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Quality and Properties of Cassava Base Biscuit as affected by Fish Flours and Arbuscular Mycorrhizal (AM) Fungi

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Abstract

Manihot esculenta crantz var. 326 (Cassava) is a mycotrophic and staple food crop grown in tropical areas. Its tuber is used in various forms for daily energy intake purpose. This study investigates the influence of three fish and cassava flours from AM fungi inoculated plant on the sensory properties and proximate composition of cassava base biscuits. Cleaned Cassava and fishes were first, washed, dry, and crushed to obtain flours used to make biscuits. Five kinds of biscuit were made and used for Sensory analysis using appropriate descriptions with numbering scores for color, texture, aroma, taste, and overall acceptability. Proximate analysis of flours and biscuits were done using standard methods. Cassava flour from AM fungi plant was significant better amount of protein, sugar, P and Mg compare to flour from none AM fungi. There were significant variation of protein, lipid, P, Ca, Mg and K in fish flours according to species. The species exhibiting the best amount of nutrient in general is *P. Obscura*. Biscuits with flour from AM fungi plant recorded significant best acceptance compare to control. When supplemented with fish flours, the acceptability rate varies according to fish species, with *P. Obscura* and *H. Niloticus* significantly best accepted compare to control. Significant increase of protein, lipid, sugar, amino acid, P, K and Mg content was record in biscuits made with flour from AM fungi plant compare to control (B-). Nevertheless, impact of supplementation with fish flours on nutrient content of biscuits was a function of fish species. P.Obscura flour affected the most number of parameters.

Keywords: Cassava, Biscuits, Flour, AM fungi, Protein

Introduction

AM fungi establish symbiosis with approximately 80% of the vascular plant species in all terrestrial biomes, with a great ecological importance, mostly improvement of plant productivity [1,2]. In all ecosystems, rhizosphere organisms act in support of plant growth and productivity in several ways. Plants growth under AM fungi symbiosis generally show high amount of mineral elements such as immobile phosphate ions, micronutrients, including nitrogen, potassium, magnesium, iron… [3-5]. Cassava is a highly mycotrophic plant widely cultivated in most country under various agroecosystems. It is an important food crop for about 500 million people in the world and provides more than 50 % of the average daily caloric intake [6]. The symbiotic association between AM fungi and cassava revealed to improve biomass production [7,8] with repercussions on its nutritional quality. Several parts of cassava are used and in various forms for nutritional and industrial needs. One of the main used forms is the production of flour that goes into the constitution of food at the family and industrial scale. Cassava flour is one of derivatives from cassava tubers whose processing technology is cheaper and easier than cassava starch production besides require less consumption of water and energy and produce smaller quantity of byproducts and waste [9]. One of the most popular uses of cassava flour in the world is in the manufacturing of baked products such as bread, cakes and pastries [10]. Cassava flour as raw material for the bakery and pastry industry or a substitute for wheat flour can be used in the elaboration of products such as thickeners, dehydrated soups, noodles, extruded products, seasonings, breaded, baby food, sweets and processed meat [11-14].

Fish is an excellent source of quality protein, a rich source of omega-3 fatty and mostly has high content of micronutrients such as vitamins, iron, zinc, iodine, selenium, potassium, and sodium [15]. Due their highly perishable properties, susceptibility to microbial contamination, high cost among other factors many people generally have low levels of consumption [16]. For health purpose, the American Heart Association recommends a minimum consumption of two fish serving per week which is not easy to the population far from the cost and those with low income. One way to improve fish consumption is the diversifications of the processing line through the development of new fish derive products [17]. Such products are credited with many health benefits such as manipulation of obesity, hypertension, cardiovascular disease, fighting against malnutrition [18]. Numerous end product such as pasta manufactured with fish powder of green mussel (Perna canaliculus), shrimp meat (Penaeus monodon) and beef meat have been credited with high nutritional and physicochemical characteristics [19-21]. Bakery products are of great importance in the diet of a large people across the world due to their high maniability and their relative high content of nutrients naturally obtained or enriched to meet specific needs [22]. Development of fortified biscuits or other composite flour bakery products is the focus of bakery industries since decays. Effort directed to improve people diets by increasing the protein content with the addition of protein-rich products was address with interesting results [23]. As illustration, biscuits and cakes made from mixtures of cassava/soy flour in 50/50 proportion were made with high scores in sensory evaluation in all evaluated attributes: color, texture, flavor and overall acceptability [24]. Cakes made with soy/cassava/wheat flour in the ratio 20:30:50 % respectively were comparable to cakes made with 100 % wheat flour in terms of quality and acceptability for color, flavor, soft-mouth and texture [25]. The inclusion of soy flour produces a significant emulsifying activity and increases the water absorption capacity, as well as contributing to increase protein content.

