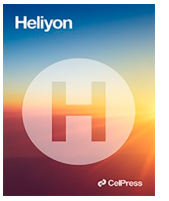
Heliyon 9 (2023) e15941

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon



Research article

Formulation of fiber enriched crackers biscuit: Effect on nutritional composition, physical and sensory properties

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ARTICLE INFO

Keywords:
Food science
Food enrichment
Food formulation
Sensory analysis

ABSTRACT

Refined wheat flour commonly used in making crackers biscuits is rich in starch but low in protein and fibre. This study investigated the effect of adding different levels of lemon basil (LBP) and scent leaf powders (SLP) and cashew kernel flour (CKF) incorporation in crackers biscuits on the nutritional, phytochemical, physical and sensory properties. Seven formulations of crackers biscuits were prepared by mixing LBP and SLP in the ratio of 1.0%, 2.5% and 5.0%, respectively and 20% CKF with wheat flour. The result showed that the ash, crude protein, fat and crude fibre content of the enriched crackers was significantly ($p < 0.05$) higher than the control. Samples containing 5.0% LBP and SLP had the highest calcium, sodium and magnesium and differed significantly ($p < 0.05$) from the control. Increase in the incorporation with LBP and SLP resulted in a significant ($p < 0.05$) increase in the phytochemical content. The incorporation of LBP and SLP had no significant ($p > 0.05$) effect on the height and weight of the crackers. The control crackers scored highest for overall acceptability and this was followed closely by the crackers enriched with 2.5% LBP and 1.0% SLP. Nutritious and acceptable crackers could thus be produced with 1.0% SLP and 2.5% LBP incorporation.

1. Introduction

Cracker biscuits, commonly known as crackers, are a type of baked snack food that is usually thin, crispy, and crunchy. They are made from a mixture of flour, water, and other ingredients, such as salt, yeast, sugar, or butter. Crackers come in a variety of shapes and sizes, and they can be plain or flavored with herbs, spices, or cheese [1]. Cracker biscuit consumption is influenced by factors such as availability, cost, taste preferences, and cultural norms. However, due to their convenience, long shelf life, and versatility, crackers remain a popular snack food around the world [2]. Flour is the primary ingredient in crackers, typically comprising more than 80% of the final product. The type of flour used in crackers can vary depending on the desired texture and flavor profile [3]. Low-protein soft flour, also known as pastry flour, may be used in some recipes to create a softer and more delicate texture. There is a growing demand for convenient and on-the-go snacks, which has contributed to the increasing popularity of crackers [4]. In addition, crackers are a versatile snack that can be enjoyed on their own or used as a base for dips, spreads, and toppings. This has made crackers a popular choice for consumers who are looking for quick and easy meal options or who are seeking healthier snack alternatives. As a result, the global market for crackers and other snack foods is expected to continue growing in the coming years.

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https://doi.org/10.1016/j.heliyon.2023.e15941
Received 19 January 2023; Received in revised form 18 April 2023; Accepted 27 April 2023
Available online 2 May 2023

The family Anacardiaceae include the cashew nut (*Anacardium occidentale* Linn), which is a popular tree nut that is consumed worldwide. Cashews are a good source of several essential minerals, including magnesium, copper, zinc, and phosphorus. These minerals play important roles in many physiological processes, such as bone health, immune function, and energy metabolism [5]. Cashew kernels are a good source of fats, including stearic, oleic, and linoleic acids in a ratio of approximately 1:2:1. These fats are known to have potential health benefits, including the ability to help lower blood serum cholesterol levels [6]. Cashew kernels can be consumed in a variety of forms and are a versatile ingredient in many different types of foods. Cashew kernels can be used to make spreads, such as cashew butter, which can be used as a healthier alternative to traditional peanut butter. Additionally, cashew kernels can be used to make cereal bars, biscuits, and other baked goods, adding a nutty flavor and crunchy texture [7]. Cashew kernels can also be used as a topping for ice cream and other desserts, or ground into a fine powder to make chocolate flour, which can be used as a gluten-free alternative to traditional wheat flour [8].

There is a growing trend towards incorporating dietary fibre into baked products as a way to increase their nutritional value. According to research, eating more veggies is linked to fewer cases of cancer, type 2 diabetes, obesity, cardiovascular disease, and chronic respiratory disorders [9]. Dietary fiber plays an important role in maintaining digestive health, regulating blood sugar levels, and promoting feelings of fullness, which can aid in weight management. The minerals found in vegetables are also essential for many physiological processes, such as bone health, immune function, and nerve and muscle function. By incorporating vegetables into baked products such as crackers biscuits, it is possible to increase their fiber and nutrient content without sacrificing taste or texture.

