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Research Article

Effect of Partial Substitution on Physical, Functional and Chemical Properties of Cookies Made from Mixture of Wheat and Coconut

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Abstract: Background: Since the closure of the wheat development company in Cameroon, all wheat is imported, but over the past year, the wheat prices have steadily increased in most of the countries' markets. The cost of a kilo, monitored by Famine Early Warning Systems Network (FEWS NET), fell from XAF 500 to XAF 600. With the use of composite flour, this will help to reduce the huge amount of money spent and lessen total dependence on imported wheat flour. Aim: The objective of this study was to produce cookies from composite flour made from coconut and wheat, and determine its nutritional properties and acceptability. Material and methods: Coconut flour was produced from fresh coconut using oven drying at standard conditions. The composite flour was formulated using the mixing plan design in Minitab 18.0. The functional properties of the flour and nutritional properties of the cookie samples were determined. Results: Results of functional properties show that the bulk density of CF1, CF2, CF3, CF4, and CF5 was 0.58, 0.50, 0.50, 0.46 and 0.47 g/L respectively; the pH was 6.42, 6.32, 6.37, 6.40, 6.46 respectively; swelling capacity was 49.10%, 44.07%, 42.02%, 46.23%, 47.09% respectively; water absorption capacity was 12%, 9%, 10.3%, 10.4%, 10% respectively; From this, the swelling capacity, water absorption and oil absorption capacity increased significantly with substitution ($p < 0.05$). The result of nutritional properties showed that the moisture was not affected by substitution in contrast to lipid, protein, fiber, carbohydrates, starch, amylose and amylopectin. The moisture, carbohydrate, starch and amylose decreased significantly ($p < 0.05$) with the substitution while ash, fat, protein and fiber increased. Results of the sensory analysis showed that the 85% wheat biscuits (CF3) had the highest scores in all the parameters evaluated and were better accepted than the other samples. Conclusion: These findings indicate that supplementation of cookies with coconut flour will improve the nutritional value of cookies and acceptability.

***Keywords*:** cookies, coconut, composite flour, functional and nutritional properties, wheat

1. Introduction

Coconut (*Cocos nucifera*) is one of the most important plants within the family of palm Araceae because of its many applications (ornamental, and food crops) [1]. Coconut pulp is rich in many nutrients like fats which have application both industrially, and for edible purposes [2]. More than half (around 70%) of the world's global production

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of coconut is directly or indirectly used for local consumption, and the remaining amount is only used in industrial applications [3]. Coconuts are produced in many parts of the world and use depends on the Region. For example, in India, they are consumed raw and used to formulate tender nuts, extract coconut oil, drying and desiccating to produce copra [4-5]. In some African countries like Nigeria, coconut milk is used to make coconut rice. Coconut meat or kernel are very rich source of fiber, fats (long-chain saturated fatty acids), vitamins D, E, and K, and other nutrients. This composition makes it a potential food that can be used to reduce in many Sub-Saharan or developing countries, nutrient deficiencies that are associated with high consumption of cereals foods which contain only carbohydrates (starch). Coconut is rich in nutrients and minerals like potassium, iron, magnesium, phosphorus, copper and zinc. The fresh coconut contains a very complete food: the immature almond. It is a gel rich in water and sugar that is found in nuts 8 to 9 months after fertilization. On 100 grams, there are on average 3.4 grams of protein, 5.9 grams of carbohydrates, 35.1 grams of fat and 9.5 grams of fiber [5]. Coconut oil belongs to the group of saturated oils with 39 to 54% lauric fatty acid [6-7]. The nutritional value of 100 grams of coconut corresponds to 353 kilocalories. The production of this fruit could also facilitate the creation of wealth for coastal populations, as its sale generates several billion dollars a year [8].

Wheat (*Triticum spp*), is a cereal grown throughout the world, particularly in temperate regions. It is the most widely produced, cultivated and consumed cereal in the world, particularly for human consumption. It is used in the formulation of numerous products such as cakes, pasta, macaroni, noodles, and couscous and also for fermentation to make beer, alcohol, vodka or biofuel [9]. Wheat is made up of several parts, including the embryo, tegument and endosperm. The endosperm contains the bulk of wheat's constituents: starch and gluten (the main proteins) [10]. Wheat flour is obtained by milling the grain and is therefore used for human consumption. Gluten content, color, the part of the grain used and the wheat variety enable wheat flours to be classified into different groups thus their use. Thus, this particularity of composition and texture will make one group or another a basic ingredient in the formulation of cakes, breads, doughnuts, cookies, etc.

Over the past year, wheat prices have steadily increased in most markets in the country, closely mirroring the levels reached before and during the Russian-Ukrainian war. The cost of a kilo of wheat flour in the markets monitored by Famine Early Warning Systems Network (FEWS NET) in Douala and Yaoundé fell from XAF 500 in February 2022 to XAF 600 today. Then, the use of composite flour will reduce the huge amount of money spent on importing wheat flour [11]. Mixing wheat flour with flour from local crops, such as coconut will help improve the nutritional value of the resulting baked goods especially an increase in fiber and protein. Therefore, this piece of work exposes the utilization of a mixture of flour (coconut and wheat) for the formulation and production of cookies. Reducing dependence on wheat by substituting it with local products such as coconut flour could reduce wheat dependence, improve the balance of trade of importing countries, and above all, offer an alternative to gluten-intolerant people. Coconut, considered as a healthy food by many organizations and in ever-increasing demand, could be an alternative to wheat imports. It also provides elements with proven functional properties. The present work was therefore initiated with the objective to evaluate the impact of the partial addition of coconut flour on the nutritional and functional properties of cookies made from mixture flours of coconut and wheat.

2. Material and methods

2.1 *Material*

2.1.1 *Area of the study*

This study was carried out in Dschang. Dschang is located in the Northwestern part of Cameroon in the West Region, Menoua division and Dschang sub-division. It's situated on a forested plateau Northwest of Yaounde. Its high elevation is about 1,379 meters. Furthermore, coconut is abundant in this area and the area is easily accessible to obtain the materials necessary for the realization of the project. The abundance of this fruit in this area makes it less expensive, which is one of the reasons this area was chosen for the project.

