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Research Article

Physico-Chemical, Mineral and Sensory Quality of *Dakuwa* Formulated from Maize, Tiger Nut, Groundnut, Dates and Cinnamon

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ABSTRACT

This study evaluated the physico-chemical, mineral and sensory properties of dakuwa formulated from maize, dates, groundnut, tiger nut, and cinnamon (Sample A) compared with the control made from 100% tiger nut (Sample B). Nutritional composition was analyzed using standard AOAC (2020) procedure; the pH was analyzed using a method prescribed by AOAC (2023), while sensory evaluation was assessed using a 9-point hedonic scale and data were analyzed using one-way ANOVA at $p \leq 0.05$. The result revealed significant variation in the means of these properties. Sample A had higher ash (6.00%), carbohydrate (53.15%) and fibre (7.43%) contents with a calorific value of 397.51 kcal while sample B had a higher protein (15.90%) and fat (18.52%) contents with a calorific value of 441.47 kcal. Sample A had markedly higher Ca (99.00 mg/100g), K (190.00 mg/100g), P (110.10 mg/100g), Mg (33.00 mg/100g), and Na (14.00 mg/100g) while sample B had higher Mn (50.00 mg/100g). Sample A and B had a pH value of 7.08 and 7.42, respectively. Findings of sensory evaluation revealed no significant difference ($p>0.05$), respectively in colour (6.1 and 6.0) and overall acceptability (6.1 and 6.5), however, sample A was significantly preferred ($p\leq0.05$) in aroma (6.4), taste (6.5) and texture (6.5). These results indicate partial substitution of tiger nuts with maize, dates, and cinnamon improved the mineral density and sensory quality without added sugar, supporting its use as a nutrient dense snack.

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1.0 INTRODUCTION

Snacks are foods or beverages consumed between regular meals to provide light sustenance, satisfy hunger, and contribute to daily nutrient and energy intake (Hess *et al*., 2016). *Dakuwa* is a prominent traditional Northern Nigeria snack called "*Shadaka*" in Hausa language (Ocheme *et al*., 2011). Dakuwa is prepared by thorough mixing, pounding and molding into balls of maize, groundnut flours, ground peppers, ginger, sugar and salt which can be eaten without

further processing (Ekpa *et al*., 2019). Studies have shown that a tiger nut-to-groundnut ratio of 2:1 produced the highest consumer acceptability, while 4:1 ratio was the least preferred (Igwe *et al*., 2016). It is made from roasted tiger nut and ground nut; it can also be made from roasted sorghum or maize (Bagirie & Adegoke, 2008). A survey conducted across six (6) local governments in Niger states reveal that the choice of ingredients varies from place to place depending on culture and individual preferences. Even where the same ingredients are used , the actual ratios were observed to be different (Ocheme et al., 2011)The maize, tiger nut and groundnut are usually roasted to achieve the desired quality. Oladele *et al.,* (2009) reported that the acceptability of *dakuwa* is dependent on its flavor, colour, and taste of the product which is achieved through roasting. Cereals make the largest percentage of carbohydrates worldwide and are the primary staple foods providing energy for a large proportion of the global population (FAO 2021; Awika, 2011). Maize has three (3) possible uses; as food, as feed for livestock, and as raw materials for industries (Awika, 2011). According to studies, regular consumption of nuts can slash the risk of heart disease and cancer because they contain Arginine which is shown to be beneficial to those suffering from high blood pressure and contains a form of phytosterol called beta-sitosterol (SIL) preventing cancer and tumor (Kelly & Sabate., 2006). Studies have also revealed that combining tiger nut and groundnut improves the protein, minerals and overall nutritional quality of foods (Yusuf & Mahmud, 2023). Date palm fruits contains anti-oxidants such as flavonoids, steroids and saponins which play a role as anti-diabetic (Alvi *et al*., 2022). Cinnamon, a spice, flavor and preservative obtained from the inner bark of several trees and are said to control blood sugar, has cancer prevention properties, contains eugenol which has anaesthetic and antiseptic properties (Ferreira *et al*., 2021). Cereals are lacking in methionine while legumes are lacking lysine which are essential amino acids. With the combination of cereals, legumes, date palm fruit and cinnamon, a snack with higher nutrient can be produced with no added sugar making it potentially suitable snack option for individuals with diabetes mellitus (Meenakshi & Misra 2023). The nutritional quality and sensory characteristics of *dakuwa* are greatly influenced by ingredient formulated and processing conditions (Ocheme *et al*., 2011). Other studies have shown how ingredients were varied in the production of *dakuwa*, however limited studies are available on the addition of dates and cinnamon in *dakuwa* formulation. Therefore, the objective of the study was to evaluate the quality of *dakuwa* formulated with maize, groundnut, tiger nut, date palm fruit and cinnamon in comparison with a 100% tiger nut control.