Sufficient literature demonstrates the application of vegetables as food ingredient to enhance the nutritional composition and functional properties of baked goods. For example, Huq et al. [10] reported that incorporation of okara flour as a dietary fiber source increased the dietary fiber of oil fried donut. Waseem et al. [11] reported that replacing wheat flour with spinach powder (5–7.5%) in chapatti enhanced the micronutrients. El Sheikh et al. [12] also showed that cauliflower addition improved the antioxidant activity and nutritional value of crackers. Other studies reported that the incorporation of *Telfaria occidentalis*, *Amaranthus viridis* and *Solanum macrocarpon* [13], broccoli leaf [14], artichoke, fennel, zucchini and mushroom [15] and debittered moringa oleifera seed flour [16] improved the nutritional values of bread. Lemon basil and scent leaf are both good sources of dietary fiber, vitamins, and minerals, including potassium, magnesium, and folate. Apart from their nutritional benefits, these leaves are known for their medicinal and curative properties and are used as natural treatment for various health problems [17]. However, their use as ingredients for the production of baked products has not yet been fully utilized for their potential benefits. The specific objective of this study was to assess the nutritional, functional and sensorial implications of adding dried lemon basil and scent leaf powders to crackers biscuit. The study hypothesized that adding these vegetables will improve the nutritional and functional attributes of crackers.

2. Materials and methods

2.1. Materials

Cashew (*Anacardium occidentale* L.) kernels (2 kg) were purchased from Kasuwa Koro market, Nasarawa, Lafia, Nigeria. Scent leaf (*Ocimum gratissimum*) and lemon basil (*Ocimum basilicum* L.) leaf were cultivated and harvested in Nigeria. Refined wheat flour, NASCON table salt, Dangote refined sugar, bicarbonate soda, baking powder and King's refined vegetable oil were purchased from Mile 3 market, Diobu, Port Harcourt.

2.2. Processing of undefatted cashew kernel flour

The oil roasting procedure reported by Emelike et al. [7] was used to process cashew nuts into cashew kernels. The roasted cashew kernels were sorted and then milled using a blender (MX-AC300 Panasonic blender model). The cashew kernel was sieved and packaged in an airtight bottle for further analysis.

2.3. Production of scent leaf and lemon basil leaf powder

Fresh leaves were sorted, hand-picked, washed and oven dried (Gallenkamp Model Oven −160) at 60 °C overnight. The dried

Table 1
Formulation of crackers biscuits.

Ingredients	Formulations						
	A	B	C	D	E	F	G
Wheat flour (g)	100	79.00	77.50	75.00	79.00	77.50	75.00
Cashew kernel flour (g)	–	20.00	20.00	20.00	20.00	20.00	20.00
Scent leaf powder (g)	–	1.00	2.50	5.00	–	–	–
Lemon basil leaf powder (g)	–	–	–	–	1.00	2.50	5.00
Baking powder (g)	1.25	1.25	1.25	1.25	1.25	1.25	1.25
Salt (g)	2.14	2.14	2.14	2.14	2.14	2.14	2.14
Sugar (g)	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Oil (ml)	7.14	7.14	7.14	7.14	7.14	7.14	7.14
Water (ml)	57.14	57.14	57.14	57.14	57.14	57.14	57.14

vegetables were ground into powder using an electrical blender (MX-AC 300 Panasonic model) and sieved to obtain fine scent and lemon basil leaf powders.

2.4. Formulation of blends and production of crackers biscuit

The experimental design was planned according to a full factor factorial arrangement in a completely randomized design (CRD) with wheat flour, undefatted cashew kernel flour, dried scent and lemon basil leaf powders. Seven formulations (as shown in Table 1) were made to produce seven coded samples. The formulations were used for the production of the crackers biscuit (as shown in Fig. 1).

2.5. Physicochemical properties and energy evaluation of the crackers biscuits

The AOAC Method 960.52 method [18] was employed to evaluate the crude protein content. Ash content of the crackers was determined by dry ashing method according to AOAC method 14.013 [19]. Moisture was determined using air oven method of AOAC Method 934.01 (AOAC 2000). Total fat was determined using an automated Soxhlet method (FOSS Soxtec Automated System 2050, FOSS, Sweden) according to AOAC Method 963.15 [18]. Total dietary fibre was determined according to AAC Method 32–05.01 [20]. Carbohydrate was derived by subtracting the other components from 100% (moisture, protein, fat, crude fiber, and ash). The Atwater factor method was used to determine the energy content [21]. The method described by AACC Method 10–50.05 [20] was used to determine the physical properties of the crackers biscuits.

