zinc contents are low in millet, cowpea and voandzou. Only the cowpea variety *Tiligré* has high iron contents of 7,06 mg / 100 g, 2 times higher than those of cereals.

Tableau 2 : Nutritional composition of raw material (exprimé en g / 100 g de matière sèche)

	Misari 1 (Millet)	Tiligré (cowpea variety)	Voandzou (voandzou variety)
Carbohydrates (g/100 g)	74.66 ± 1.09	67.98 ± 0.37	61.33 ± 1.12
Lipids (g/100 g)	4.56 ± 0.13	1.42 ± 0.05	6.54 ± 0.06
Proteins (g/100 g)	11.8±0.93	19.72 ± 0.30	21.34 ± 1.00
Ash (g/100 g)	1.53 ± 004	2.92 ± 0.01	3.02 ± 0.02
Iron (mg/100 g)	5.02 ± 0.03	7.06 ± 0.21	3.23 ± 0.23
Zinc (mg/100 g)	3.01 ± 0.23	2.65 ± 0.09	1.85 ± 0.27

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Nutritional composition of biscuits

The nutritional analyzes results were presented in the table 3 and 4 respectively for cowpea and voandzou formulations. There was no significant difference (P<0,05) between the lipid, iron and zinc contents of biscuits with "millet-cowpea" and "millet-voandzou" formulations. While the difference is significant in the levels of protein, carbohydrates content and energy value.

Tableau 3 : Nutritional composition of biscuits with « Millet + Cowpea »

	Biscuit control	Biscuit Millet+15% cowpea	Biscuit Millet+30% cowpea	Biscuit Millet+50% cowpea
Humidity	6.38±0.09	6.77±0.11	7.40±0.06	8.57±0.08
Carbohydrates	69.34±0.23	69.43±0.40	67.95±0.31	66.84±0.77
Lipids	20.15±0.13	19.19±0.33	18.33±0.20	17.92±0.48
Proteins	7.85±0.11	8.78±0.07	11.14±0.11	12.82±0.30
Energy	490.07±0.66	485.52±1.69	481.32±1.04	479.89±2.39
Iron	2.44±0.10	2.82±0.34	3.60±0.08	2.23±0.74
Zinc	2.22± 0.10	2.10±0.12	2.05±0.01	1.94±0.14

Tableau 4 : Nutritional composition of biscuits with « Millet + Voandzou

	Biscuit Voandzou 15%	Biscuit Voandzou 30 %	Biscuit Voandzou 50%
Humidy	5.74±0.16	6.26±0.02	8.00±0.09
Carbohydrates	67.74±0.28	68.65±0.22	68.26±0.23
Lipids	20.35±0.37	19.24±0.10	18.33±0.31
Proteins	9.19±0.08	9.34±0.11	10.47±0.08
Energy	490.90±1.87	485.09±0.50	479.87±1.56
Iron	1.64±0.18	1.85±0.41	1.87±0.19
Zinc	1.71±0.10	1.71±0.17	1.94±0.18

Acceptability tests

- "Millet-Cowpea" Biscuit

Profile tests showed a significant difference (p <0.05) for smell while there was no significant difference in color and texture results. For the control biscuits, 15% and 30% were assessed as having good smell while 50% cowpeas biscuits were assessed as having very bad smell. All the biscuits were assessed as having nice color. At the texture level the 30% and 50% biscuits were assessed soft compared to the 15% control biscuit which was assessed less soft. In the hedonic test there is no significant difference in the assessment of the biscuits. From 30% the biscuits were considered neither pleasant nor unpleasant while the control biscuits and those of 15% were assessed pleasant.

- "Mil-Voandzou" Biscuits

The "Mil-Voandzou" biscuits were assessed as having nice color and the control ones as having poor color. There is no significant difference in the smell of biscuits. The control biscuit was assessed as having good smell and the voandzou biscuits were assessed as having fair smell. All the biscuits were assessed soft.

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The hedonic test showed a pleasant appreciation for all the biscuits except the 50% voandzou biscuit which was considered unpleasant.

DISCUSSION

The *Misari 1* variety, like the other varieties of millet, is characterized by a high carbohydrate content and a low fat content. The cowpea and voandzou varieties used have protein contents 2 to 3 times higher than cereals. Similar results were obtained on some cowpea and voandzou varieties consumed in Burkina Faso (Hama-Ba et *al*., 2017).

The biscuits formulated have moisture contents of less than 13%. High moisture content has been associated with short shelf life of baked products, as they encourage microbial proliferation that lead to spoilage (Ezeama, 2007) avoiding any microbial growth. The carbohydrate, lipid, protein and energy contents of the various biscuits are in accordance with the recommendations of the Codex Alimentarius STAN 074-1981 Rev 2006. E

The energy values of the biscuits are high. For all biscuits the energetic value of biscuits is dominated by carbohydrates (60% to 70%). It decreases when the proportion of legumes increases because of the importance of carbohydrates in cereals. Millet supplementation with legumes improved protein levels. The control biscuit has a low protein content. Cereal-based biscuits are poor nutritional value. Protein levels of 5.4% and 10.5% were reported respectively by Adeyeye and Akingbala (2014) on corn biscuits and by **Folorunso et *al*. (2016)** on rice biscuits. The protein content of biscuits increases as the quantity of legume flour increases. Similar results were obtained with wheat biscuits supplemented with chickpeas and mung beans (Aziah et *al*. 2012). The cowpea biscuits have higher protein contents than the voandzou biscuits. Nearly 35% of protein losses were noticed in voandzou-enriched biscuits. Legumes are rich in soluble proteins, 51% of globulins and 45% of albumins (**Freitas et *al*., 2004).**

Legume supplementation did not improve the iron and zinc levels of biscuits. The cowpea biscuits have higher iron and zinc contents than those in the voandzou. The cowpea has iron contents 2 times higher than that of the voandzou. However, significant losses were observed during processing operations, including soaking resulting in reduced iron and zinc levels.
On the organoleptic level, supplementation with cowpea and voandzou improved the color of the biscuits. The color of the voandzou biscuits has a better average. In terms of texture, the addition of cowpea hardened the biscuits while that of the voandzou did not change the texture of the control biscuit. Biscuits supplemented with legumes are accepted up to 30% of supplementation. At 50%, the smell and taste of biscuits has changed significantly. At 15% the supplemented biscuits are not significantly different from the control millet biscuit when it comes to smell and taste. The biscuits supplemented with legumes were assessed as having nice color and soft texture. At the hedonic level there is no significant difference between the control and the 15% biscuit. Biscuits with 50% cowpea and voandzou supplementation were less appreciated for smell than for taste

CONCLUSION

Supplementation with cowpea and voandzou in the production of millet biscuits leads to high energy biscuits. It improves the levels of protein, iron and zinc. However the soaking time of the raw

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materials must be controlled to reduce the losses of soluble proteins, minerals that are high in the case of the voandzou. Cowpea and voandzou supplementation improves the color and softness of biscuits. Biscuits at 50% supplementation with legumes are considered unpleasant.

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