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Physicochemical Properties of Soya Beans Milk (Dage), Sold and Consumed within Kano State Metropolis

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ABSTRACT
The study was carried out to evaluate the physicochemical properties, proximate composition, anti-oxidant properties and anti-nutritional content, micro and macro elements concentrations, and sensory acceptability of soybean milk ("dage") sold within kano State metropolises, Nigeria. The drinks were analyzed for (Physico-chemical (pH, total titratable acidity, Brix and turbidity) anti-nutritional (Phyate, and oxalate), anti-oxidant (flavonoid), proximate (moisture, fat, protein, ash, crude fiber, carbohydrate and total energy contents), Macro-element (calcium, iron, potassium, and magnesium). Micro elements (cadmium, nickel and lead). The results showed significant variations in moisture (76.96–80.05 %), protein (5.90–7.36%), fat (3.55–4.38%), and fibre (2.10–2.88%) contents. Anti-oxidants analysis revealed presence of flavonoids (0.22–0.59 mg/100L) while anti-nutrients contents; phytates (148.15–289.83 mg/100L), and oxalates (15.94–31.05 mg/100L). Physicochemical properties indicated acidic pH (3.78–4.98) and varying viscosity (415.00–840.50 mPa·s). Macro-element analysis showed presence of calcium, iron, potassium, and magnesium, Micro-elements (cadmium, nickel, lead) were detected at low levels. Sensory evaluation indicated the control sample had the highest overall acceptability (8.35/10). In conclusion, this study underscores the need for quality control measures in traditional "dage" production to enhance safety, nutritional value, and consumer acceptability.

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INTRODUCTION

Nigerian indigenous drinks are becoming popular in both urban and rural communities because they are cheaper than imported drinks. These beverages are well accepted among Nigerians (Oboh and Okhai, 2012). Beverages in general are food items that are quite different and distinct from other food items; mainly in liquid state but have lower food values relative to other food products (Adelekan et al., 2014). Moreover, they are important sources of nutrients and phytonutrients, phenolic acids and flavonoids (Ferruzzi *et al.*, 2020). They are widely widely consumed, especially by children, pregnant women, the sick, and the elderly and also used during the weaning of infants. It is also reported that, social, religious, nutritional, and therapeutic values are associated with an increase of their consumption (Ezekiel *et al.*, 2018).

Recent research shows that Street foods are food or drinks, sold by street vendors which is becoming highly acceptable by consumers due to their low price and constant availability at a given time (Mohd Nawawee *et al.*, 2019). However these locally processed beverages have poor shelf life, besides the fact that they are drinks processed in condition lacking quality assurance and control measures (Kigigha *et al.*, 2018). Their consumption has been reported to potentially increase the risk of food borne diseases caused by a wide variety of pathogens.

Glycine max, or soybean, is a leguminous crop (Mossie *et al.*, in 2024. Due to its high nutritional content, it is referred to as the "miracle plant" (Güzeler and Yildirim 2016). a significant source of oils and proteins from plants (Liu *et al.*, in 2020). It provides an inexpensive and adaptable plant base-protein component (Belobrajdic *et al.*, (2023). Additionally, it is the only highly sought-after component for creating meat substitutes that contain all the essential amino acids in quantities sufficient to satisfy human physiological needs (Voora 2020). with the potential to reduce widespread protein malnutrition (Kamble 2021). When consumption begins in childhood, it may aid in the prevention of breast cancer (Messina *et al.*, (2017)). Additionally, consumption of soy-based foods may also modulate gastrointestinal (GI) health, in particular colorectal cancer risk, (Belobrajdic *et al.*, 2023). It contains the inhibitory activity of an angiotensin 1-converting enzyme (ACE) and a suitable diet for milk allergic infants and the practice of its consumption can help in prevention of different diseases (Alı *et al.*, 2020). Such as Chronic Kidney Disease, Hypotensive Action, Hypercholesterolemia Circulatory Strain, Diabetes, and Platelet Accumulation etc. (Saha and Mandal 2019). It is also very effective in reducing the oxidative stress and destruction of the free radicals. (Amol *et al.*, 2021).

Soymilk, a diluted extract is one of soybean products. It is an infusion that offers both refreshment and nutrition and can be labelled as a healthy food because of its composition (Neeta, 2015). Soy milk, sometimes called soy drink or soy beverage, is a white suspension which resemble cow milk in both form and evenness (Neets, 2015). The amino acids distribution of soybean is close to that recommended by Food and Agricultural Organization (FAO) of United Nations for human nutrition in terms of essential and nonessential amino acids. Adejuyitan, *et al*., (2014) Over the years, it has been developed into a food for infant suffering from various forms of malnutrition (Igantius, *et al*., 2010).

Dage, a popular soya beans milk beverage, is widely consumed in Nigeria, particularly in Kano Metropolitan. Local producers manufacture Dage using traditional methods, which may compromise its safety and quality. The World Health Organization (WHO) estimates that 70% of foodborne diseases in developing countries are attributed to contaminated food products (Daniel, *et al*., 2024).

MATERIALS AND METHODS

Sample Collection

The samples of locally produced soyabeans drinks (Dage) were selected at random from different locations within the local Government areas of Kano State metropolises. the soybeans for the production of Dage (control sample), were purchase at Wudil central market Kano State.

Study Design and Data Selection Criteria

The study was a cross-sectional descriptive involving only people Salling soybeans beverages (Dage) on the Street and withing Kano State Metropolises.