2.6. Determination of minerals

Mineral analysis was done by dry ashing according to procedure 14.013 of AOAC [19] Calcium, sodium, and magnesium were determined using an Atomic Absorption spectrophotometer (AAS) (Buck Scientific - 210VGP, USA).

2.7. Phytochemical analysis

Total saponin content was determined using the method of Obdoni and Ochuko [22], tannin content [23], flavonoid content [24], alkaloid content [25] and total phenol content [26].

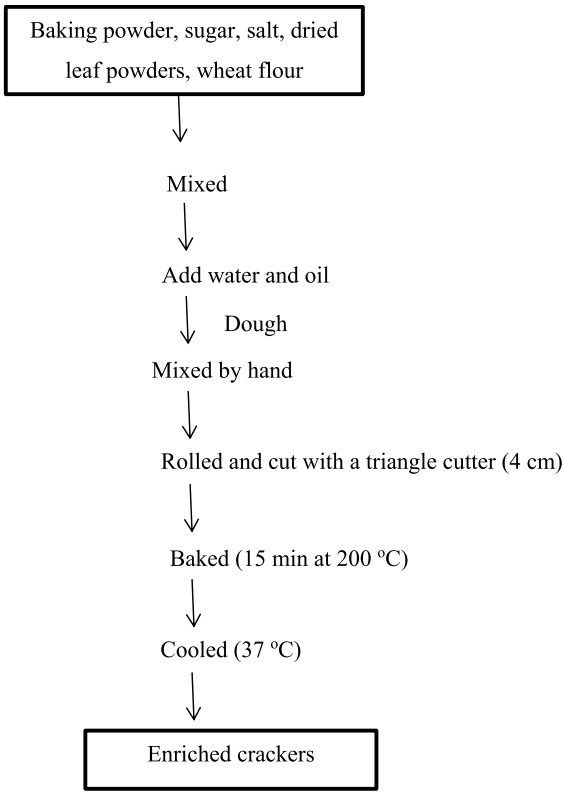

Fig. 1. Flow chart diagram for the production of cracker biscuits.

2.8. Sensory evaluation of the crackers biscuits

Sensory evaluation was carried out in accordance to the International Standardization Organization (ISO) standard 13299 [27] by a trained panel of 20 members. Panelists (6 men and 14 women) ranged in age from 19 to 27 years, were regular consumers of biscuits and had neither food allergies nor intolerances. They were informed about the study aims and provided written consent to perform the sensory analysis, according to the ethical guidelines of the laboratory of Food Science and Technology, Rivers State University, Nigeria. A 9-point structured hedonic scale (1 = disliked and 9 = liked extremely) was used to assess liking and disliking extremes. Color, flavor, taste, texture, crispiness, and general acceptability were among the attributes assessed.

2.9. Statistical analysis

The results were expressed as the mean ± standard deviation (SD). Data obtained from the analysis was subjected to one-way analysis of variances, all means were separated using Duncan Multiple Range Test (DMRT) at 5% probability level ($p > 0.05$) using Minitab Statistical Software (Minitab Inc., State College, PA, USA).

3. Results

3.1. Proximate and energy composition

Table 2 shows the proximate and energy composition of crackers biscuit enriched with cashew kernel flour and dried vegetable powders. Moisture content of the crackers biscuits ranged between 5.04 and 5.50% with the lowest value (5.04%) observed in sample E and the highest moisture content (5.50%) in sample G. Ash content of the samples ranged between 0.82 and 2.09% with the lowest (0.82%) and highest (2.09%) ash content found in samples A and G respectively. Crude protein content of the crackers biscuit ranged between 9.99 and 15.53% with the lowest value (9.99%) found in sample A while sample D which has 5.0% SLP supplementation had the highest crude protein value (15.53%). Fat content of the cracker biscuits ranged between 12.45 and 13.72% with the lowest value (12.28%) found in sample E and the highest value (13.72%) in sample G. The percentage crude fibre value for the samples ranged from 1.30 to 8.65% with sample D having the highest value (8.65%) and sample A had the lowest value (1.30%). The carbohydrate content ranged between 52.10 and 71.49% with sample D having the lowest value (52.10%) and sample A been the highest value (71.49%). The energy value of the samples decreased with increase in the addition of the vegetables and it ranged between 392.02 and 437.93 kcal/g with sample A having the highest (437.93 kcal/g) and sample D had the lowest (392.02 kcal/g). From the result, there was a significant ($p < 0.05$) increase in the moisture, ash, crude protein, fat, and crude fibre content with a corresponding decrease in carbohydrate content of the samples as the supplementation with leafy powders increased and upon incorporation of cashew kernel flour.

