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Incorporation of *Ricinodendron heudolotti* Meal into Blends of Wheat and Precooked Taro Flour for Production of Nutrient Dense Biscuits

Research Article

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Abstract

Protein energy malnutrition remains the biggest nutritional problem in children under five years in developing countries. Provision of nutritious snack foods to children could go a long way in resolving this problem. Composite flours of wheat (45-80%), precooked taro flour (20%) and njansang meal (0-35%) were studied for the production of energy and nutrient dense biscuits. Chemical composition of flours and biscuits were determined, as well as the physical and sensory properties of biscuits. Nutritional evaluation of biscuits was carried out to determine its contribution to protein and energy RDA of children 3-5 years old. Results show that protein, lipid, and ash contents of flours increased by 84%, 105% and 221% respectively at 35% incorporation of njansang meal. Biscuit diameter and spread ratio decreased, while weight and thickness increased with njansang meal incorporation. Njansang meal improved nutritional quality of biscuits. Best organoleptically accepted biscuits were obtained with a combination of 55% wheat flour, 20% precooked taro flour and 25% njansang meal, with energy and protein values of 398 kcal and 11.22 g respectively per 100g of biscuit. Thus, 100 g of biscuits could supply respectively 86.4% and 33.2% of protein and energy needs of children 3-5 years old.

Keywords: Composite flour (wheat, precooked taro and Njansang); Biscuit nutritional quality; Sensory analyses; Biscuit physical characteristics

Introduction

Undernutrition in children manifesting as stunting, underweight and wasting remains the biggest nutritional problem in many developing countries in Asia, Latin America, the Middle East, and Africa [1]. They are a major contributing factor to child mortality, disease and disability [1]. Globally, 165 million children are stunted and undernutrition is responsible for 3·1 million deaths annually in children younger than 5 years [2]. Undernutrition early in life has major consequences for future educational, income and productivity outcomes. Stunting is associated with poor school achievement and poor school performance [3].

The absence of nutritious foods in quantity and quality stands out as one of the major causes of malnutrition (Protein energy malnutrition - PEM), alongside poor health care and hygienic practices. This form of malnutrition (PEM) usually sets in as from six months of age, which coincides with the introduction of complementary foods into the diets of children, although, poor nutrition during pregnancy is also a contributing factor [4]. To meet children's nutritional needs at this stage and to help resolve the problem of malnutrition in children under five years of age, much effort is being consecrated to

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the development and provision of nutrient dense complementary foods to children as from the age of weaning [5]. Unfortunately, the problem still persists and is even degenerating in some areas, continuing into adolescence with devastating consequences on child development [1]. Most weaning foods given to children in developing countries are made of starchy gruels with low protein and mineral contents [5]. To complement the nutrient intake of children 2-5 years old, snacks such as biscuits are increasingly being given to them [6]. Biscuits could thus be used as a vehicle to provide nutritious snack foods to children through fortification of wheat flour with protein and lipid rich flours. Biscuits of acceptable textural and organoleptic properties have been developed with partial replacement of wheat flour with flours produced from local foodstuffs such as beniseed and plantains [7]; taro tubers [8] and chickpea and plantains [9].

In an effort to improve the utilization of taro tubers, Himeda et al. [9] prepared organoleptically acceptable biscuits by replacing 20% of wheat flour with precooked taro flour. These biscuits however, were of low protein content (9.5%). Taro flour is poor in protein (1.0 to 4.5%), but rich in carbohydrates (60-90% DM) [10]. Its starch granules have a small diameter (1.5- 5µm) [11] conferring on it a good digestibility and a potential for use in the development of children foods. It is high in the minerals phosphorus, potassium and magnesium [12]. Its fiber content varies from 5.02 to 9.01% and is mostly soluble fiber [10].