Organizations such as Food and Agriculture Organization of the United Nations, International Center for Tropical Agriculture, the International Institute of Tropical Agriculture and Federal Institute for Industrial Research con cent that there is a need for to include important crops like cassava for producing low cost foods such as bread and baked foods for strategic development purpose. Inclusion of cassava flour as ingredient for production of foods such as noodles, breakfast cereals, cookies, breads, cakes, pastries, muffins and doughnuts among others could reduce costs and increase the production of these products locally [26-28]. Although the addition of fish flour in cassava is of great contribution to the resolution of the problems of malnutrition, information on the impact of cassava origins on the quality of flour and even end products based is rare. The broad objective of this work was to Study the influence of three freshwater fish flours and AM fungi cassava flour on cassava base biscuits qualities. First analyze the composition of fishes and cassava flours before used for biscuits production. Secondly evaluate the sensory properties and proximate analysis of AM fungi cassava base biscuits supplemented with fishes' flours.

Material and methods

Biscuits ingredients

Cassava root harvest at maturity range in two groups, one growth with AM fungi inoculation and the second without AM fungi was provide by the Soil Microbiology Laboratory of the University of Yaoundé I and transported to the Laboratory of Food Technology, the Institute of Agricultural Research for Development, Yaoundé in Cameroon for flour production.

Three fish species freshly capture were purchased at the abroad of the Nyon River in the East region of Cameroon and transported in frozen blocks to the Laboratory of Food Science and Technology, the Institute of Agricultural Research for Development, Cameroon for flour production. They include Parachana obscura (*P. obscura*), Oreochromis niloticus (*O. niloticus*) and Heterotis niloticus (*H. niloticus*).

Other ingredients such as rice, salt, sugar, shortening fat, vanilla, baking powder, eggs and milk were purchased from local market, Yaoundé, Cameroon.

Productions of fish and cassava flour

The fish were descaled, beheaded, eviscerated, and washed with potable water. The dressed fish were cooked by boiling in water for 10min. The cooked fish were deskinned and deboned manually before drying in a cabinet dryer (Jouen) at 45 °C for 16 h. The dried fish muscle was ground with a blender to produce a powder and sieved to pass through the appropriate 0.5 mm mesh screen [29]. Samples of each fish species were treated separately to avoid contaminations. Dried powder was put in a sealed polythene bag and stored at -20 °C temperature until required.

Harvested cassava tubers were washed to remove all the dirty. The washed roots were then peeled and kept under water to avoid discoloration. After peeling the roots were cut into small chips, drained to remove the water and dried at 50 °C for 8h. When completely dry, cassava chip was milled using a hammer mill. The first 2kg of the milled cassava of each sample was discarded to avoid contamination. Two groups of flour were obtain including nonarbuscular mycorrhizal fungi flour (Namf) and arbuscular mycorrhizal fungi flour (Amf). The flours were store in polythene bags until used for the study.

Production of cassava base biscuits

Biscuits production was done according to the method described by American Association of Cereal Chemists [30] with modifications. The ingredients were weighed at the formula: 60g of cassava flour (AM fungi cassava and NAM fungi cassava), 40g of rice flour, 3% supplementation with each fish flour, 50.0g of fine sugar, 1.0 egg (50.0g), 28.0g of shortening, 0.93g of salt, 1.11g of sodium bicarbonate and 1.0g of vanilla. The ingredients were properly mixed to form a paste, introduced into the molds before

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baking at 180 °C for 20 min. At the end of the cooking, the biscuits are taken out of the oven, cooled and introduced into the plastic bags, then stored in the fridge for analysis. At all, 5 groups of biscuits were producing and label as follow: B-= biscuit from none Arbuscular mycorrhiza fungi cassava flour, B+= biscuit from Arbuscular mycorrhiza fungi cassava flour, B-H = biscuit from none Arbuscular mycorrhiza fungi cassava flour supplemented with *H. niloticus* flour, B-O= biscuit from non-Arbuscular mycorrhiza fungi cassava flour supplemented with *O. niloticus* flour, B-P= biscuit from non-Arbuscular mycorrhiza fungi cassava flour supplemented with P. obscura flour.