3.2. Mineral composition

Table 3 shows the mineral composition of crackers biscuit enriched with cashew kernel flour and dried vegetable powders. Calcium content of the samples ranged between 5.91 and 33.80 mg/100 g with the lowest value (5.91 mg/100 g) found in sample A while the highest in sample D (33.80 mg/100 g). Sodium content of the samples analyzed ranged between 100.53 and 466.38 mg/100 g with the lowest value (100.53 mg/100 g) found in sample B while sample G had the highest (466.38 mg/100 g). Magnesium content of the crackers biscuit samples ranged between 46.01 and 70.98 mg/100 g with sample B having the lowest value (39.01 mg/100 g) while the highest magnesium content was in sample (59.43 mg/100 g). There was a significant ($p < 0.05$) increase in the mineral content of the crackers with an increase in the dried vegetable powders (SLP and LBP) respectively.

3.3. Phytochemical composition

Table 4 shows the phytochemical composition of crackers biscuit enriched with cashew kernel flour and dried vegetable powders. Tannin content of the crackers biscuit ranged between 0.007 and 0.034 mg/100 g with sample A having the lowest value (0.007 mg/100 g) and the highest value (0.034 mg/100 g) was sample G. Alkaloid content of the crackers biscuit samples ranged between 4.950

Table 2
Proximate composition of crackers biscuit.

Samples	Moisture (%)	Ash (%)	Crude protein (%)	Fat (%)	Crude fibre (%)	Carbohydrate (%)	Energy (kcal/g)
A	$5.27^{b} \pm 0.07$	$0.82^{f} \pm 0.04$	9.99 ± 0.62^{e}	12.45 ± 0.07^{de}	1.30 ± 0.14^{c}	71.49 ± 0.64^{a}	437.93 ± 0.52^{a}
B	$5.28^{b} \pm 0.01$	$1.50^{e} \pm 0.01$	10.81 ± 0.00^{d}	12.61 ± 0.09^{d}	2.20 ± 0.28^{c}	67.61 ± 0.18^{b}	427.13 ± 1.56^{b}
C	$5.33^{b} \pm 0.04$	$1.57^{d} \pm 0.04$	12.25 ± 0.00^{c}	12.84 ± 0.03^{c}	6.30 ± 0.57^{ab}	61.72 ± 0.54^{d}	411.44 ± 2.40^{c}
D	$5.43^{a} \pm 0.01$	$1.94^{c} \pm 0.00$	15.53 ± 0.31^{a}	13.50 ± 0.14^{a}	8.65 ± 2.76^{a}	52.10 ± 0.83^{f}	392.02 ± 5.85^{d}
E	$5.04^{d} \pm 0.06$	$1.52^{de} \pm 0.03$	11.69 ± 0.11^{c}	12.28 ± 0.01^{e}	2.20 ± 0.28^{c}	67.27 ± 0.27^{b}	426.36 ± 1.40^{b}
F	$5.13^{c} \pm 0.00$	$2.02^{b} \pm 0.02$	12.07 ± 0.01^{c}	13.16 ± 0.18^{b}	3.60 ± 0.85^{bc}	64.04 ± 0.70^{c}	422.82 ± 4.40^{b}
G	$5.50^{a} \pm 0.04$	$2.09^{a} \pm 0.01$	12.91 ± 0.01^{b}	13.72 ± 0.00^{a}	7.20 ± 1.13^{a}	58.59 ± 1.11^{e}	409.44 ± 4.41^{c}

Mean values are of triplicate determinations. Mean values within a column with different superscripts are significantly different at ($p < 0.05$).

Table 3
Mineral composition (mg/100 g) of crackers biscuit.