Oilseeds, such as njansang (*Ricinodendron heudelotii,* Bail.), mostly used as ingredients in food preparations have been shown to contain important amounts of proteins (22-31%) similar to legumes, with a high lipid content (45%) made up essentially (79%) of polyunsaturated fatty acids (PUFA), and a non-negligible ash content [13,14]. Significant levels of vitamin A and E, have been reported in these seeds along with a good percentage of essential to total amino acids (40.6%) [13]. Its high protein and polyunsaturated fatty acid content, could be exploited in the production of novel foods such as biscuits to improve their nutrient density while also bringing in much needed PUFA, with beneficial effects on the growth and wellbeing of children. It would equally contribute to valorizing local food resources. The objective of this work was thus to evaluate the use of composite flours of wheat/precooked-taro/njansang, for the production of energy and protein dense biscuits and to evaluate their acceptability and nutritional quality as potential snack foods for children less than five years old, to help in the fight against protein energy malnutrition.

Materials and Methods

Biological Materials

The plant materials used for this work were taro tubers (*Colocossia esculenta*) harvested from Bafia (Centre Region, Cameroon), Njansang seeds (*Ricinodendron heudelotii*) and wheat flour purchased from a local market in Ngaoundere, Cameroon.

Methods

Production of taro flour

Pre-cooked Taro flour was produced as depicted in Figure 1. Taro tubers were washed and cooked in their peels using a pressure cooker for 15 mins. Boiled tubers were then peeled manually and cut into slices 0.5 cm thick. Slices were dried at 45 °C for 24 h in an electric dryer (Riviera and Bar L0075). Dried taro slices were milled using a laboratory mill (Cullati, Polymix, France, Kinematica, Luzernerstrasse, Germany), and sieved through a 500 um sieve. The flour obtained was sealed in polythene bags and stored at freezing temperatures until needed. Njansang seeds were sorted and milled in a blender to obtain a meal.

Preparation of Composite Flours

To prepare composite flours, taro flour in the mixture was fixed at 20% following previous findings by Himeda et al. [8] that this level of substitution produced biscuits of acceptable organoleptic characteristics. The concentration of wheat flour and njansang meal was then varied to give incorporation levels of 0 - 35% njansang meal and 80 - 45% wheat flour (Table 1).

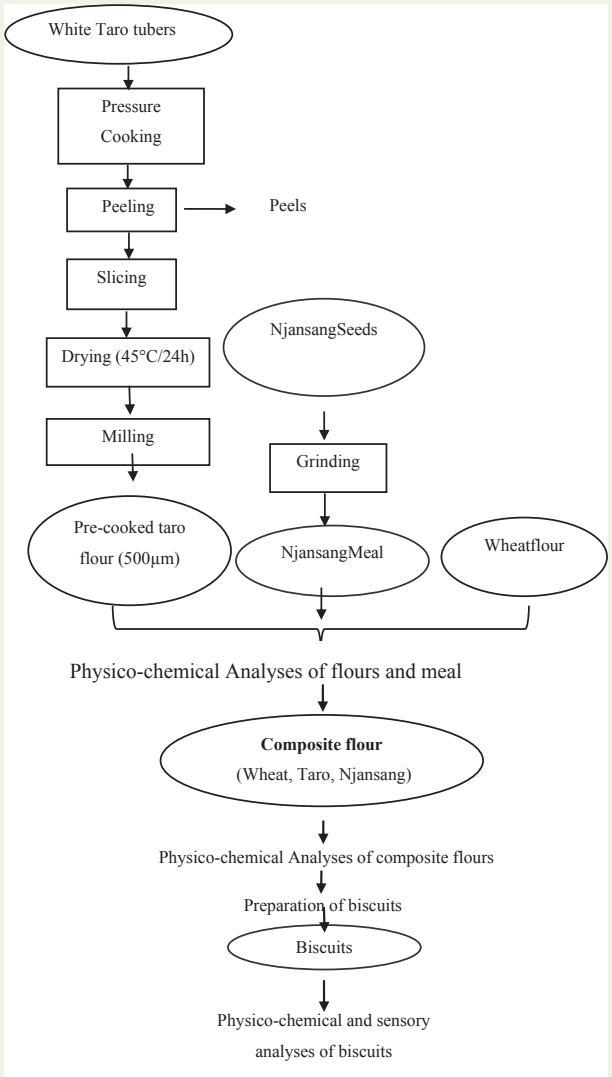

Figure 1: Preparation of flours and biscuits.