Proximate analysis of cassava base biscuit enriched with fish flour

Total lipid was extracted following the method describe by Folch et al. [31]. Crude protein (nitrogen x 6, 25) was determined using a modified Kjeldahl procedure that uses H_2SO_4 and hydrogen peroxide for sample decomposition without added salts or metal catalysts [32]. The ash and sugar content were determined following the method of AOAC [33]. Amino acids were determined following the method describe by Yemm & Cooking [34]. The minerals content was determined using atomic absorption spectrophotometer following the method describe by Pauwels et al., [35].

Sensory evaluation and acceptability of cassava base biscuit

Twenty-five untrained consumer panelists were recruited, targeting biscuit eaters from students of the Yaoundé I University, Yaoundé, Cameroon. The ages of the panelists were 18-35 years. Evaluation of biscuits was replicated three times in sessions of 1.5 h a day in the morning for three days. This was done in the Food Technology Laboratory with individual booths following standard good sensory practices [36]. Filtered tap water and raw carrot slices were provided as palate cleansers. AM or none AM fungi cassava base biscuits supplemented or not with fish flours were presented to each panelist and labeled with a randomized three-digit code. Panelists were requested to appreciate biscuits for aroma, taste, touch, texture and over all acceptability by assigning a score based on a six-point hedonic scale (0 means dislikes extremely, and 5 means likes extremely).

Statistical analysis

The statistical analysis was carried out using one-way analysis of variance (ANOVA) for chemical composition, and sensory acceptability data. The experiments were run in triplicate. Means were separated using Turkey's (HSD) test, and p-values < 0.05 at 95 per cent confidence interval were considered as significant.

Results

Proximate analysis of flours

The proximate analysis of three fish species flour including *P. obscura, O. niloticus*, and *H. niloticus* as well as cassava flour from AM fungi and none AM fungi plant, are shown in Table 1. The percentage of protein, lipid and ash content in flours varied according to the fish species, with the best amount addressed to P. obscura for protein and ash, follow by *O. niloticus*. The best lipid percentage was record in flours of the fish *H. niloticus*. Although sugar content of all fish flours remains very low, there were no significant variations (P<0.05) from one species to another in this study. The percentage of protein, sugar and ash in cassava flours significantly (P<0.05) increase following inoculation of plant with AM fungi. The best percentages of protein, sugar and ash was record in flour from AM fungi plant. In contrast, no significant variation was record for lipid content of the flour following Am fungi inoculation of the cassava plant.

Table 1: Chemical analysis of *P. obscura*, *O. niloticus* and *H. niloticus* flours from Cameroon, arbuscular mycorhizal fungi (Amf) and nonarbuscular mycorrhizal fungi (Namf) cassava flour.

	O. niloticus	*H. niloticus*	*P. obscura*	Amf	Namf
Proteins (%)	15,78^{b}	6,31^{c}	20,51^{a}	8,5^{a}	4,9^{b}
Lipid (%)	1,2^{b}	5^{a}	1,2^{b}	0,4^{a}	0,5^{a}
Sugar (%)	0,4^{a}	0,2^{a}	0,46^{a}	94,9^{a}	87,2^{b}
Ash (%)	3,41^{b}	1,7^{c}	4,2^{a}	4,59a	2,95^{b}

Each value is a mean of triplicate determinations. Mean value with the same letter as superscript on the same line are not significantly different from one another (p < .05).