Samples	Calcium	Sodium	Magnesium
A	5.91 ± 0.00^{g}	430.26 ± 0.00^{d}	46.01 ± 0.00^{f}
B	20.44 ± 0.00^{e}	100.53 ± 0.04^{g}	39.01 ± 0.00^{g}
C	24.71 ± 0.00^{b}	281.26 ± 0.05^{f}	57.61 ± 0.00^{c}
D	33.80 ± 0.04^{a}	427.28 ± 0.03^{b}	70.98 ± 0.00^{a}
E	9.68 ± 0.00^{f}	371.26 ± 0.00^{c}	49.69 ± 0.01^{e}
F	20.50 ± 0.00^{d}	319.19 ± 0.00^{e}	54.01 ± 0.00^{d}
G	24.21 ± 0.00^{c}	466.38 ± 0.04^{a}	59.43 ± 0.00^{b}

Mean values are of triplicate determinations. Mean values within a column with different superscripts are significantly different at ($p < 0.05$).

and 18.906% with the lowest value found in sample A while the highest (18.906%) in sample D. Flavonoid content of the crackers biscuit ranged between 6.945 and 10.545% with increase in the dried vegetables. The lowest value (6.94%) was recorded in sample A while the highest (10.545%) in sample G. Saponin content of the crackers biscuit ranged between 0.650 and 2.040% with the lowest value (0.650%) recorded in sample A while sample G had the highest (2.040%). Total phenol content of the crackers biscuit samples ranged from 0.948 to 8.746 mg/100 g with sample E recording the lowest value (0.948 mg/100 g) while sample D had the highest (7.95 mg/100 g). There was also a significant ($p < 0.05$) increase in the phytochemical composition of the crackers with an increase in the dried vegetable powders (SLP and LBP) respectively.

3.4. Physical properties

Table 5 shows the physical properties of crackers biscuit enriched with cashew kernel flour and dried vegetable powders. The diameter of the crackers biscuit samples ranged from 3.95 to 4.10 cm with the lowest value (3.95 cm) recorded in sample F and the highest value (4.10 cm) in sample A. There was a decrease in the diameter of the samples upon supplementation with cashew kernel and dried vegetables, however, no significant ($p > 0.05$) difference were observed between the fortified samples. Height of the crackers biscuit samples were not significantly ($p < 0.05$) different from each other while the weight of the crackers biscuits ranged from (3.77–4.83 g) with the lowest values (3.77 g) recorded in sample G and the highest value (4.83 g) for sample D. Although a reduction in the height and weight of the samples was observed upon incorporation with cashew kernel flour and dried vegetables, however height and weight of the fortified and unfortified samples were not significantly ($p > 0.05$) different from each other. The spread ratio of the crackers biscuit ranged from 9.88 to 10.25 with an increase in dried vegetables. The lowest value (9.88) was recorded in sample F while sample A (10.25) had the highest value.

3.5. Sensory properties

Table 6 shows the sensory properties of crackers biscuit enriched with cashew kernel flour and dried vegetable powders. Mean score for colour ranged between (4.80–1.55) with sample A (4.80) as the most preferred while sample D had the least (1.55) acceptability. The mean score for flavour ranged from 2.90 to 3.65 with the lowest acceptability (2.90) recorded in sample D while the most preferred (3.65) in sample G. The mean score of texture for the crackers biscuit samples ranged from 2.85 to 3.70. The lowest texture score (2.85) was in sample C while sample D had the highest (3.85). The mean score for taste ranged from 2.80 to 3.35 with sample A as the most preferred while sample E was the least preferred. The incorporation of dried vegetables and cashew kernel four had no significant ($p > 0.05$) effect on the taste of the samples. The mean score for overall acceptability of the crackers biscuit ranged from 2.80 to 3.95 with the lowest score (2.80) recorded in sample C while sample A had the highest (3.95).

4. Discussion

There high moisture content of the enriched crackers as compared to the control crackers is due to the incorporation of cashew kernels. The moisture level of any food is an indicator of its water activity and is used to assess its vulnerability to microbial infection.

Table 4
Phytochemical content of crackers biscuit.

Samples	Tannin (mg/100 g)	Alkaloid (%)	Flavonoid (%)	Saponin (%)	Total phenol (mg/100 g)
A	0.007 ± 0.00^{d}	4.950 ± 1.40^{d}	6.945 ± 0.26^{d}	0.650 ± 0.07^{e}	0.948 ± 0.378^{d}
B	0.017 ± 0.00^{cd}	7.951 ± 0.04^{c}	7.060 ± 0.38^{c}	1.580 ± 0.00^{c}	2.165 ± 0.34^{c}
C	0.020 ± 0.01^{bc}	11.386 ± 0.70^{b}	7.850 ± 0.42^{bc}	1.760 ± 0.00^{b}	3.977 ± 0.73^{b}
D	0.032 ± 0.01^{ab}	18.906 ± 0.13^{a}	8.350 ± 0.07^{b}	1.820 ± 0.00^{d}	8.746 ± 0.48^{a}
E	0.021 ± 0.01^{bc}	5.496 ± 0.63^{d}	8.060 ± 0.20^{b}	1.300 ± 0.00^{d}	0.866 ± 0.17^{d}
F	0.032 ± 0.00^{ab}	7.045 ± 0.06^{c}	8.330 ± 0.01^{b}	1.320 ± 0.00^{b}	2.012 ± 0.00^{c}
G	0.034 ± 0.01^{a}	7.911 ± 0.01^{c}	10.545 ± 0.64^{a}	2.040 ± 0.00^{a}	4.281 ± 0.47^{b}

Mean values are of triplicate determinations. Mean values within a column with different superscripts are significantly different at ($p < 0.05$).