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Preparation of biscuits

Biscuits were prepared according to Himeda et al. [8]. Sugar (125 g), margarine (125 g) and eggs (2) were creamed together in a food processor (Clatronic, Profi Cooks KM 2961, Germany) until light and fluffy. The amount of fat added was adjusted in accordance with that initially present in the composite flour to give a final fat content of 125 g. Composite flour (250 g) salt (2 g) and 5 g baking powder was mixed together and added to the creamed mixture, and mixing continued to obtain a uniform dough. The dough was then rolled out into a continuous sheet of approximately 0.5 cm and cut into round pieces using a biscuit cutter. Baking was done at 180 °C for 15 mins in an oven. The biscuits were cooled and kept frozen until needed for analyses. Biscuits for sensory analyses were cooled and used immediately.

Analyses

Proximate Composition: Precooked taro flour, wheat flour, njansang meal and biscuits were analysed for moisture, ash, protein and lipid contents using AOAC [15] methods. Available sugars were determined according to Fischer and Stein, [16] following acid hydrolysis of samples. The energy density of the biscuits was calculated from the caloric value of the energy nutrients using the Atwater factor [17] where 1 gram of carbohydrate supplies 4 kcal, 1 gram of protein 4 kcal and 1 gram of fat 9 kcal.

Physical characteristics of biscuits: Weight (g) of biscuits was measured using a digital balance and was the average value of six individual biscuits. Biscuit thickness (cm) was determined by stacking six biscuits on top of each other and taking the average thickness. Diameter (cm) was the average value of six biscuits measured using a caliper [9]. Volume was determined by calculation. Spread ratio was calculated by dividing the average value of diameter by the average value of thickness of biscuits, and density as weight/volume.

Sensory evaluation of biscuits: Sensory evaluation of the biscuits was carried out as described by Himeda et al. [8], using a consumer panel of 56 persons and a 9 point hedonic scale where 1 stands for dislike extremely and 9 for like extremely. Sensory attributes evaluated were color, taste, texture, flavor, acridity and overall acceptability.

Statistical Analysis

Analyses were carried out in triplicates and results are presented as means and standard deviations. Mean separation was done using the Duncan Multiple Range test. Stat graphics version 5.0 (Manugistics, Rockville, Maryland, USA) statistical software was used for these analyses.

Results and Discussion

Chemical composition of flour samples

The proximate composition of wheat flour, precooked cooked taro flour and njansang meal are presented on Table 2. Njansang meal had the highest concentration of lipids (47.66%), protein (25.05%) and ash (7.48%) contents (Table 2), consistent with the fact that it is an oilseed. Accordingly, it had the lowest available sugar content. Oil contents obtained in this study were similar to the 44.7% reported by Ezekwe et al. [13]. Previous studies had reported oil contents in njansang seeds to range between 49.25 and 63.48% [18].The protein content of njansang obtained in this study is comparable to the 22% reported by Tchiégang et al. [14], but lower than the 31% reported by Ezekwe et al. [13]. Njansang could thus be a good source of protein for the diet.

Wheat flour is of intermediate protein content (10.47%), and this is in agreement with values reported by Akubor and Badifu [19]. Protein content for precooked taro flour found in this work falls within the range of 2.7 to 5.4% obtained by Mbofung et al. [20] in taro tubers. Taro like other tubers is poor in proteins and thus could not be envisaged as a protein source.