2.1.2 *Research design*

According to Trochim [12], the type of research design used in this work was the Experimental and Descriptive

Research Design. For the experimental design, quantitative data obtained from experiments (evaluation of different functional and nutritional parameters) carried out on the various samples were collected, analyzed and interpreted. While the descriptive design was used to describe some characteristics of the product (hedonic). The type of descriptive design used was the survey descriptive design which involves collecting data from a sample population through semi-guided questionnaires. It gives information on how the population appreciates the product.

2.1.3 *Purchase of food material*

The coconuts, wheat flour for the baking, milk, sugar, yeast, salt, eggs and margarine (fat) were purchased from traders in the city of Dschang, more precisely at market B and acuminated to the laboratory. They were then processed and used for the production of the cookies.

2.2 *Methods*

2.2.1 *Processing of coconut flour*

The coconut endosperm after the removal of shell and paring, was shredded, grated and oven dried at 50 °C for 24 h in a hot air oven (model QUB 305010G, Gallenkamp, UK), milled using a mill (model MXAC2105, Panasonic, Japan) to obtain coconut flour. The flour obtained was then packaged in a polyethylene bag and stored in the desiccator before use.

2.2.2 *Formulation of composite flour*

A mixing plan was applied to obtain the different proportions of flour. The design was carried out using software from Minitab version 18. From this, different formulations of compound flours have been made. The coconut flour has been incorporated at 7.5%, 0.0%, 15%, 22.5% and 30% into the wheat flour. These are the CF1, CF2, CF3, CF4 and CF5 flours (Table 1).

Table 1. Formulation of composite flour

Formulations	Wheat flour (%)	Coconut flour (%)
CF1	92.5	7.5
CF2	100.0	0.0
CF3	85.0	15.0
CF4	77.5	22.5
CF5	70.0	30.0

CF: composite flour

2.2.3 *Production of cookies*

The cookies were formulated and produced using the modified creaming method described by Okaka [13]. The basic ingredients used were shown in Table 2: mixture flour (1,000 g), fat (500 g), sucrose (450 g), milk (100 g), eggs (10 g) and yeast (10 g). The sugar and eggs were initially creamed in a mixer to produce a creamy mixture before the flour and other dry ingredients were added. The mixture was thoroughly mixed to form a dough. After that, the dough was kneaded, cut and baked at 180 °C for 20 min, cooled, and packed. The different formulated cookies are represented in Figure 1.

Table 2. Formulation of cookies

Formulations	Wheat flour (%)	Coconut flour (%)	Fat (g)	Sugar (g)	eggs	Milk (g)	Yeast (g)
CF1	92.5	7.5	500	450	10	100	10
CF2	100.0	0.0	500	450	10	100	10
CF3	85.0	15.0	500	450	10	100	10
CF4	77.5	22.5	500	450	10	100	10
CF5	70.0	30.0	500	450	10	100	10

CF: composite flour

Figure 1. Cookies from different formulation

2.2.4 *Evaluation of physical and functional properties of composite flours*

2.2.4.1 *Bulk density*

The method described by Okaka et al. [14] was used to evaluate the bulk density. An empty crucible (M_0) of known volume (V) was filled with flour and weighed (M_1). The bulk density (DM) is determined according to the formula 1:

$$DM = \frac{M_1 - M_0}{V} \tag{1}$$

Were M_1: mass flour weighed; M_0: empty crucible mass; V: crucible volume; DM: bulk density.

2.2.4.2 *Measurement of pH of the different mixture*

The standard method described by Association of Official Analytical Chemists (AOAC) [15] allowed us to measure the pH. Indeed, in one (1) g of flour sample weighed into 15 mL centrifuge tubes, 10 mL of distilled water was added. The suspension obtained was stirred using a "Barnstead/Thermolyne" brand vortexer for 30 min and then centrifuged at

4,000 rpm for 5 min with a refrigerated "Heraeus" brand centrifuge. The pH value was recorded in the aqueous phase using a calibrated pH-meter at 25.03 ± 0.22 °C.

2.2.4.3 *Evaluation of the swelling capacity*

The method described by Okezie and Bello [16] allowed us to determine swelling capacity. Indeed, 10% (w/v) flour solution was prepared and placed in a water bath at 90 °C. The mixture was stirred (80 rpm) for 30 minutes then centrifuged at 4,500 rpm for 15 minutes using a "Heraeus" refrigerated centrifuge. The swelling capacity was estimated as being the difference between the mass of the sample having retained the water (M_1) and that of the start (M_0). The swelling capacity is given by the equation 2:

$$\text{Swelling capacicy}(\%) = \frac{\left[(M_1 - M_0) \times 100\right]}{M_1} \tag{2}$$

With: M_1: mass of the pellet or mass after water intake (g); M_0: mass of the test sample (g).

2.2.4.4 *Evaluation of the water retention capacity*

Water Retention Capacity (WRC) was performed using the of Lin et al. [17]. In fact, flour solution at 10% (w/v) was prepared and the mixture was stirred (80 rpm) for 30 minutes then centrifuged at 4,000 rpm for 5 minutes using a "Heraeus" refrigerated centrifuge. The water retention capacity was estimated as being the quantity of water retained by the base after decantation per gram of cake according to the following formula 3:

$$\text{WRC}(\%) = \frac{V_0 - V_1}{M} \times 100 \tag{3}$$

With: M = mass of dry sample (g); V_0 = initial volume of water (mL); V_1 = sedimented volume after centrifugation (mL); WRC = water retention capacity.

2.2.4.5 *Oil retention capacity*

The oil retention capacity of the different mixture flours was performed using the standard method of Lin et al. [17]. To 1 g of flour from each sample, 10 mL of refined olive oil were added. The mixture was stirred vigorously using the vortex for 1 min. and left to stand for 1 hour. After this rest time, the tube containing the sample oil mixture is centrifuged at 4,000 rpm for 5 min. The sedimented oil volume was measured. The oil retention capacity is calculated as the quantity of oil in ml retained by the base after decantation per gram of flour according to the formula 4:

$$\text{ORC} = \frac{V_0 - V_1}{M} \times 100 \tag{4}$$

With: M = mass of dry sample (g); V_0 = initial volume of oil (ml); V_1 = sedimented volume after centrifugation (ml); ORC = oil retention capacity.