MATERIALS AND METHODS

2.1 Sample Collection

The raw materials; maize, tiger nut (bigger variety), groundnut, dates and cinnamon used for this study were obtained from Maiduguri Monday Market. The control sample was made of 100% tiger nut of the smaller variety, selected because this is the variety and formulation typically sold as commercial *dakuwa* obtained in the market. Seven *Dakuwa* sellers around post office area, Maiduguri, Borno State, were interviewed and their response was that, they used a 100% tiger nut because it is more economical to use a single product than to use variety of ingredients at the same time which still gives a better flavor.

2.2 Sample Preparation and Processing

Sample A was prepared following method described by Bagirie and Adegoke (2008) with modification. The raw materials (maize, tiger nut and groundnut) were cleaned, sorted and toasted using oven at 140^{o}C for 8 mins. The roasted maize and tiger nut were allowed to cool while the groundnut was dehulled and winnowed to remove the coating. The date palm fruits were de-seed, washed, and sun dried for 12 hours. The raw materials were mixed together and milled using local attrition mill and pounded into dough to

achieve a uniform consistency, which were molded and cut in to shapes.

2.2.1 Blend Formulation

One (1) kg of *dakuwa* was produced using 120 g of maize, 240 g of tiger nut, 360 g of winnowed groundnut, 275 g of de-seeded dried dates, and 5g of cinnamon powder.

2.3 *Dakuwa Production*

The production of *Dakuwa* was carried out following the flow chart (fig. 1).

Cleaning and sorting
↓
Washing and sun drying (12 hours)
↓
Toasting of groundnuts, tiger nuts and maize (140ºC for 8 min)
↓
Mixing/formulation
↓
Milling of the roasted maize, tiger nuts and groundnuts
↓
Pounding until a uniform consistency is formed
↓
Molding in to desired balls or shapes
↓
Packaging

Source: Bagirie and Adegoke (2008) with slight modifications

2.4 Determination of Proximate and mineral composition

All analyses were performed in triplicate (n=3) for each sample. The samples were analyzed AOAC 925.10 for moisture, AOAC 920.9 for crude fat, AOAC 920.87 for crude protein, AOAC 923.03 for total ash and AOAC 962.09 for crude fiber contents according to AOAC (2020) methods. Total carbohydrate contents of the samples were determined by difference and the total calorific value was determined using Atwater factor (Nielsen, 2017), the mineral content (Ca, Mg, Mn, K, P, Na) was determined by atomic absorption spectroscopy (AAS) following AOAC (2020), and pH was determined according to AOAC method 981.12 (2023) using a caliberated digital pH meter

2.5 Determination of Sensory evaluation

The sensory evaluation of the *dakuwa* samples was conducted using twenty (20) panelists who were familiar with *dakuwa* consumption. The samples were evaluated for colour, taste, texture, aroma and overall acceptability using a 9-point hedonic scale questionnaire, where 9 = like extremely, 8 = like very much, 7 = like moderately, 6 = like slightly, 5 = neither like nor dislike, 4 = dislike slightly, 3 = dislike moderately, 2 = dislike very much, and 1 = dislike extremely. About 2 g of each sample was presented to the panelists, each coded differently to prevent bias. Clean drinking water was provided to the panelists to rinse their palates before and after tasting each sample.

2.6 Statistical analysis

The data were analyzed using SPSS version 16.0 (SPSS Inc., Chicago, IL) and expressed as mean ± standard deviation (SD). t-test was used to determine and compare the statistical differences of each data in this study at $p \leq 0.05$.