Available sugars were highest in wheat flour (56.70%) followed by precooked taro flour (48.41%). This is explained by the fact that wheat and taro flours are made up predominantly of starch which when hydrolyzed gives sugars. Available sugar contents of taro flour is comparable to that by Mbofung et al. [20] for raw white Ibo taro tubers (48.01%).

Wheat flour and taro flour had negligible oil contents in comparison to njansang (Table 2). The wheat flour used in this study was refined wheat flour in which most of the germ had been removed and this explains its low oil content (0.94%). Tubers generally are poor sources of lipids. Lipid contents of precooked taro flour in this study (1.33%), were slightly higher than that (0.6%) reported by Himeda et al. [8], and (0.82%) by James et al. [21].

Ash content for njansang falls within the range of 6.94-7.61 g/100g DM reported by Abubakar [22]. Lowest values in wheat flour could be attributed to the refining process which removed most of the bran where the minerals were concentrated. Ash content of taro flour (4.37%) was within the range of 3.5-7.5% reported by Mbofung et al. [20] for six varieties of taro. Taro tubers are reportedly high in minerals such as potassium and magnesium [23] amongst others and thus accounts for the high ash contents of taro tubers.

Table 1: Formulation of Composite Flours.

	Formulations							
Ingredients	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Njansang Meal (%)	0	5	10	15	20	25	30	35
Wheat Flour (%)	80	75	70	65	60	55	50	45
Pre-cooked Taro Flour (%)	20	20	20	20	20	20	20	20

Table 2: Proximate Composition of wheat flour, precooked taro flour and njansang meal (g/100g DM).

Flour	Available Sugars	Lipids	Proteins	Ash
Wheat Flour	56.70 ± 1.96^{c}	0.94 ± 0.01^{b}	10.47 ± 0.16^{b}	1.17 ± 0.01^{a}
Precooked Taro Flour	48.41 ± 1.30^{b}	1.33 ± 0.39^{a}	2.58 ± 0.30^{a}	4.37 ± 0.03^{b}
Njansang Meal	4.93 ± 0.34^{a}	47.66 ± 0.86^{c}	25.05 ± 1.21^{c}	7.48 ± 0.05^{c}

Means in the same column with different superscripts are significantly different (P<0.05).

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Chemical composition of composite flour mixtures

Composite flours prepared using blends of 20% precooked taro flour, 0 to 35% njansang meal and 80-45% wheat flour, were analysed for their proximate composition (Table 3). Available sugar content decreased significantly ($p<0.05$) with increasing incorporation of njansang meal (Table 3). Given that taro flour composition was constant and that wheat flour had the highest sugar content (Table 2), it follows therefore that its substitution with njansang meal brought about a reduction in sugar content of the composite flour. Sugar content dropped by as much as 29% with incorporation of 35% njansang meal. On the other hand protein, lipid and ash contents of composite flours increased significantly ($p<0.05$) with increasing incorporation of njansang meal, and is in correlation with the high concentration of these nutrients in njansang meal (Table 2). At 35% incorporation of njansang meal, protein, lipid and ash content increased by 84%, 105% and 221% respectively (Table 3). It emerges from these analyses that incorporation of njansang meal into wheat taro flour improves the latter's nutritional quality to give flours that could be utilized for the production of biscuits of good nutritional and energy value.

Nutritional Composition and Energy value of biscuits

Biscuits prepared using the different composite flour mixtures were analysed for their nutritional composition. Available sugars in biscuits decreased with incorporation of njansang meal as observed with the composite flours (Table 4). This observation is consistent with the fact that the amounts of the other ingredients used in the production of the biscuits were identical, thus differences in nutrient composition resulted mainly from the composition of the flour used. On the other hand protein and ash content in biscuits increased with incorporation of njansang meal in accordance with observations made in the flours (Table 3). Lipid contents appeared stable in biscuits because the amount of margarine added was adjusted to take into consideration the initial lipid contents of the flours.