2.2.5 *Proximate chemical composition of cookies*

The standard method of AOAC [15] allowed us to evaluate the moisture, carbohydrates, ash, dietary fibre and lipids content of the different cookies. Protein content was evaluated using the same standard method after complete mineralization of azote and the result was estimated using the formula 5:

$$\text{Protein content } (\%) = N \times 6.25 \tag{5}$$

With: N = Azote content (g); 6.25 = Conversion factor.

Caloric energies (Ec) were determined by applying ATWATER coefficients [18]: 1 g of carbohydrates or proteins provides 4 kcal while 1 g of lipid provides 9 kilocalories. The expression of the energy value per 100 g of cookies is given by the following equation 6:

$$\text{Calorific energy (kcal)} = (4 \times (\%\ \text{carbohydrate})) + (9 \times (\%\ \text{lipid})) + (4 \times (\%\ \text{protein})) \quad (6)$$

The total starch, amylose and amylopectin content of the different cookies were evaluated according to the method of Jarvis and Walker [19]. In fact, iodine (I_2) interacts with the hydroxylic surface group of amylose and amylopectin to give a blue and brown color respectively. As a result, these complexes have maximum wavelengths for amylose (λmax = 630 nm) and amylopectin (λmax = 548 nm) which are different. We can therefore use this spectral difference to simultaneously measure total starch, amylose and amylopectin. In this manipulation, it was considered that the absorbance at 580 nm is linked both to amylose and to amylopectin, on the other hand, the absorbance at 720 nm is essentially linked to amylose. Using these measurements, the proportions of total starch and amylose in the samples were calculated.

The amylopectin content was obtained by difference (equation 7):

$$\%\ \text{Amylopectin} = \%\ \text{starch} - \%\ \text{amylose} \quad (7)$$

2.2.6 *Sensory evaluation of cookies*

The classification test is a hedonic test which consists of giving, simultaneously and in random order, the different samples coded by numbers to each taster. This technique makes it possible to objectively describe and measure the organoleptic characteristics of cookies [20]. Each taster received an evaluation sheet base (5-hedonic scale and classification of the product) and a glass of water to rinse their mouth. The tasters were invited to assess the samples on the basis of the assessment elements of the evaluation sheet. The forms duly completed by the tasters were analyzed at the end of the evaluation and the data were organized and then processed [21].

2.2.7 *Statistical analysis*

The experimental data reported as means ± standard deviation was calculated using Excel 2013 software. Mean comparison was done using ANOVA and independent sample t-test using MINITAB 18.1. (IBM STATISTICS Software) software. The significant difference was observed at the level of 5% threshold. The significance of each sample was determined by the Fisher test.

3. Results and discussion

3.1 *Functional properties of the composite flours*

Table 3 presents the overall approximate functional characterization of the different composite flour. A significant difference was observed at the level of 5%.

The bulk density is an important parameter used in food industry to determine the type of material used to manufacture the packaging, and it also predicts the food intake of foods formulated with these flours [22-23]. It comes from Table 3 that the bulk density varies from 0.46 to 0.58 g/mL. These results are in the same range as those of Harijono et al. [24], who found that the bulk density ranges from 0.46 to 0.59 g/mL on blended flour between coconut and wheat flours. It is significantly ($p < 0.05$) affected by the substitution level of coconut flour. This can be explained by the nutrient composition, particularly in terms of protein and lipids with respect to correlations between them [25-26]. In fact, the high protein content of coconuts leads to a high occupancy of the interstitial spaces, resulting in a reduction in porosity and hence an increase in mass density [25-26]. Tambo et al. [25] also reported a positive correlation between protein content and mass density in corn and cassava flours. The values of the bulk density obtained remain nevertheless within the range of the norm (less than 0.60 g/mL) for a good food intake by children from 6 to 59 months making this biscuit a good supplement for children of weaning age.

Table 3. Functional properties of composite flour

Paramters	CF1	CF2	CF3	CF4	CF5
Bulk density (g/mL)	0.58 ± 0.003^{a}	0.50 ± 0.0001^{b}	0.50 ± 0.001^{b}	0.46 ± 0.0001^{d}	0.47 ± 0.01^{c}
pH	6.41 ± 0.01^{b}	6.32 ± 0.01^{d}	6.37 ± 0.01^{c}	6.40 ± 0.0^{b}	6.46 ± 0.03^{a}
Swelling (%)	49.10 ± 3.94^{a}	44.07 ± 0^{d}	42.02 ± 0.12^{e}	46.23 ± 3.55^{c}	47.09 ± 0.39^{b}
WAC (%)	12 ± 0^{a}	9 ± 1.41^{c}	10.3 ± 2.40^{b}	10.4 ± 2.26^{b}	10 ± 2.82^{b}
OAC (%)	57.77 ± 0.23^{a}	55.23 ± 1.67^{b}	55.09 ± 1.19^{b}	51.66 ± 0.32^{d}	53.43 ± 1.13^{c}
WAC/OAC	1.18 ± 0.09^{cc}	1.25 ± 0.03^{b}	1.31 ± 0.02^{a}	1.12 ± 0.007^{d}	1.13 ± 0.03^{d}

Results are expressed as mean ± deviation of triplicate samples. The means standard deviations followed by the same letter in the same line indicate that the differences are not significant ($p > 0.05$)
CF1 = 92.5% wheat flour + 7.5% coconut flour, CF2 = 100% wheat flour + 0% coconut flour, CF3 = 85% wheat flour + 15% coconut flour, CF4 = 77.5% wheat flour + 22.5% coconut flour, CF5 = 70% wheat flour + 30% coconut flour, WRC = water retention or absorption capacity, ORC = oil retention or absorption capacity

The pH is another parameter used in food industry to evaluate the acceptability of food products and characterize the flour samples [26]. Low pH values generally reflect sour taste in the food product which is not really appreciated by consumers [27]. It comes from Table 3 that all the pH values were ranged between 6 and 6.50. CF5 records the highest value while CF2 records the least value. These values were in agreement with those obtained by Mingle et al. [23], who reported pH values varying between 6.0 and 6.8 with blended flour of wheat and aerial yam flours. The lowest pH recorded in CF2 formulation can be explained by the fact that during the processing of wheat flour, there is the formation of acidic substances as a result of chemical actions and biological fermentation that result in the decrease in pH observed. Furthermore, its cultivation of acid soil and its high mineral content, such as phosphorus, increases its acidity. The coconut flour also has a basic pH (8), which reduces the acidity of wheat flour. Tambo et al. [25] also found values similar to those in this study and further demonstrated that such values facilitated food intake and digestion. This makes these cookies very digestible food.