RESULTS AND DISCUSSION

Proximate composition of the Two dakuwa Samples

The results of the proximate analysis are presented in Table 1. The moisture contents of Sample A and Sample B (control) were 4.97% and 5.47%, respectively. The low moisture contents indicate that both samples are relatively stable under appropriate storage conditions, as reduced moisture inhibits the growth of microorganisms and decreases enzymatic activity. This may be attributed to the roasting process at 140°C, which promotes moisture evaporation (Campbell-Platt 2017).

The protein contents were 14.21% for Sample A and 15.90% for Sample B, while the fat contents were 14.23% and 18.52%, respectively. The relatively high protein content of the samples may be attributed to the inclusion of groundnut and tiger nut, indicating

that the products are good sources of plant-based protein. The inclusion of protein-rich ingredients in cereal based snacks enhances their nutritional quality and makes them more suitable for improving dietary protein intake (Arya *et al.,* 2016). The relatively high fat content is due to the incorporation of groundnut and tiger nut both of which are naturally rich in lipids. Fat contributes to desirable sensory characteristics such as flavor, texture and mouth feel. However, Belewu & Belewu (2007) observed that products with higher fat content may be susceptible to oxidative rancidity during storage, emphasizing the need for appropriate packaging and storage conditions.

The crude fibre contents were 7.43% for Sample A and 6.26% for Sample B. The higher fiber of sample A may be due to the tiger nut residue, date fruit solids and whole grains. This is significant for healthy digestion, prevention of constipation and reduced glycemic response (Giuntini *et al.,* 2022). The crude fiber above 6% is generally considered desirable from a nutritional standpoint, as it contributes to satiety and supports digestive health (Sanchez-Zapata *et al.,* 2012).

The carbohydrate contents were 53.15% for Sample A and 52.79% for Sample B. The high carbohydrate content indicates that both samples are good sources of energy, with only a slight variation observed between the two formulations. As a cereal-based snack, these findings suggest that *dakuwa* is an energy-dense food capable of providing both rapid and sustained energy, making it a suitable snack for meeting daily energy requirements.

The total calorific values were 397.51 kcal/100 g for Sample A and 441.47 kcal/100 g for Sample B, indicating that both products are good sources of dietary energy. The higher calorific value observed in Sample B may be attributed to its higher fat content, as fat provides more energy per gram (9kcal/g) than carbohydrates and proteins which contributes about 4kcal/g each (Arya *et al.,* 2016).

Sample A has higher carbohydrate, crude fibre, and ash content but a lower calorific value than Sample B, which may be attributed to the larger tiger nut variety used in Sample A having a lower fat content than the smaller variety used in the control. This agrees with the findings of Moussa *et al.* (2023), who reported that small tiger nut ecotypes possessed a higher average lipid (21.60%) content than large ecotypes (14.90%). Similarly, Imam *et al*., (2013) observed that the small brown tiger nut variety contained more fat content than the larger yellow variety. In contrast, Sample B (control) had higher protein, fat, and total calorific value, which may similarly be attributed to the smaller tiger nut variety used, believed to have a higher fat content and commonly used in the commercial production of *dakuwa*

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Table 1: Proximate Composition (100%) of the *dakuwa* samples

Composition	**A**	**B**
Dry Matter	$95.03^{a} \pm 0.42$	$94.53^{b} \pm 0.45$
Moisture content	$4.97^{b} \pm 0.15$	$5.47^{a} \pm 0.45$
Crude Protein	$14.21^{b} \pm 0.30$	$15.90^{a} \pm 0.73$
Crude Fat	$14.23^{b} \pm 1.11$	$18.52^{a} \pm 1.75$
Crude Fiber	$7.43^{a} \pm 0.15$	$6.26^{b} \pm 0.55$
Ash	$6.00^{a} \pm 0.04$	$1.04^{b} \pm 0.02$
Carbohydrate	$53.15^{a} \pm 1.37$	$52.79^{b} \pm 2.42$
Energy (kcal)	$397.51^{b} \pm 3.54$	$441.47^{a} \pm 4.37$