The quantities of available sugars in cookies was however smaller than those observed with the flours. Similarly, protein contents of biscuits were lower than in the corresponding flours. The decreases in sugars and protein contents of biscuits compared to flours could be attributed to maillard type reactions involving sugars and proteins as well as caramelisation of sugars that occur during baking [24]. These reactions, although they negatively affect proteins and sugars, contribute to the development of color and flavour in biscuits [24].

Interestingly, the energy content of the biscuits were similar ($p>0.05$). This could be as a result of the fact that the lipid contents of the biscuits were identical and the decrease in available sugars observed with substitution by njansang meal was compensated

Table 3: Proximate composition of composite flour blends (g/100 g DM).

Blends PTF:WF:NM[1]	Availablesugars	Lipids	Proteins	Ash
20:80:0	55.96 ± 0.86^{f}	14.33 ± 0.57^{a}	9.33 ± 0.32^{a}	1.73± 0.80^{a}
20:75:5	54.13 ± 0.55^{e}	16.66 ± 0.57^{b}	10.06 ± 0.31^{b}	2.27 ± 0.03^{ab}
20:70:10	50.05 ± 0.01^{d}	19 .01± 0.01^{c}	10.56 ± 0.15^{b}	2.82 ± 0.82^{abc}
20:65:15	48.38 ± 0.70^{c}	21.33 ± 0.57^{d}	13.41 ± 0.62^{c}	3.07 ± 0.41^{bc}
20:60:20	42.64 ± 0.27^{b}	23.01 ± 1.73^{e}	14.4 ± 0.15^{d}	3.35 ± 0.02^{bc}
20:55:25	42.96 ± 0.80^{b}	25.66 ± 0.57^{f}	15.18 ± 0.15^{e}	3.42 ± 0.02^{bc}
20:50:30	40.22 ± 1.66^{a}	26.33 ± 0.57^{f}	16.20 ± 0.15^{f}	3.86 ± 0.75^{c}
20:45:35	39.60 ± 0.50^{a}	29.33 ± 0.57^{g}	17.17 ± 0.15^{g}	5.55 ± 0.08^{d}

[1] PTF, Precooked Taro Flour; WF, Wheat Flour; NM, Njansang Meal

Table 4: Nutritional Composition and Energy value of biscuits (g/100 g DM).

Blends PTF:WF:NM[1]	Available sugars	Lipids	Proteins	Ash	Energy Kcal/100g
0:100:0	42.58 ± 0.92^{e}	23.00 ± 1.40^{a}	6.25 ± 0.28^{a}	1.01 ± 0.01^{a}	408.65 ± 7.50^{a}
20:80:0	40.66 ± 2.35^{d}	22.50 ± 0.70^{a}	6.18 ± 0.58^{a}	1.04 ± 0.01^{a}	391.31 ± 4.03^{abc}
20:75:5	39.31 ± 0.47^{c}	22.00 ± 1.40^{a}	7.21 ± 0.29^{b}	2.09 ± 0.01^{b}	384.08 ± 13.89^{bc}
20:70:10	37.20 ± 0.71^{b}	22.50± 0.70^{a}	8.03 ± 0.56^{b}	2.55 ± 0.75^{bc}	383.42 ± 4.09^{c}
20:65:15	36.48 ± 0.05^{b}	23.00 ± 1.41^{a}	9.27 ± 0.29^{c}	2.61 ± 0.72^{bc}	390.00 ± 11.56^{abc}
20:60:20	36.57 ± 0.04^{b}	23.50 ± 0.70^{a}	10.19 ± 0.28^{d}	3.04 ± 0.02^{cd}	398.84 ± 5.28^{abc}
20:55:25	36.41 ± 0.01^{b}	23.05 ± 0.07^{a}	11.22 ± 0.28^{e}	3.10± 0.02^{cd}	398.00 ± 2.00^{abc}
20:50:30	33.88 ± 0.51^{a}	24.50 ± 0.70^{a}	12.08 ± 0.28^{f}	3.50± 0.69^{d}	404.34 ± 7.52^{a}
20:45:35	32.94 ± 1.29^{a}	24.00 ± 1.41^{a}	13.32 ± 0.29^{g}	5.15 ± 0.07^{e}	401.00 ±12.00^{ab}
P	< 0.05	ns	< 0.05	< 0.05	0.1041

[1] PTF, Precooked Taro Flour; WF, Wheat Flour; NM, Njansang Meal.
Means in the same column with different superscript are significantly ($p<0.05$) different from each other.