The swelling capacity represents the degree of water absorption of starch granules [25-26, 28-29]. The swelling rate ranged from 42.02 to 49.10%. Sample CF1 recorded the highest value (49.10%) while CF3 recorded the least value (42.02%). The improvement in this parameter with substitution is linked to the fact that the proteins and starches present in wheat are in crystalline form and therefore bind less water and swell less. Furthermore, the richness of simple sugars such as glucose and fructose in coconut flour would help to improve this capacity, as demonstrated by the work of Tambo et al. [25-26] who found a positive correlation between reducing sugars and this parameter. High swelling capacity has been reported as part of the criteria of a good product [30]. The results of this study indicated that all the samples were of good quality because of their swelling rate above the average [31].

Water retention capacity refers to the capacity of flour or its ingredients (proteins and glucids) to retain water and it can also apply to evaluate the level of incorporation or substitution of cereal meal by protein rich flour [28, 32]. The result of the water retention capacity of all the samples ranged from 9.00 to 12%. Sample CF1 recorded the highest water retention capacity while sample CF2 had the least value. The improvement in water retention with substitution is explained by the presence of hydrophilic amino acids on the surface of globular proteins. Indeed, these amino acids can form numerous interactions (ionic and hydrogen) with water molecules. Tambo et al. [26] revealed that flour with high water retention capacity implies that its starch or proteins are not in crystalline form and can therefore be easily digestible. The water retention capacity also represents the ability of a product to associate with water under conditions where water is limited, in order to improve its handling characteristics and dough making potentials [28-29, 33]. Therefore, the supplementation of wheat flour with coconut flour will improve the reconstitution of flour for product processing.

The ability of material to be bound to oil and retain it is characterized by oil retention capacity (ORC) [34]. ORC is affected by the chemical characteristics of the flour notably the presence of protein and glucids [35]. The oil absorption in this work ranged from 51.66 to 57.09. Sample CF1 had the highest value. This value is slightly lower than the one observed by Muhammad et al. [35] which is 72.5%. Sample CF4 recorded the least value in the oil absorption capacity and this could be due to the saturation of lipid-binding sites on the surface of hydrophobic amino acids [35]. The oil retention capacity (ORC) of cookie flour is important as it improves the mouth feel and the ability of products to retain flavor [36].

The ability of proteins and carbohydrates to fix water and oil molecules in water/oil interfaces or emulsions is assessed by the hydrophilic/lipophilic ratio (WRC/ORC) [37]. It is an indicator that shows the balance between water and lipid binding by the flour and then reveals its hydrophilic/lipophilic index. It is highly preferable that a perfect balance (1) is achieved between WRC and ORC, particularly in the formulation of complex foods such as doughnuts, cakes and porridges, which are both compact solids, emulsions and air-retaining foams. The ratio of lipophilic to hydrophilic varies from 1.25 to 1.12. The CF2 records the highest value while CF4 recorded the lowest value. The molecular arrangement of amino acids within gluten and the protein's ability to reduce interfacial tensions in a heterogeneous mixture are thought to be responsible for this property. No significant differences ($p < 0.05$) were noted for this study between the different samples regardless of the substitution level of coconut flour. It should be noted that all flours had a hydrophilic/lipophilic ratio lower than 1.5 indicating a lower ability to fix water than oil and thus explained their smell. Dongmo et al. [34] also found values similar to those in this study.

3.2 *Nutritional characterization*

Table 4 below shows the chemical characterization of cookies.

It comes from this table that the moisture, which is an important parameter used to predict the stability and shelf life of a food product [38], ranged from 3.84 to 3.95% with sample CF1 having the highest values while CF5 had the least moisture content. This result is different from those observed by Nasir et al. [39] who founded that the water content ranged from 9.20 to 9.60%. The moisture content of sample decreased significantly ($p < 0.05$) with increasing levels of coconut flour. This reduced moisture could be as a result of an increase in the fiber and protein content with an increase in the level of substitution from the results, as they both have the ability to bind water and make it unavailable. This is also explained by the fact that coconut flour is better dried than wheat flour. This may be an advantage as reduced moisture may increase the shelf life of the products by reducing water activity and discouraging microbial activities [39]. Madukwe et al. [40] also revealed that moisture is a very important parameter in keeping the quality of cookies and the high value of this parameter has an adverse effect on storage stability and shelf life.

The lipid content ranges from 30.68 to 15.54%. CF5 recorded the highest value while CF2 records the lowest value. This parameter significantly ($p < 0.05$) increases with the rate of coconut flour and can be explained by the richness of coconut flour in lipids [41]. Daniela [42] also reported in their studies that the lipids content of cookies made from composite rice and coconut flour increased with the level of coconut flour added. In the same vein, Yelegama et al. [43] explained that fat which is attached to the fibers remains with cell wall components resulting in high fat content in coconut flour. This result was higher than those reported by Jayasundara et al. [44] which ranged from 20.82 to 24.90%. Sujirtha and Mahendran [45] reported that the lipid content in the biscuit produced with the coconut flour and wheat flour ranges from 16.80 to 24.50%. The values obtained with formulated cookies would contribute more than 90% to the recommended daily needs for children from 6 to 59 months which makes them a cheaper food source for the reduction of child malnutrition. In addition, the contribution percentages are higher than those of Dongmo et al. [34] thus demonstrating the need for the sixth body of cereals.