Note: Values represent mean ± standard deviation (n=3); mean with different superscripts within a column differs significantly at $p \leq 0.05$ A: with dates and cinnamon;B: control sample made from 100% tiger nut

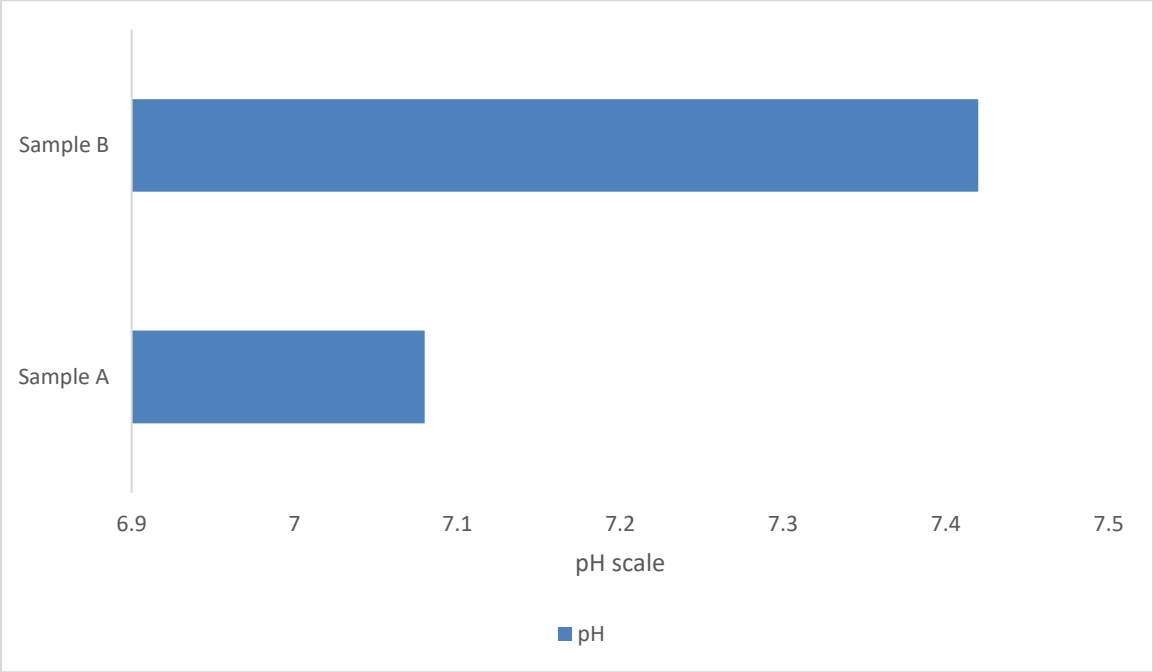

Fig 2: pH values of the formulated *dakuwa* samples

The pH values of Sample A and Sample B were 7.08 and 7.42, respectively, as presented in Figure 2. Both samples exhibited near-neutral pH values, which may influence their sensory characteristics, microbial stability, and overall shelf life. The neutral to slightly alkaline nature of the samples may be attributed to the buffering capacity of the food matrix, which is influenced by the relatively high protein content and the presence of mineral ash constituents, particularly potassium, sodium, calcium, and magnesium salts. These minerals contribute to the alkalinity of food systems and help maintain pH stability (Mennah-Govela *et al.*, 2020).

Mineral composition of the dakuwa samples

Mineral analysis was carried out on two *Dakuwa* samples A and B, and the results obtained were shown in Table 2. Sample A has 99.00mg/100g calcium and B has 19.05 mg/100g. Calcium is known to be associated with growth and maintenance of bones (Al-Farsi & Lee, 2008). Magnesium content of sample A is 33.00mg/100g and 6.35 mg/100g in sample B. Magnesium is important in connection with calcium metabolism in bones and in glucose metabolism (Sanchez-Zapata *et al.,* 2012). Manganese content of sample A is 15.01mg/100g and 50.00 mg/100g in sample B. Manganese is needed for processing of oxygen. Potassium in sample A is 190.00mg/100g and 10.80 mg/100g in sample B, which is also needed for heart and nerve health, and with sodium, potassium is involved in maintaining normal water balance. Phosphorus in sample A is 110.10mg/100g and 61.0 mg/100g in sample B, which is also needed in maintenance of bones, muscles, and teeth. Sodium in sample A is 14.00mg/100g and 3.14 mg/100g in sample B. The higher calcium, potassium, phosphorus,magnesium content observed in sample A may be attributed to the contribution of dates and groundnuts which are known to contain appreciable amount of calcium, potassium, magnesium and phosphorus (Al-Farsi & Lee, 2008)