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by a corresponding increase in proteins, both of which are similar in energy density; supplying each 4 Kcal per gram of nutrient. The difference in these biscuits therefore is not in the amount of energy they supply but in their nutritional composition such as the amount and quality of their proteins as well as in the quality of their oils. Although the biscuits all have similar oil content, the type of oil differ and likewise their fatty acid composition, as some biscuits have more njansang oil than others. Njansang oil is rich in polyunsaturated fatty acids - PUFA (79%) [13,14], with the most abundant being α-eleostearic acid which represents about 51% of its total fatty acids content followed by linoleic acid (28%) [14]. Thus biscuits with high concentration of njansang had more of these PUFA. With their high content of PUFA, and other antioxidant nutrients such as Vitamin A and E [14] they could enhance nutritional status and promote healthy growth in children [25].

The amino acid profile of njansang cake shows that it is limited in the essential amino acid lysine, but has a good essential amino acid to total amino acid ratio (40.6%) slightly above that for a balanced protein (33%) [13]. This implies that njansang protein is of good nutritional value and can thus be expected to support growth. This has actually been supported by the works of [13], who demonstrated that pigs fed meals containing njansang had growth rates comparable to those fed a control diet, and the carcasses of the animals were of better nutritional quality. From these, it can be expected that cookies with a high proportion of njansang are nutritionally superior to those with lower concentrations and could contribute to improving the nutritional status of growing children who need high amounts of good quality proteins and essential fatty acids [25]. Worthy of note, is the fact that protein contents in the biscuits were improved by over 100% with the incorporation of njansang meal at levels of 35% into composite flours.

Physical characteristics of biscuits

Biscuits were analysed for their physical characteristics; weight, diameter, thickness, density, spread ratio, and the results are presented on Table 5. Diameter and spread ratio of biscuits generally decreased significantly ($p = 0.0001$) with incorporation of njansang meal compared to control (100% wheat flour). On the other hand, thickness, density and volume increased significantly ($p = 0.0001$)

Table 5: Physical characteristics of biscuits.

Blends PTF:WF:NM[1]	Weight (g)	Diameter (cm)	Thickness (cm)	Density (g/cm^3)	Spread Ratio	Volume (cm^3)
0:100:0	3.86 ± 0.01^{a}	3.64 ± 0.01^{e}	0.79 ± 0.01^{b}	0.46 ± 0.01^{b}	4.61 ± 0.06^{c}	8.25± 0.16^{d}
20:80:0	3.91 ± 0.01^{a}	3.49 ± 0.02^{b}	0.80 ± 0.01^{b}	0.50 ± 0.01^{c}	4.36 ± 0.04^{b}	7.68 ± 0.02^{b}
20:75:5	3.97 ± 0.05^{a}	3.56 ± 0.06^{d}	0.79 ± 0.01^{b}	0.42 ± 0.07^{a}	4.51 ± 0.07^{c}	7.92± 0.19^{c}
20:70:10	4.02 ± 0.01^{a}	3.43 ± 0.01^{a}	0.76 ± 0.01^{a}	0.57 ± 0.01^{d}	4.51 ± 0.03^{c}	7.04± 0.02^{a}
20:65:15	4.08± 0.01^{a}	3.51 ± 0.01^{bc}	0.85 ± 0.01^{c}	0.58 ± 0.01^{d}	4.13 ± 0.04^{ab}	8.25± 0.02^{d}
20:60:20	4.07 ± 0.01^{a}	3.63 ± 0.01^{e}	0.85 ± 0.01^{c}	0.46 ± 0.01^{b}	4.27 ± 0.05^{b}	8.80± 0.08^{e}
20:55:25	4.13 ± 0.01^{a}	3.49 ± 0.01^{bc}	0.84 ± 0.01^{c}	0.50 ± 0.01^{c}	4.15 ± 0.02^{ab}	8.12± 0.04^{d}
20:50:30	4.52 ± 0.01^{b}	3.52 ± 0.01^{c}	0.89 ± 0.01^{e}	0.51 ± 0.01^{c}	3.96 ± 0.02^{a}	8.75± 0.04^{e}
20:45:35	4.61 ± 0.01^{b}	3.62 ± 0.01^{e}	0.87 ± 0.01^{d}	0.51 ± 0.01^{c}	4.16 ± 0.02^{ab}	9.01± 0.07^{f}
P	0.000	0.000	0.000	0.000	0.000	0.000