Proteins are biological macromolecules made up of an association of at least a hundred amino acids linked by peptide bonds, whose metabolism provides the body with 4 kcal. The protein content ranges from 17.05 to 27.12%. The protein content of the four composite samples (CF1, CF3, CF4 and CF5) increased significantly ($p < 0.05$) with increasing levesl of coconut flour which are 18.37%; 18.79%; 19.27%; 27.12% respectively. These observations comply with the level of proteins in coconut. These results are higher than those observed by claims of Makinde [46] who found that the protein increased from 4.98 to 11.96% with the increase in the percentage of coconut flour. According to Bressani et al. [47], partial substitution of wheat with coconut will correct limitations on some essential amino acids such as such as lysine. However, from this research, partial substitution with coconut flour may help to improve the protein content in biscuits prepared from this combination. The consumption of 100 g of these formulated cookies (CF1, CF3, CF4 and CF5) would cover more than 95% of the daily requests of children between 24 to 59 months.

Table 4. Chemical characterization of cookies

Parameters	CF1	CF2	CF3	CF4	CF5
Moisture (%)	3.91 ± 0.00[a]	3.95 ± 0.06[a]	3.93 ± 0.15[a]	3.87 ± 0.06[a]	3.84 ± 0.09[a]
Lipid (%)	18.9 ± 0.7[d]	15.54 ± 0.04[e]	26.79 ± 0.1[c]	27.25 ± 0.4[b]	30.68 ± 0.09[a]
Ash (%)	1.11 ± 0.02[d]	1.02 ± 0.02[e]	1.58 ± 0.03[c]	2.02 ± 0.03[b]	2.09 ± 0.01[a]
Carbohydrates (%)	57.70 ± 0.01[b]	62.45 ± 0.07[a]	48.91 ± 0.2[c]	47.59 ± 0[d]	36.27 ± 0.13[e]
Protein (%)	18.37 ± 0.01[d]	17.05 ± 0.01[e]	18.79 ± 0.02[c]	19.27 ± 0.04[b]	27.12 ± 0.02[a]
Fiber (%)	3.28 ± 0.01	2.59 ± 0.01[e]	3.43 ± 0.01[c]	3.62 ± 0.04[b]	4.61 ± 0.01[a]
Energy (kcal/100 g)	474.38 ± 0[c]	457.86 ± 0.34[d]	511.71 ± 0.71[b]	512.71 ± 0.14[b]	529.66 ± 0.42[a]
Starch (%)	20.22 ± 3.19[a]	16.53 ± 1.5[b]	17.22 ± 1.5[c]	13.7 ± 3.3[d]	8.16 ± 1.5[e]
Amylose (% starch)	9.46 ± 2.06[b]	11.18 ± 1.3[a]	7.55 ± 0.64[d]	9.3 ± 1.8[c]	9.09 ± 3.5[c]
Amylopectin (% starch)	90.54 ± 2.06[d]	88.82 ± 1.3[c]	92.45 ± 0.64[a]	90.69 ± 1.8[c]	90.90 ± 3.5[b]

Values are expressed as means ± SD of triplicate determinations. Means with different superscripts in the same row are significantly different ($p < 0.05$). CF1 = 92.5% wheat flour + 7.5% coconut flour, CF2 = 100% wheat flour + 0% coconut flour, CF3 = 85% wheat flour + 15% coconut flour, CF4 = 77.5% wheat flour + 22.5% coconut flour, CF5 = 70% wheat flour + 30% coconut flour

The fiber content ranges between 2.59 to 4.61%. CF5 recorded the highest value while CF2 recorded the lowest value. The higher fiber content caused by the increase in the proportion of coconut flour in the cookies was so as coconut flour has higher fibre content when compared to wheat flour [31, 48]. Increased fibre content indicates that consumers of such products may have a better digestibility of the products. The values obtained are greater than those of Tambo et al. [25-26] which was between 1 to 3% in dehulled and non-dehulled maize flours thus confirmed the richness of coconut flours and the different cookies in fibre. These results also suggest that these cookies could be recommended for obese people.

The carbohydrate content of the sample reduced from 62.45% to 36.27%, with an increase in the level of coconut flour. Sample CF2 had the highest value while CF5 had the least value. A similar result was observed by Sujirtha and Mahendran [45] who found that the carbohydrate content ranged from 65.7 to 44.7% with an increase in the rate of the coconut flour. Tambo et al. [25-26] reported a negative correlation between carbohydrate and protein content in cassava and maize flours. The high carbohydrate content of the products indicates that consuming these products will provide an adequate supply of energy required for the day to day activities, especially for healthy brain function.

The ash content of the sample ranged from 1.02% to 2.09%. The Ash content is indicative of the amount of minerals in any food sample [36] and a high content indicates a high mineral content. Increased ash with substitution percentage signifies that coconut contains higher mineral content, especially calcium, magnesium and potassium [48]. The values obtained in this study were similar to those observed by Marikkar et al. [49] which is 1 to 2.4%. The values obtained are within the range (less than 5%) of the norm and thus made cookies obtained products that can be used in the fight against hidden hunger.

The usable energy value of a food depends on its protein, fat and carbohydrate composition [29]. The energy content of the cookie samples varies from 457.86 to 529.66 kcal/100 g. The metabolizable energy increases with the addition of coconut flour to wheat cookies. The highest energy content (529.66 kcal/100 g) was observed in CF5 and is higher than in 100% wheat sample (457.86 kcal/100 g). The high metabolizable energy values obtained with the composite samples can be due to high level of lipids content, since a gram of fat provides 9 kcal of energy compared to carbohydrates and proteins that provide 4 kcal/g. Tambo et al. [25] obtained similar results with CF2 but they were less than those of composite samples of this study. Additionally, the consumption of 100 g of these composite cookies would cover up to 70% of the daily energy needs of children aged 24 to 59 months.

Starch, amylose and amylopectin are the main carbohydrate components that influence the applicability and functional properties of flour [25-26, 28-29]. In this study the Starch contents ranged from 20.22 to 8.16%, amylose contents from 11.18 to 7.55% and the amylopectine content from 92.45 to 88.82% which are lower than those observed by Aldana and Quintero [50] who founded that the amylose and amylopectine ranged from 16 and 20% and 80-84% respectively. This shows that they are influenced by the level of coconut flour incorporation into the wheat flour. The level of incorporation of coconut flour significantly ($p < 0.05$) lower the starch and amylose contents as opposed to the amylopectin content. The decrease in amylose content might have been due to more destruction of α-1.4 glycosidic bonds during baking [51]. The heat treatment breaks down carbohydrate macromolecules (starch, amylose and amylopectin) into simple molecules such as glucose.