Table 2: Mineral Analysis of the dakuwa Sample

Samples	Minerals(mg/100) Ca	Mg	Mn	P	K	Na
A	99.00^{a}±0.36	33.00^{a}±0.17	15.01^{b}±0.01	110.10^{a}±0.02	190.00^{a}±0.02	14.00^{a}±0.20
B	19.08^{b}±0.22	6.35^{b}±0.13	50.00^{a}±0.02	61.00^{b}±0.02	10.80^{b}±0.02	3.14^{b}±0.04

Note: Values represent mean ± standard deviation (n=3); mean with different superscripts within a column differs significantly at $p \leq 0.05$. Sample A: with dates and cinnamon; Sample B: control sample made from 100% tiger nut.

Sensory Properties of dakuwa

The mean sensory scores obtained were statistically analysed and presented in Table 3. There was no significant difference in colour and overall acceptability ($p > 0.05$). The absence of significant difference in some sensory attributes observed is consistent with the findings of Oladele & Sogunle (2020) who reported variations in *dakuwa* formulation did not significantly affect the overall sensory acceptability while suggesting that the addition of dates and cinnamon did not adversely affect the consumer preference and overall acceptability, Similar findings were reported by Ibrahim *et al*., (2021) who observed improved sensory characteristics and overall acceptability in snack bars formulated with date paste, but sample A is significantly different from B in terms of taste and aroma which may be due to the added dates and cinnamon. Cinnamaldehyde in cinnamon that contributes to desirable flavor and aroma characteristics of *dakuwa*, and A is significantly higher than B in terms of texture. It is observed that sample A had softer texture which might be associated with moisture–retaining properties of dates which may have reduced the firmness and compactness of the product. Similar observations were reported by Bchir *et al*., (2018) who found that incorporation of fruit fibers influenced the texture and sensory acceptability of cereal bars.

Table 3: Sensory score of the formulated *dakuwa*

Samples	Aroma	Taste	Colour	Texture	Overall acceptability
A	6.4^{a}±0.52	6.5^{a}±0.71	6.1^{a}±0.99	6.5^{a}±0.97	6.1^{a}±0.97
B	5.9^{b}±0.74	6.1^{b}±0.74	6.0^{a}±0.52	5.4^{b}±0.79	6.5^{a}±0.57

Values represent mean ± standard deviation (n=20 panelists); mean with different superscripts within a column differs significantly at $p \leq 0.05$ Sample A: with dates and cinnamon; Sample B : control sample from 100% tiger nut

CONCLUSION

Sample A had lower moisture, crude protein, and crude fat contents than Sample B. These differences may be attributed to the roasting conditions and formulation of the products, while the addition of dates and cinnamon contributed to the higher ash content observed in the formulated product. Although the two samples did not differ significantly in colour and overall acceptability, they showed significant differences in aroma, taste, and texture. These findings demonstrate that ingredient selection and formulation can be strategically modified to produce *dakuwa* with desirable nutritional and sensory qualities for different consumer preferences and commercial applications.

RECOMMENDATION

This study was limited to a single enriched formulation against one control; in addition, Sample A and the control (Sample B) differed simultaneously in ingredient composition and in tiger nut variety (larger vs. smaller), so the observed difference in mineral content and sensory properties might

be attributed to the composition of the enriched sample partly due to the inclusion of cinnamon and dates, while the fat content of the control is due to the variety of tiger nut used. Future work should evaluate a range of maize-tiger nut-date-cinnamon substitution levels, holding tiger nut variety constant across treatments, to identify an optimal balance of nutritional density and sensory acceptability, and should include shelf-life and microbial stability assessment given the elevated fat content of both samples.

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