[1] PTF, Precooked Taro Flour; WF, Wheat Flour; NM, Njansang Meal.
Means in the same column with different superscript are significantly ($p<0.05$) different from each other.

Table 6: Sensory Characteristics of Biscuits.

Blends PTF:WF:NM[1]	Taste	Colour	Texture	Acridity	Flavour	General Acceptability
0:100:0	6.78 ± 1.20^{c}	6.62 ± 1.50^{bc}	6.87 ± 1.76^{b}	5.62 ± 1.64^{b}	6.28 ± 1.64^{c}	6.69 ± 1.51^{c}
20:80:0	6.75 ± 1.44^{bc}	6.46 ± 1.38^{abc}	6.83 ± 1.61^{ab}	5.55 ± 1.63^{b}	6.00 ± 1.65^{bc}	6.39 ± 1.33^{bc}
20:75:5	6.08 ± 1.88^{a}	6.40 ± 1.70^{abc}	6.66 ± 1.77^{ab}	5.25 ±1.67^{ab}	5.68 ± 1.88^{abc}	5.91 ± 1.88^{ab}
20:70:10	6.08 ± 1.85^{a}	6.82 ± 1.65^{c}	6.72 ± 1.70^{ab}	5.10 ± 1.69^{ab}	5.50 ± 1.85^{ab}	6.16 ± 1.55^{abc}
20:65:15	5.91 ± 1.85^{a}	6.41 ±1.79^{abc}	6.70 ± 1.61^{ab}	4.89 ± 1.78^{a}	5.26 ± 1.99^{a}	5.91 ± 1.97^{ab}
20:60:20	6.04 ± 1.83^{a}	6.30 ± 1.70^{abc}	6.39 ± 1.89^{ab}	5.10 ± 1.66^{ab}	5.80 ± 1.87^{abc}	6.08 ± 1.49^{ab}
20:55:25	6.14 ± 1.57^{ab}	6.12 ± 1.71^{ab}	6.57 ± 1.59^{ab}	5.26 ± 1.48^{ab}	5.72 ± 1.69^{abc}	6.28 ± 1.24^{abc}
20:50:30	5.98 ± 1.76^{a}	6.37 ± 1.63^{abc}	6.56 ± 1.56^{ab}	5.26 ± 1.47^{ab}	5.80 ± 1.56^{abc}	6.05 ± 1.66^{ab}
20:45:35	5.84 ± 1.91^{a}	5.91 ± 1.90^{a}	6.23 ± 1.68^{a}	5.08 ± 1.59^{a}	5.57 ± 1.99^{ab}	5.71 ±1.79^{a}
P	0.022	0.200	0.570	0.346	0.166	0.067

[1] PTF, Precooked Taro Flour; WF, Wheat Flour; NM, Njansang Meal
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with substitution of wheat flour by njansang meal (Table 5). Yadav et al. [9] reported increases in spread ratio of biscuit when wheat flour was supplemented with plantain and chickpea flour. Biscuit weight however, remained constant with incorporation of up to 25% njansang meal and thereafter increased. Similar observations have been made by Rezzoug et al. [26] of no variation in biscuit weight when wheat flour was substituted with protein flour at levels of up to 20% protein.