Mineral composition of flours

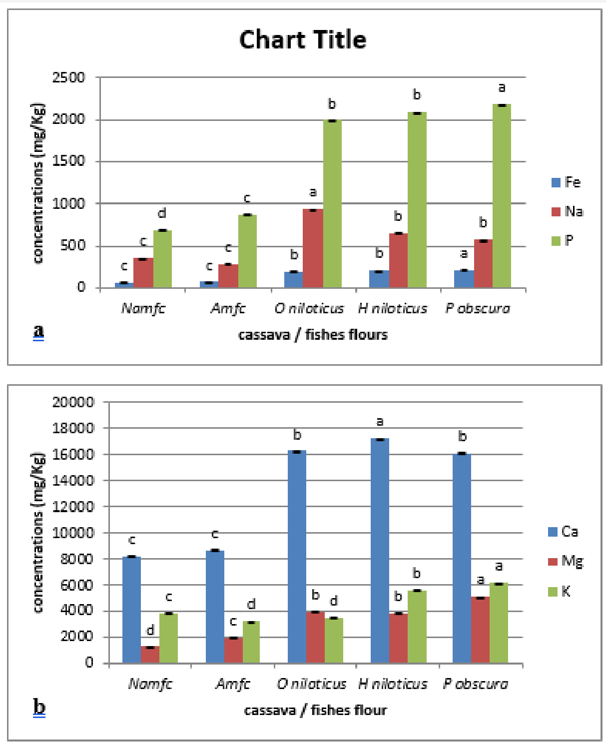

Figure 1: Micro elements content of cassava and fishes' flours. a (Fe, Na, P) and b (Ca, Mg, K). Namfc= non-Arbuscular mycorrhiza fungi cassava flour, Amfc= Arbuscular mycorrhiza fungi cassava flour. Bars of the same color with the same letter are not significantly different from p < .05.

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The mineral analysis of cassava flour from AM fungi and none AM fungi plant, as well as three fish species flour including *P. obscura*, *O. niloticus*, and *H. niloticus* is shown in Figure 1. The concentration of Fe, Ca, and Na in cassava flour was not significantly affected by AM fungi inoculation; however, P, Mg, and K concentration was significantly increased in cassava flour from plant inoculated with AM fungi. Related to minerals of the three species of fish flour, the distribution is variable, and allows classifying those fish species sometimes in three groups but also in two. Following Fe, P, and Mg concentrations, P. obscura is of best quality follow by the two others appreciated at the same level. While looking to Na and Ca concentrations, *O. niloticus*, and *H. niloticus* are of best quality follow by *P. obscura*. The concentration of K allows distinguishing three groups as follows: P. obscura follow by *H. niloticus* and *O. niloticus*.

Sensory properties of biscuits

Table 2: sensory evaluation of mycorhizal (AMF) and nonmycorrhizal (NAMF) cassava base biscuits supplemented with three fish flour from Nyon river in Cameroon. B-= biscuit from none Arbuscular mycorrhiza fungi cassava flour, B+= biscuit from Arbuscular mycorrhiza fungi cassava flour, B-H = biscuit from none Arbuscular mycorrhiza fungi cassava flour supplemented with *H. niloticus* flour, B-O= biscuit from none Arbuscular mycorrhiza fungi cassava flour supplemented with *O. niloticus* flour, B-P= biscuit from none Arbuscular mycorrhiza fungi cassava flour supplemented with P. obscura flour.

	Aroma	Taste	Touch	Texture	Overall
B-O	3.13^a	2.97^b	3.13^a	2.57^b	2.57^b
B-H	3.27^a	3.43^a	3.27^a	3.53^a	3.10^a
B-P	3.2^a	3.5^a	3.20^a	3.57^a	2.83^a
B-	2.5^b	2.93^b	2.6^b	2.5^b	2.68^b
B+	2.87^a	2.93^b	3.6^a	3.66^a	3.11^a

Each value is a mean of triplicate determinations. Mean value with the same letter as superscript on the same column are not significantly different from one another ($p < .05$).