Table 5
Physical properties of crackers biscuit.

Samples	Diameter (cm)	Height (cm)	Weight (g)	Spread ratio
A	4.10 ± 0.00^{a}	0.40 ± 0.00^{a}	4.83 ± 0.23^{a}	10.25 ± 0.33^{a}
B	4.00 ± 0.00^{b}	0.40 ± 0.00^{a}	4.49 ± 1.07^{a}	10.00 ± 0.77^{b}
C	4.00 ± 0.00^{b}	0.40 ± 0.00^{a}	4.23 ± 0.57^{a}	10.00 ± 1.09^{b}
D	4.00 ± 0.00^{b}	0.40 ± 0.00^{a}	4.11 ± 0.21^{a}	10.00 ± 0.24^{b}
E	4.00 ± 0.00^{b}	0.40 ± 0.00^{a}	4.49 ± 0.48^{a}	10.00 ± 0.68^{b}
F	3.95 ± 0.00^{b}	0.40 ± 0.00^{a}	4.07 ± 0.10^{a}	9.88 ± 0.41^{b}
G	3.95 ± 0.00^{b}	0.40 ± 0.00^{a}	3.77 ± 0.25^{a}	9.88 ± 0.44^{b}

Mean values are of duplicate determinations. Mean values within a column with different superscripts are significantly different at ($p < 0.05$).

Table 6
Mean sensory scores of crackers biscuit.

Samples	Colour	Flavour	Texture	Taste	Crispness	Overall Acceptability
A	4.80 ± 0.41^{a}	3.35 ± 1.09^{ab}	3.70 ± 1.26^{a}	3.25 ± 0.97^{a}	4.10 ± 0.72^{a}	3.95 ± 0.51^{a}
B	3.55 ± 0.89^{b}	3.55 ± 0.69^{ab}	3.50 ± 1.00^{ab}	2.60 ± 0.94^{a}	3.25 ± 1.02^{bc}	3.30 ± 0.57^{b}
C	2.60 ± 0.68^{c}	3.25 ± 0.79^{ab}	2.85 ± 0.99^{b}	2.85 ± 1.14^{a}	2.85 ± 1.04^{c}	2.80 ± 0.62^{c}
D	1.55 ± 0.69^{d}	2.90 ± 0.97^{b}	3.85 ± 1.14^{a}	2.90 ± 1.17^{a}	4.30 ± 0.92^{a}	3.10 ± 0.64^{bc}
E	3.55 ± 0.69^{b}	3.15 ± 1.18^{ab}	3.15 ± 0.99^{ab}	2.80 ± 0.89^{a}	3.25 ± 1.29^{bc}	3.20 ± 0.77^{bc}
F	3.00 ± 0.73^{c}	3.15 ± 1.04^{ab}	3.35 ± 1.35^{ab}	3.20 ± 0.89^{a}	3.95 ± 1.05^{ab}	3.35 ± 0.59^{b}
G	1.80 ± 0.70^{d}	3.65 ± 1.09^{a}	3.10 ± 1.37^{ab}	3.00 ± 1.08^{a}	3.60 ± 1.43^{ab}	3.10 ± 0.72^{bc}

Mean values within a column with different superscripts are significantly different at ($p < 0.05$) ($n = 20$).

According to Rebellato et al. [28], the moisture content of biscuits should not surpass 14%, with 5% moisture content being the optimum because it has a better shelf life. As a result, the moisture content of the cracker biscuits was well within an appropriate range (5.0–5.5%). Increase in the ash content on substitution with the dried vegetables and cashew kernel is expected as dried vegetables and cashew nuts are high in ash content and the leaves are rich in mineral elements such as sodium, magnesium, and calcium and phosphorous [17]. The percentage ash of a sample gives an idea on the inorganic content of the samples from where the mineral content could be obtained. Samples with high ash contents is expected to have high concentration of various mineral elements, which are expected to speed up metabolic processes, improve growth and development.