These changes in biscuit physical characteristics could be attributed to differences in protein contents of the composite flour as a result of substitution of wheat flour with njansang meal. The quantity and quality of the proteins present in flour have a major role in influencing the rheological behaviour of the dough, and of biscuits, as they influence water absorption capacity of dough. The greater the protein content, the more water it absorbs. Addition of proteins will thus lead to an increase in dough extension, and consequently, the shrinkage of dough after cutting would be considerable [26]. Also, the presence of gluten proteins allows biscuit dough to form a good protein network that entraps air and spreads, but given that njansang meal has no gluten, it reduces the spread of the biscuits during cooking, thus giving thicker biscuits. These explain the decrease in diameter and in spread ratio, as well as the increase in thickness of biscuits with increased njansang concentration.

Sensory analyses of biscuits

Substitution of wheat flour with taro flour had no significant influence on biscuit sensory characteristics (Table 6). This is in accordance with previous observations by [8], that incorporation of precooked taro flour into wheat flour at levels up to 30% produced biscuits of acceptable organoleptic properties; although beyond 10% the acceptability was slightly lower than with wheat biscuits.

In general, incorporation of njansang meal into wheat taro blend did not significantly ($p>0.05$) affect the color, texture, flavor, acridity and overall acceptability of the biscuits (Table 6). On the contrary, the appreciation of the taste of the biscuits was significantly reduced with incorporation of njansang meal, with lowest values recorded at 35% incorporation. The decrease in the appreciation of taste may be attributed to the strong flavor of njansang. The absence of any perceived differences in the acridity of the biscuits is no surprise given that the amount of taro flour, which contributes to acridity, in the composite flour mixtures was identical. Oxalates have been associated with acridity in taro tubers [23].

The overall acceptability of the biscuits was strongly positively correlated to flavour ($r = 0.789$), taste ($r = 0.892$) and acridity ($r = 0.811$), implying that these attributes contributed much to the general acceptability of the biscuits. It is worth noting, that none of the biscuits were disliked, suggesting that these biscuits could actually be consumed especially if consumers are made to understand the added nutritional benefit (increased protein content and quality, polyunsaturated fatty acids) that addition of njansang meal confers on these biscuits. In general, wheat biscuits were most appreciated. Amongst the njansang incorporated biscuits, the 25% was the most appreciated. The least accepted was the 35%, probably due to the strong njansang flavor. Acceptability could thus be improved by reducing the njansang flavor, through addition of flavor compounds.

Contribution of biscuits to RDA of preschool children 3-5 Years Old

This consists in evaluating the contribution of 100 g of biscuits that could be used as daily snacks for preschool children 3 to 5 years old, with a daily energy recommendation of 1200 kcal, and 13 g protein [25]. Considering biscuits with njansang meal incorporated at 25%, as this was the best appreciated organoleptically, 100 g of biscuits supply 398 kcal and 11.22 g protein (Table 5). Therefore, 100 g biscuits would meet respectively 33.2% and 86.4% of daily energy and protein needs for children 3 to 5 years of age. These biscuits could thus be considered adequate as a snack for children in helping to alleviate the problem of protein energy malnutrition.

Conclusion

It emerges from this study that organoleptically acceptable biscuits of good nutritional quality, capable of meeting respectively 86.4% and 33.2% of protein and energy needs of children 3-5 years old can be prepared using a combination of wheat flour, precooked taro flour and njansang meal at levels of 55, 20 and 25% respectively. This would help in the fight against malnutrition and improve utilization of local food crops.

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