The result of the sensory evaluation of cassava base biscuits supplemented with fish's flour is shown in Table 2. Scores of the parameters aroma, taste, touch, texture, and overall acceptability evaluated clearly shown that biscuits made with cassava flour from AM fungi plant without supplementation (B+) was significantly most preferred ($P<0.05$) compare to those from NAM fungi cassava flour (B-) by the 25 untrained panelists in regard of the overall criteria. While supplemented, cassava base biscuits receiving *P. obscura* (B-P) and *H. niloticus* (B-H) flours were preferred at the same rate compared to B+ biscuits. In contrast, biscuits receiving *O. niloticus* (B-O) flours were appreciated at similar score compare to B- in regard of the overall sensory criteria. In general, the lowest record score was 2.5 for aroma and texture for B- biscuits, while the highest was 3.66 for texture obtained with B+ biscuit. Except the taste parameter, B+ biscuits were significantly best preferred for all other parameters compare to B- biscuit. There were no significant differences ($P<0.05$) between cassava biscuit made with flour from AM fungi plant and those supplemented with P. obscura and H. niloticus flours for all the sensory parameters tested except the taste, showing a high similitude between those biscuits. B+ biscuit showed significant preference compare to B-O for the parameters taste and texture.

Mineral composition of biscuits

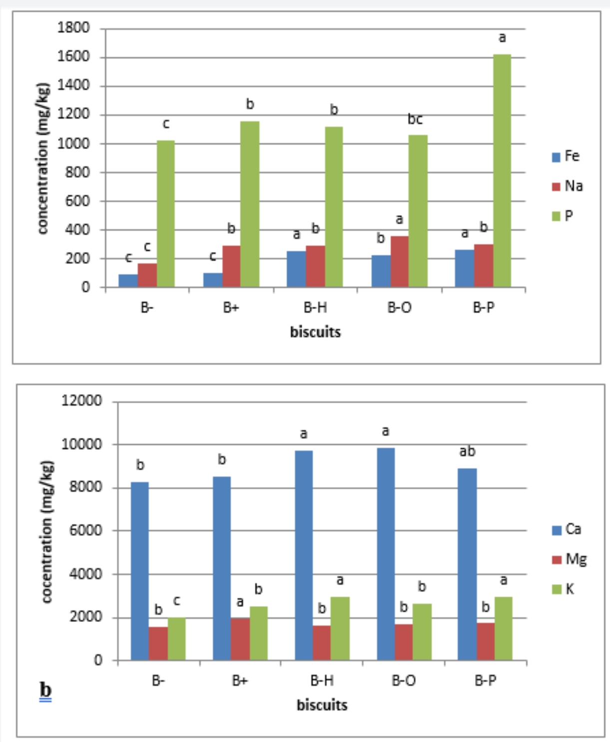

Figure 2: Micro elements content of biscuits from cassava with fishes flours supplementation, a (Fe, Na, P) and b (Ca, Mg, K). B-= biscuit from none Arbuscular mycorrhiza fungi cassava flour, B+= biscuit from Arbuscular mycorrhiza fungi cassava flour, B-H= biscuit from none Arbuscular mycorrhiza fungi cassava flour supplemented with *H. niloticus* flour, B-O= biscuit from none Arbuscular mycorrhiza fungi cassava flour supplemented with *O. niloticus* flour, B-P= biscuit from none Arbuscular mycorrhiza fungi cassava flour supplemented with *P. obscura* flour. Bars of the same color with the same letter are not significantly different from $p < .05$

The mineral analysis cassava base biscuit supplemented with three fish flours including P. obscura, O. niloticus, and *H. niloticus* is shown in Figure 2. Large significant variation ($P<0.05$) in minerals concentration of the various biscuit's formula was record in regard of treatments. Fe, Na, and Ca concentrations were not significantly affected in biscuits made from flour derived from cassava inoculated with AM fungi (B+) compare to the control B-. However, P, Mg, and K concentrations increases significantly ($P<0.05$) in these biscuits compared to B-. The supplementation of cassava base biscuits with flours from the three species of fish has variable influences on the concentration of the different minerals studied and thus the quality of the end product. Supplementation with P. obscura flour has the best significant influence ($P<0.05$) on the concentration of Fe, P, and K while supplementation with H. niloticus, and O. niloticus flours significantly impact the concentration of Fe, K and Na, Ca respectively compare to the control.