3.3 *Sensory evaluation of the cookies*

Sixty (60) semi-trained panelists evaluated the cookies for their overall consumer acceptability using questionnaires. The panelists were selected on the basis of their familiarity and regular consumption of the product and the cookies were coded randomly. The results are in Table 5.

Table 5. Sensory evaluation results

attributes	CF1	CF2	CF3	CF4	CF5
Texture	3.25 ± 0.85^{c}	3.49 ± 1.03^{bc}	3.95 ± 1.10^{a}	3.79 ± 1.08^{ab}	3.48 ± 1.06^{bc}
Appearance	3.46 ± 0.99^{a}	3.44 ± 1.01^{a}	3.70 ± 1.09^{a}	3.51 ± 1.06^{a}	3.49 ± 0.96^{a}
Taste	3.75 ± 0.87^{ab}	3.38 ± 1.08^{c}	4.03 ± 0.98^{a}	3.95 ± 0.97^{ab}	3.66 ± 1.05^{bc}
Smell	3.49 ± 0.98^{b}	3.51 ± 0.81^{b}	3.89 ± 0.97^{a}	3.61 ± 0.99^{ab}	3.57 ± 0.98^{ab}
Acceptability	3.54 ± 0.94^{b}	3.41 ± 0.90^{b}	3.89 ± 0.90^{a}	3.69 ± 0.94^{ab}	3.61 ± 0.88^{ab}
Position rank	2.69 ± 1.23^{bc} 4th	2.46 ± 1.34^{c} 5th	3.84 ± 1.37^{a} 1st	3.10 ± 1.30^{b} 2nd	2.87 ± 1.49^{bc} 3rd
Classification	Taste > texture > appearance > smell				

Values are expressed as means ± SD of triplicate determinations. Means with different superscripts in the same row are significantly different ($p < 0.05$). CF1 = 92.5% wheat flour + 7.5% coconut flour, CF2 = 100% wheat flour + 0% coconut flour, CF3 = 85% wheat flour + 15% coconut flour, CF4 = 77.5% wheat flour + 22.5% coconut flour, CF5 = 70% wheat flour + 30% coconut flour

The results presented in Table 5 show the sensory evaluation scores of cookie samples at different levels of substitution of coconut flour. The increasing level of coconut significantly ($p < 0.05$) and negatively influenced each sensory parameter. According to the results presented, substitution with coconut flour at 15% level was graded as "Excellent", at 22.5% coconut flour level, biscuits were rated as "very good", at 30% substitution level, the cookies were graded as "good" and at 7.5%, cookies were average. Thus, these results show that 15% to 25% substitution is possible to produce cookies with acceptable sensory qualities. Gunathilake et al. [41] observed different results for those of this study when incorporating coconut into wheat flour noodles. The crust texture of cookies is related to the external appearance of the cookies top which is smoothed or rough. The cookies texture analysis showed that the increasing level of coconuts in the mixture flour significantly ($p < 0.05$) affected the parameter. In the same vein, we observed the decreasing trend in the quality score when the level of coconut flour increased. The decreasing trend for texture of the cookies may be due to the proteins and fibers present in coconut flour. These two nutrients affect the smoothie of the product. The score for taste decreased from 4.03 to 3.38 on increasing the level of substitution of coconut flour. The significant ($p < 0.05$) increasing trend of taste compared to 100% wheat flour cookies may be due to the own taste of coconut flour which dominated when used in high amounts [52]. The control cookies made with 100% wheat flour and 0% coconut flour (CF2) have the lowest mean score of 3.38 for taste whereas 15% coconut flour added cookies (CF3) has the highest score of 4.03. Smell of cookies increased from 3.49 to 3.89 with increasing level substitution of the coconut flour. Quality score of the cookies revealed that smell of biscuits varied significantly ($p < 0.05$) among the substitution level of coconut flour. The results indicated that the cookies prepared from CF3 significantly ($p < 0.05$) got the highest score for flavor. Overall acceptability includes many implications, which is an important parameter in sensory estimation. There was a significant ($p < 0.05$) difference between control (CF2) and 15% coconut flour added biscuits (CF3). The cookies made with 15% coconut flour added cookies (CF3) have the highest mean value for overall acceptability while the control biscuits (CF2) have the lowest score.

4. Conclusion

The present study aimed to evaluate the impact of the partial substitution of wheat flour by coconut flour on nutritional, functional and sensorial acceptability of cookies. The results showed that increasing substitution by coconut flour increased nutritional properties (protein, ash, fat, fiber and energy contents) of the cookies produced. Results from functional properties of the flour also showed that supplementation of wheat flour with coconut flour, produced flour that has a good bulk density, increased water and oil absorption and good swelling capacity. The partial substitution of coconut flour at different levels slightly altered the organoleptic properties of cookies in terms of taste, although it was acceptable up to the 30% substitution level. However, cookie samples produced from 15% coconut flour were graded as the best in organoleptic quality. It is therefore concluded that adding up to 30% coconut flour is advantageous as it increases the nutritional quality of the biscuit in terms of protein, fat, ash and fiber without adversely affecting the functional, and sensory properties of the cookies.

5. Significance of the study

To the population: This study will go a long way to create self-employment to the population who can grow coconut, produce flour and sell to generate income and also due to the fact that it is rich in fiber, protein, and calorific metabolizable energy.

Society: The production of cookies with a certain amount of coconut flour led to the innovation of new products by utilizing the entire or by-products from coconut. Nowadays, people are aware about the consumption of healthier food in their daily life. The innovative idea was then in coherent with consumers' demand for a healthier choice of food product in the society.

Diabetics: Cookies rich in fiber are especially important because they help intestinal mobility, reduce intestinal cancer risk, and additionally reduce the glycemic load fieviting the circulating glucose peaks which are risky for diabetes mellitus patients.

Authors' contributions

TTS, SKM and CN designed the study. TTS, SKM, DSBD, PTF and SVG carried out the experimental work. TTS, SKM and CN wrote the paper, and did the data entry. All authors participated in the interpretation, read and approved the final manuscript.