The high crude protein in the enriched crackers is due to the supplementation with dried vegetables and cashew kernel incorporation. This correlates with the findings of Ayo et al. [29] for malted soy-acha biscuit. Ifediba and Egbuna [30] who also fortified biscuit by blending wheat flour with moringa leaf powder on 1:10 (w/w) ratio and the results showed that addition of moringa leaf powder increased protein from 11.14 to 11.47%. The result revealed that the protein content of the fortified crackers biscuit would be of better quality as compared with 100% wheat flour biscuit. The elevation in fat content of the crackers biscuit was mostly due to the incorporation of undefatted cashew kernel flour. Odunlade et al. [13] also reported a significant content in the fat content of wheat bread (1.27–2.00%) upon supplementation with *Telfairia occidentalis*, *Amaranthus viridis* and *Solanum macrocarpon.* The presence of fat influences the shelf life of foods [31]. A high fat content may hasten deterioration by encouraging rancidity, which may give rise to unpleasant flavors and odors. Despite the observed increase, fat content remained below 15%, which is the minimum limit for fat [32].

The high values of crude fibre obtained for the enriched crackers might be because both vegetables (scent leaf and lemon basil leaf) and cashew kernel are rich sources of dietary fibre which therefore increased the fibre content of the crackers biscuits. Odunlade et al. [13] equally reported an increase in the bread samples with different levels of vegetables and it ranged between (1.81–4.00%). The increased fibre content of the cookies suggests that these items will improve digestion and so reduce constipation [33]. The Institute of Medicine's Dietary Reference Intakes (DRIs) state that males over the age of 50 on a 2000 kcal diet should consume 30 g of dietary fiber per day, while women over the age of 50 should consume 21 g of dietary fiber per day [34]. Crackers biscuits enriched with 2.5 and 5.0% scent leaf can contribute an average of 24% RDI (Recommended Daily Intake) requirement for fibre for males over the age of 50 while crackers biscuits enriched with 5.0% lemon basil leaf can contribute 35.59% RDI requirement for fibre for women over the age of 50. This suggests that these samples can contribute meaningful amount of dietary fibre for the elderly. Consuming foods high in dietary fiber may lower the risk of cardiovascular disease, certain cancers, and type 2 diabetes, as well as enhance the regulation of physiological functions, according to epidemiological research [35].

The decrease in the carbohydrate content as the supplementation with dried vegetables increased and upon incorporation with cashew kernels may be due to the low carbohydrate content in vegetables and cashew kernel as compared to wheat flour. Olubukola et al. [36] equally reported that carbohydrate decreased for chin-chin enriched with Ugu and Indian spinach vegetables while Ifediba and Egbuna [30] showed a significant decrease in carbohydrate from 49.38% in wheat flour biscuit to 47.80% in moringa wheat flour biscuit. The obtained energy value in this study was higher than the suggested value for the expected energy value intake of infants aged 1–24 months (479–1148 KJ/day) [37], but lower than the prescribed threshold for adults (7500 KJ/day) [38]. The daily energy need varies according to height and age. Food energy is particularly essential since it helps determine the fuel worth of food. Although energy is not a nutrient, it is essential in the system for metabolic activities, biological functioning, muscle activity, heat production, development, and tissue formation [39].

The enriched crackers have better calcium, sodium and magnesium content than the crackers without the addition of dried vegetables and cashew kernel and it is in agreement with the work of Ndife et al. [40]. The high calcium, sodium and magnesium content in the enriched cracker biscuit is due to the high mineral content of cashew kernels and dried vegetables. The result of this study confirms previous research by Emelike et al. [5] that cashew kernels are high in minerals such as calcium (59.0 mg/100 g) and magnesium (190 mg/100 g) and can serve as functional ingredient in the formulation of snack products. Ajayi [41] also reported that vegetables are good sources of minerals which are usually in short supply in daily diets. The sodium observed by Chinma et al. [42] for cookies prepared from unripe plantain-defatted sesame flour blends was 81.12–413.20 mg/100 g and it was within range of values obtained in the crackers biscuit. The magnesium content of the crackers biscuit from this study compared favorably with the value of 57.19–289.30 mg/100 g for cookies produced from unripe plantain defatted sesame flour blends as reported by Chinma et al. [42].

The increase in the tannin content is due to the addition of dried vegetables and incorporation of undefatted cashew kernel flour because leafy vegetables and cashew nuts are good source of tannin [17]. Tannins have been discovered to inhibit trypsin, chemotrypsin, amylase, and lipase, as well as to partially make proteins inaccessible or to suppress digestive processes in humans and animals. The level of tannin found in the study is less than the mean daily intake of 1000 mg and 820 mg [43].