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Proximate analysis of biscuits

The proximate analysis of cassava base biscuits supplemented with three fish flours including P. obscura, O. niloticus and H. niloticus is shown in Table 3. Large significant variation (P<0.05) in nutrient composition of the various biscuits was record in regard of treatments. The percentage of protein, sugar, amino acids, and ash content of the cassava base biscuits significantly (P<0.05) varied according to the symbiotic status of the plant used to produce flours. All those parameters were in high amount in biscuits made with flour from AM fungi plant (B+) compared to control (B-) with the respective increase rate of 46%, 7%, 51%, and 29% for protein, sugar, amino acids, and ash content. The supplementation of biscuits with three fish species flour has variable effects on the content of all the parameters studied. Protein content was significantly (P<0.05) improved at the rate of B-O > B-P > B-H, compared to the none supplemented B-. Lipid and amino acids content were significantly improved (P<0.05) in the B-O and B-P biscuits respectively compared to B-. Except B-H, sugar content was significantly increase in the supplemented biscuits compare to B-, while ash content was improve in the B-P biscuits only compared to the control B-. In general, supplementation of biscuits with P. obscura flour was the best formulation in regard of the parameters tested, follow by the supplementation with O. niloticus flour.

Discussion

The protein concentration of the three fish flours studied varied from 6.31 to 20.51% respectively for H. niloticus, and P. obscura. This observation falls in line with those of other studies who generally show protein concentration to greatly vary according to fish species. As illustration, study on 23 different dried species of fish reported that protein content varied widely from 17.2 to 78% [37], while another in fourteen selected dried fish species found that protein content varying between 40.69 to 66.52% [38]. The best protein content in this study was address to P. obscura which is similar to data obtained in other work for the same fish species. In the addressed study, observation was extended to the species of the Channidae family [39,40]. A number of researchers believe that P. obscura is a highly valued food for population, and thus its aquaculture should be more explored to highlight this property. The lipid content of the fish flours studied show the best proportion of 5% for the H. niloticus flour and around 1% for each of the two other species. In general fish can be grouped into four categories according to their lipid content as lean fish (< 2%), low (2 - 4%), medium (4 - 8%) and high lipid (>8%) [40]. In line with this classification, the three fish species used to produce flours can be grouped as medium lipid content (H. niloticus) and lean fish (*P. obscura* and *O. niloticus*) category. lipid content variation of the fish used in this study corroborate findings of other researcher who noted its variation with species, age, size, and season [42]. The protein, lipid, and sugar content of cassava flours were shown to significantly increase following AM fungi inoculation. This observation is similar to that record while study interaction between AM fungi and cassava showing improvement of various aspect of the host physiology, including biomass production [7,8]. The principal role of AM fungi in the symbiotic system is improvement mineral acquisition especially P. Even if the mechanisms still to be fully clarified, researchers believed that AM plants are more nutrient dense [43]. Study related to the interaction between potato plant and AM fungi show increase in various biochemical compound including protein and sugar [44]. Significant increase of P, Ca, and Mg content was noted in cassava flour from AM fungi inoculated plant compare to the control none inoculated showing the possible implication of this symbiosis to the uptake of these nutrient. Study on Vicia faba L under dual inoculation with rhizobium and AM fungi show improvement in growth and yield attributes, better uptake of N and P content and significant protein content of groundnut plant at various growth stages [45, 46].

Flours were now used to produce biscuits that were subject to sensory and proximate analysis. Cassava base biscuit made with flour from AM fungi plant was significantly best accepted compared to the control made with flour from none AM fungi cassava plant in regards of the overall acceptability (Table 2). This observation corroborate others who found that Cassava strips prepared from cassava flour and cowpea paste introduces good taste and aroma to the product (International Institute for Tropical Agriculture, 2006). Despite a wide range of benefits attributed to AM fungi plants such as better nutritional status, better productivity, vigor and good health, it appears that process products derived from fruits produce by plants growth with AM fungi have better nutritional and organoleptic properties. Except the taste, all the sensory parameters tested point out significant differences between B- and B+ supporting the view that AM fungi is of great contribution to the quality of process derive food. It is accepted in many descriptive profiling procedures that sensory panelists are a significant source of variation for all the attributes [47]. Large proportion of researcher are consistent with the fact that texture is an essential characteristic of food acceptance by consumers and therefore, an important step in quality assessment [48]. In general, one of the most popular uses of cassava flour in the world is in the manufacturing of baked products such as bread, cakes and pastries [10]. This use involves various advantages over the quality and properties of the by-products. As illustrations, biscuits and cakes made from mixtures of cassava/soy flour in 50/50 proportion had high scores in sensory evaluation in all evaluated attributes: color, texture, flavor and overall acceptability [24]. Cakes made with soy/cassava/wheat flour in the ratio 20:30:50 % respectively were comparable to cakes made with 100 % wheat flour in terms of quality and acceptability for color, flavor, softmouth and texture [25]. Supplementation of cassava base biscuit with fish flours resulted in a significant (p < 0.05) best acceptability of B-P and B-H compared to the control (Table 2), however, no significant difference was observed between B-O and the control (B). This observation may be close related to the proximate composition of the various fish flours as they exhibit significant differences in their proximate and nutritional composition. Analysis of the chemical composition of the biscuits showed large variation in the content of minerals and macronutrients according to the sym-