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Data availability

The data used to support this study are provided within the article.

Conflicts of interest

The authors declare no conflict of interest.

References

[1] Fife BF, Uwubanmwen IO, Nwawe CN, Okene RA, Dada M, Eseigbe E. Harnessing the potentials of the coconut palm in the-Nigerian economy. *Journal of Agricultural Sciences*. 2011; 7(6): 684-691.

[2] Yalegama LLWC, Chavan JK. Studies on utilization of coconut flour as asource of cell wall polysaccharides. *Tropical Agriculture and Research*. 2006; 18: 126-134.

[3] Peiris TSG, Peiris TUS, Rajapaksha S. Prediction of annual national coconut production: a statistical approach. *Sri Lankan Journal of Applied Statistics*. 2000; 1(1): 25-31.

[4] Dhankhar P. A study on development of coconut based gluten free cookies. *International Journal of Engineering Science Invention*. 2013; 2(12): 10-19.

[5] Hareya F, Guarino L, Sharrock S, Bhagmal HT, Iwanaga M. Diversity for food security: improving human nutrition through better evaluation, management, and use of plant genetic resources. *Food and Nutrition Bulletin*. 2000; 21(4): 497-502.

[6] Hall RA, Becerril EA. *The Coconut Mite Eriophyes Guerreronis with Special Reference to the Problem in Mexico*. Farnham: British Crop Protection Council; 1981. p.113-120.

[7] Moore D. Bract arrangement in the coconut fruit in relation to attack by the coconut mite Eriophyes guerreronis Keifer. *Tropical Agriculture*. 1986; 63: 285-288.

[8] Danyo G. Review of scientific research into the cape saint paul wilt disease (CSPWD) of coconut in Ghana. *African Journal of Agricultural Research*. 2011; 6(19): 4567-4578.

[9] Abulude FO. Distribution of selected minerals in some nigerian white bread. *Nigerian Food Journal*. 2005; 23: 139-147.

[10] Ang Z. Effect of wheat flour with different quality in the process of making flour products. *International Journal of Metrology and Quality Engineering*. 2020; 11(6): 1-6.

[11] INS. *Enquête Annuelle dans les Entreprises, Rapport 2017 [CAMEROON-Annual Business Survey, 2017 Report]*. National Institute of Statistics; 2017.

[12] Trochim WM. *Research Methods: The Concise Knowledge Base*. Cincinnati: Atomic Dog Publishing; 2005.

[13] Okaka JC. *Cereals and Legumes: Storage and Processing Technology*. Enugu, Nigeria: Data and microsystem publishers; 1997. p.11-124.

[14] Okaka J, Okorie P, Ozo O. Quality evaluation of sun dried yam chips. *Tropical Sciences*. 1991; 31: 265-275.

[15] AOAC. *Official Methods of Analysis* (15th edition). Washington DC, USA: Association of Official Analytical Chemists; 1990. p.808-835.

[16] Okezie O, Bello A. Physicochemical and functional properties of winged beans flour and isolate compared with soy isolate. *Journal of Food Science*. 1988; 53(2): 450-454.

[17] Lin MJY, Humbert ES, Sosulski FW. Certain functional properties of sunflower meal products. *Journal of Food Science*. 1974; 39: 368-370.

[18] Atwater W, Benedict F. *Experiments on the Metabolism of Matter and Energy in the Human Body*. Bulletin (United States. Office of Experiment Stations), no. 69. Washington, DC: U.S. Government Publishing Office; 1899. p.112.

[19] Jarvis C, Walker J. Simultaneous, rapid, spectrophotometric determination of total starch, amylose and amylopectin. *Journal of the Science of Food and Agriculture*. 1993; 63(9): 53-57.

[20] Sènan VE, Alidou C, Aboudou K, Soumanou MM. Formulation de biscuits à base de farine de blé enrichie à la farine de patate douce à chair orange [Formulation of biscuits based on wheat flour enriched with orange-fleshed sweet potato flour]. *Afrique Science*. 2017; 13(6): 405-416.

[21] Kalaki KP, Mutinsumu MPC, Ndungi NA, Metena MM, Umba MJ. Contribution à la valorisation alimentaire des feuilles de Moringa oleifera par les biscuits à base des ingrédients locaux à Kikwit/RD Congo [Contribution to the food valorization of Moringa oleifera leaves through biscuits made from local ingredients in Kikwit/DR Congo]. *Journal of Animal & Plant Sciences*. 2022; 51(2): 9241-9253.

[22] Odadeji JO, Oyeleke WA. Comparative studies on functional properties of whole and dehulled cowpea seed flour (Vigna unguiculata). *Pakistan Journal of Nutrition*. 2011; 10(9): 899-902.

[23] Mingle E, Sanful RE, Engmann NF. Sensory and physicochemical properties of bread made from aerial yam

(Dioscorea bulbifera) and wheat (Triticum aestivum) flour. *International Journal of Innovative Food Science and Technology*. 2017; 1: 29-35.

[24] Harijono H, Teti E, Saputri DS, Kusnadi J. Effect of blanching on properties of water yam (dioscorea alata) flour. *Advance Journal of Food Science and Technology*. 2013; 5(10): 1342-1350.

[25] Tambo TS, Klang JM, Ndomou HSC, Teboukeu BG, Womeni HM. Characterisation of corn, cassava and commercial flours: use of amylases rich flours of germinated corn and sweet potato in the reduction of the consistency of the gruels made from these flours-influence on the nutritional and energy value. *Food Science and Nutrition*. 2019; 7(4): 1190-1206.

[26] Tambo TS, Klang JM, Ndomou HSC, Kohole FHA, Womeni HM. Application of amylase rich flours of corn and sweet potato to the reduction of consistency of cassava and corn gruels. *Journal of Food Processing and Preservation*. 2019; 43(9): e14058.

[27] Apea-Bah FB, Oduro I, Ellis WO, Safo-Kantanka O. Factor analysis and age harvest effect on the quality of flour from four cassava varieties. *World Journal of Dairy & Food Sciences*. 2011; 6(1): 43-54.