Alkaloids are mostly used in medicine due to their effect on the body's physiology. Alkaloids are phytochemicals that are often thought to be anti-nutrients. When present in significant concentrations, they impair electrochemical communication in the nervous system. A substantial proportion of alkaloid can be harmful to human health, especially if it reaches the fatal level of 20 mg/100 g. Alkaloid content of the crackers exceeds the fatal dosage, implying that the dried vegetables should be further processed. Increase in the flavonoid content of the cracker biscuits was due to the substitution with dried vegetables. Pasqualone et al. [44] equally observed significant increase of flavonoids in biscuits and indicated that the increase was due to the contribution of semolina and shortening as well as incorporation of the plant by products which impacts their compounds. Flavonoids are known for their antioxidant, anti-atherosclerotic and anti-carcinogenic properties. They are among antioxidant defensive systems protecting vegetable oils against oxidative damage [45]. The saponin concentration recorded in this study is within acceptable levels (<10%). Igile et al. [46] reported that saponins at levels <10% are harmless to the body and so the consumption of crackers biscuit with the different ratios of SLP and LBP with regards to saponin should be encouraged, especially for health benefits. The increase in the phenolic content of the crackers biscuit as the supplementation with dried vegetables increased agrees with the study of Elhassaneen et al. [47] who reported that incorporation of prickly pear peel and potato peel powders at 5% level improved the total phenolic compound of the biscuit. Ahmed and Abozed [48] also reported an increase in total phenolic content in snack crackers fortified with *Hibiscus sabdariffa* by-product.

The supplementation with dried vegetables and cashew kernel incorporation had no significant effect on the diameter, weight and height of the crackers. Spread ratio has long been utilized as a key criterion for measuring the quality of flour used in the manufacturing of crackers biscuits [49]. Higher spread ratios are preferred over lower spread ratio. Therefore, the crackers without the supplementation with dried vegetables and cashew kernel flour incorporation had the highest spread ratio and it was followed closely by samples enriched with scent leaf powder.

There was a decrease in the colour of the samples upon incorporation with cashew kernel flour and dried vegetables. According to Olubukola et al. [36], consumer acceptance of enriched food samples was affected by its coloration, which was affected by the green color of the vegetables added, and this was seen with a drop in acceptability in crackers biscuit sample enriched with dried vegetables. Drisya et al. [50] observed that the supplementation of *Murraya koegnigii* leaf powder at 10% level was found to be acceptable in cookies with a pleasant curry leaf flavour and quality and this is observed that sample G which has 5% lemon basil powder had the highest value of acceptability (3.65). The supplementation with dried vegetables and cashew kernel incorporation had no significant effect on the taste of the crackers. Crackers without the supplementation with dried vegetables and cashew kernel flour supplementation was the most acceptable sample and this was followed closely by samples B and F respectively. Ifediba and Egbuna [30] equally showed that wheat flour biscuit was significantly superior compared to moringa-wheat flour biscuit. Odunlade et al. [13] also showed that the sensory result decreased significantly in sensory qualities with increase in supplementation.

5. Conclusion

Dried vegetables are a viable alternative as ingredient in crackers biscuit. Higher contents of ash, crude fiber, crude protein, fat, calcium, sodium, magnesium, and total phenolic and flavonoid compounds are observed after the incorporation with cashew kernel flour, dried lemon basil and scent leaf powders, which improves the nutritional profile of the product. Moreover, the addition of dried LBP at 5% improved the flavour whereas colour, texture, taste and crispiness decreased. Among the enriched crackers, the samples enriched with 2.5% LBP and 1.0% dried SLP were the best. Consumption of 100 g of crackers biscuits enriched with 2.5 and 5.0% dried SLP can meet roughly 24% RDI (Recommended Daily Intake) requirement for fiber for males over the age of 50 while crackers biscuits enriched with 5.0% lemon basil leaf can contribute 35.59% RDI requirement for fibre for women over the age of 50. Therefore, the application of dried lemon basil and scent leaf powders in the production of crackers biscuit is recommended to improve the dietary fiber intake and overall health, especially among older persons.

Data availability statement

Data will be made available on request.

Credit author Statement

Ujong Anim Ekpo: Conceived and designed the experiments; wrote the paper, **Nkechi Juliet Tamuno Emelike:** Contributed reagents and materials; wrote the paper, **Favour Ihuoma Woka:** Performed the experiments; Analyzed and interpreted the data, **Francis Otekeiwebia JNR:** Contributed materials and wrote the paper.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declaration of competing interest

We declare that there are no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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