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biotic status of the plant or the fish species used to produce flour (Table 3 and Figure 2). Flour from AM fungi plant showed significant increase of P, Mg and K in biscuits (B+) compared to control (B-). Such variation could be attributed to AM fungi as a number of researches points out the implication of these fungi in physiology and nutrient uptake including minerals. However, supplementation with fish flours showed significant increase ($p<0,05$) of all the tested minerals except Mg. In between remarkable increase was noted for P and Ca content in biscuits following supplementation respectively with *P. obscura* and *O. niloticus*; *H. niloticus* flours. It is generally known that fish is considered a valuable source of calcium and phosphorus in particular, and it provides moderate amounts of other minerals [49]. Study on the substitution of wheat flour by fish flour in bread at different concentration showed significant increase of minerals especially Ca and P.

Table 3: Proximate analysis of arbuscular mycorrhizal (AM) fungi and nonarbuscular mycorrhizal (NAM) fungi cassava base biscuits supplemented with three fish flour from Nyon river in Cameroon. *O. niloticus*, *P. obscura*, *H. niloticus*. B-= biscuit from none Arbuscular mycorrhiza fungi cassava flour, B+= biscuit from Arbuscular mycorrhiza fungi cassava flour, B-H= biscuit from none Arbuscular mycorrhiza fungi cassava flour supplemented with *H. niloticus* flour, B-O= biscuit from none Arbuscular mycorrhiza fungi cassava flour supplemented with *O. niloticus* flour, B-P= biscuit from none Arbuscular mycorrhiza fungi cassava flour supplemented with *P. obscura* flour.

	Protein (%)	Lipids (%)	Sugar (%)	Ash (%)	Amino acids (mg/g)
B-O	11.59[a]	8.2[a]	34.45[a]	5.80[b]	13.82[b]
B-H	9.73[b]	6.82[b]	32.9[b]	4.21[b]	14.04[b]
B-P	13.2[a]	6.83[b]	34.08[a]	7.10[a]	17.50[a]
B-	6.44[c]	6.8[b]	32.05[b]	3.5[c]	13.44[b]
B+	9.39[b]	7.2[b]	34.26a	5.3[b]	17.40[a]

Each value is a mean of triplicate determinations. Mean value with the same letter as superscript on the same column are not significantly different from one another ($p < .05$).

Significant increase in protein, sugar and amino acids content was record in cassava base biscuits following P. obscura flour supplementation (Table 3). This was evidence for *O. niloticus* flour, except the content of amino acids. It is believable that P obscura flour is the best for the supplementation of biscuits as its better improve all the parameter tested. Proteins derived from animal sources, like fish, are considered nutritionally superior to those from vegetal sources because the former contain a better balance of essential amino acids [50]. Despite the fact that food products from cassava are energy- rich foods [51], supplementation with fish flour tends to improve the nutrient content of those foods according to the species [52-53].

Conclusion

In relation to the flour's characterization, cassava flour from AM fungi inoculated plant record significantly improve of P, protein and sugar content. Nutrient content particularly protein greatly varying according to fish species, with P Obscura having the best amount. For sensory evaluation, the biscuits with AM fungi cassava base flour received better sensory acceptance than that made with none AM fungi cassava base. Supplementation with fish flours show better acceptance for P obscura and H Niloticus. Related to the chemical composition, biscuits with flour from AM fungi plant as well as those supplemented with fish flours show better nutrient content, particularly protein, P and Ca. Baked products made with cassava flour supplemented with fish flour offering food alternatives to a range of people who claim products gluten-free and those with restricted meat diet.

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