[28] Klang JM, Tambo TS, Doungmo FA, Tsopbeng TAB, Womeni HM. Application of germinated corn flour on the reduction of flow velocities of the gruels made from corn, soybean, moringa oleifera leaf powder and cassava. *Journal of Food Processing and Technology*. 2019; 10(7): 800.

[29] Klang JM, Tambo TS, Nguemguo KLG, Teboukeu BG, Ndomou HSC, Kohole FHA, et al. Effect of bleaching and variety on the physico-chemical, functional and rheological properties of three new Irish potatoes (Cipira, Pamela and Dosa) flours grown in the locality of Dschang (West region of Cameroon). *Heliyon*. 2019; 5(12): e02982.

[30] Achiniewhu SC, Baiben IJ, Ijeoma JO. Physio-chemicalproperties and certification of selected cassava cultivators in River State. *Plant Food for Human Nutrition*. 1998; 52: 133-140.

[31] Obaroakpo JU, Iwanegbe I, Ojokoh A. The functional and sensory evaluation of biscuits produced from wheat, defatted soybean and coconut flour. *Current Journal of Applied Science and Technology*. 2017; 23(6): 30836.

[32] Singh U. Functional properties of grain legume flours. *Journal of Food Science and Technology*. 2001; 38(3): 191-199.

[33] Iwe MO, Onadipe OO. Effect of extruded full fat soy flour into sweet potato. Flour on functional properties of the mixture. *Journal of Sustainable Agriculture and Environment*. 2001; 2(1): 109-117.

[34] Dongmo H, Tambo TS, Teboukeu BG, Mboukap NA, Fotso SB, Djuidje TMC, et al. Effect of process and variety on physico-chemical and rheological properties of two new corn flour varieties (Atp and Kassaï). *Journal of Agriculture and Food Research*. 2020; 2: 10075.

[35] Muhammad AS, Haq N, Misbah N, Hafiz BA, Mazhar H, Muhammad AC. Functional properties of maize flour and its blends with wheat flour: optimization of preparation conditions by response surface methodology. *Pakistan Journal of Botany*. 2013; 45(6): 2027-2035.

[36] Igbabul B, Num G, Amove J. Quality evaluation of composite bread produced from wheat, maize and orange fleshed sweet potato flours. *American Journal of Food Science and Technology*. 2014; 2(4): 109-115.

[37] Zhen M, Boye JI, Simpson BK, Prasher SO, Monpetit D, Malcolmson L. Thermal processing effects on the functional properties and microstructure of lentil, chickpea, and pea flours. *Food Research International*. 2011; 44: 2534-2544.

[38] Ndangui CB. *Production and characterization of sweet potato flour (Ipomoea batatas Lam): Optimization of bread-making technology*. PhD Thesis. University of Lorraine, France; 2015.

[39] Nasir S, Allai FM, Gani M, Ganaie S, Gul K, Jabeen A, et al. Physical, textural, rheological, and sensory characteristics ofamaranth-based wheat flour bread. *International Journal of Food Science*. 2020; 2020: 8874872.

[40] Madukwe EU, Eme PE, Okpara CE. Nutrient content and microbial quality of soymilk-carrot powder blend. *Pakistan Journal of Nutrition*. 2013; 12(2): 158-161.

[41] Gunathilake KDPP, Yalegama C, Kumara AAN. Use of coconut flour as a source of protein and dietary fibre in wheat bread. *Asian Journal of Food and Agro-Industry*. 2009; 2(3): 386-395.

[42] Daniela S. Researches regarding the influence of coconut flour addition on the nutritional value of gluten-free cookies. *Journal of Agro-Alimentary Processes and Technologies*. 2016; 22(4): 292-300.

[43] Yelegama C, Gunathilake KD, Kumara AA. Use of coconut flour as a source of protein and dietary fiber in wheat bread. *Asian Journal of Food and Agro-Industry*. 2013; 2: 382-391.

[44] Jayasundara S, Wagner-Riddle C, Parkin G, Bertoldi PV, Warland J, Kay B, et al. Minimizing nitrogen losses from a corn-soybean-winter wheat rotation with best management practices. *Nutrient Cycling in Agroecosystems*. 2007; 79(2): 141-159.

[45] Sujirtha N, Mahendran T. Use of defatted coconut flour as a source of protein and dietary fibre in wheat biscuits.

International Journal of Innovative Research in Science, Engineering and Technology. 2015; 4(8): 7344-7352.
[46] Makinde FM, Eyitayo AO. The evaluation of nutritional composition and functional and pasting properties of wheat flour-coconut flour blends. *Croatian Journal of Food Science and Technology*. 2019; 11: 21.
[47] Bressani R, Wilson DL, Behar M, Scrimshaw NS. Supplementation of cereal protein with amino acids, 111. Effect of amino acid supplementation of wheat flour. *Journal of Nutrition, American Society of Nutrition*. 1960; 70(2): 176-186.
[48] Trinidad TP, Valdez DH, Mallillin AC, Askali FC, Maglaya AS, Chua MT, et al. Coconut flour from residue: A good source of dietary fibre. *Indian Coconut Journal*. 2001; 33(6): 9-13.
[49] Marikkar JMN, Jayasundara JMMA, Rupanjali APD, Fernandopulle MND. Effect of different levels of fortification of wheat flour with defatted coconut flour on the quality of fibre-enriched biscuits. *Cord*. 2007; 23(2): 16-27.
[50] Aldana AS, Quintero AF. Physicochemical characterization of two cassava (Manihot esculenta Crantz) starches and flours. *Revista Scientia Agroalimentaria [Science Agrifood Magazine]*. 2013; 1: 19-25.
[51] Ndjang MMN, Klang JM, Njapndounke B, Foko MEK, Dongmo JR, Kamdem MHK, et al. Optimization of the processing conditions for the production of a gluten-free bread from sour cassava starch (manihot esculenta) and some legumes (arachis hypogaea, vigna unguiculata, and glycine max). *Foods*. 2023; 12(17): 3180.
[52] Hossain S, Rezaul MIS, Saifullah M, Kayshar SM, Tonmoy SW, Rahman A, et al. Incorporation of coconut flour in plain cake and investigation of the effect of sugar and baking powder on its baking quality. *International Journal of Nutrition and Food Sciences*. 2016; 5(1): 31-38.