Laboratory Analysis of the Samples

Determination of physicochemical properties of the samples

Determination pH: The pH of the fresh samples was determined using the method described by (Nkama et al., 2010) using pH meter (TECPEL pH meter, model 705) after standardization with pH 4 and pH 7 buffers (BDH, England).

Brix reading determination: The brix of the samples was determined according to the method described by (Bankole *et al*., 2013) using the hand refractor-meter.

Determination of titratable acidity (TTA): The titratable acidity (TTA) of the fresh samples was determined using the method described by (Nkama *et al*., 2010), 10 ml of the sample was titrated with 0.1 N sodium hydroxide to phenolphthalein end point (pink). The titratable acidity was calculated for each sample as described by Field (1977).

Turbidity was measured in nephelometric turbidity units (NTU) as described by (Nkama *et al*., 2010).

Determination of Proximate Composition and Energy Value of the Dage Samples

Proximate composition (moisture, crude protein, fat, ash, fibre, and carbohydrate contents), was determined using (AOAC) standard methods.

The proximate composition (moisture content, crude fibre, crude fat, total ash, and crude protein contents) of both grains (wheat and millet) and the flour were determined using standard methods as described by (A.O.A.C. 2012). Carbohydrate content was determined by difference thus:

Carbohydrate (%) = 100 − (% protein + % fat + % fibre + %ash + % moisture).

Estimation of Energy Value

The energy value (kca/100 g) was calculated using Atwater factor method described by (Obiegbuna, 2005). The fat, protein, and carbohydrate were multiplied by their physiological fuel values of 9.0, and 4.0 respectively and taking the sum of the products.

Energy value = $(4 \times P) + (9 \times F) + (4 \times C)$

Where;

P = Protein (%)

F = Fat content (%)

C = Carbohydrate content (%)

Determination of Phytochemical Properties of the Samples

Phytic Acid Content

Phytic acid was analyzed by Davis and Reid method as described by Abulude (2007) with minor modification. 2 g of the sample will be dissolved in 30 ml of 2% hydrochloric acid for 3 h with continuous shaking (Onwuka, 2018). The mixture was filtered and 25 ml of the filtrate will be mixed with 5 ml of ammonium thiocyanate solution which was titrated against ferric chloride solution containing 1.95 mg Fe/ml to brownish yellow color that lasted for 5 min. Phytate content was calculated as follows:

Phytate phosphorus = iron equivalent × 1.95 mg of titre.

Phytate = phytate phosphorus × 3.65 g

Oxalate Content

Oxalate content of the samples will be analyzed by dissolving 1.0 g of the sample in 75 ml of 1.5 M sulphuric acids, stirred for 1 h and filtered. The filtrate (25 ml) was titrated while hot with 0.05 M potassium permanganate to a faint pink color that persisted for 30 s. Oxalate composition in the samples was calculated using the following equation (Mishra et al., 2017).

1 ml of 0.05 M $KMnO_4$ = 2.2 mg Oxalate.

Flavonoids Content

The flavonoids composition in the samples will be determined by the method of AOAC (2012). Flavonoid will be extracted from 10 g of the sample with 300 ml of methanol: water (80:20 v/v) solution at room temperature for 1 h. The solution was filtered through a 125 mm Whatman filter paper and the filtrate was dried in the oven in a weighed porcelain crucible to constant weight.

Determination of Minerals Content

The mineral contents of the smoked cat fish samples were determine using a method described by AOAC, (2012). The samples were digested in concentrated HNO_3. The digest was quantitatively transferred into a 25 ml volumetric flask with deionized water and made up to volume with deionized water. A blank of the digested sample was prepared in the same way.

Determination of Heavy Metals Concentration

Digestion of Samples for Essential Mineral Analysis

The digestion of samples was carried out using a mixture of concentrated HNO_3 and $HClO_4$ in the ratio of 2:1. 10 cm^3 of the mixture were add into a digestion flask containing 2.0 g of the pulverized the samples. The sample were digested in a fume hood until a clear solution/digest is obtain, this were then cool down and filter using Whatman No1 filter paper into a 100 cm^3 volumetric flask and then make up to the mark with distill water. Same digestion method will be carried out for all the samples.

The heavy metals concentration was analyze using Atomic Absorption Spectrophotometer (AAS) method. One (1 g) of the dry sample were weighed into a digestion flask and 20ml of acid mixture were added (650 ml conc. HNO_3; 80 ml of PCA; 20 ml of conc. H_2SO_4). The flask will be heated until a clear digest is obtained. The digest was diluted with distill water to 500ml mark and an appropriate dilution were prepared for each element. A stock solution was prepared for each heavy metal following a standard method of AOAC, (2012) for (Cd, Pb, Hg, Cr, Cu and Ni). The samples are were run using AAS machine.

Statistical Analysis

Except otherwise stated, all determinations were carried out in triplicates, subjected to analysis of variance ANOVA and the means were separated by New Duncan Multiply Range Test (NDMRT). Mean and standard deviation of all the samples were calculated and compared. SPSS for Windows program version 21.0 was used to analyze the results obtained.

RESULTS AND DISCUSSION

The proximate composition of soyabeans milk is presented in Table 1. The moisture content of the soyabeans milk ranged from 76.96- 80.05 %. The moisture content of the samples obtained from Tarauni and Gwale Local government area was significantly ($p<0.05$) higher when compared with the other samples including control, this may be as the result of processing method applied (Ijah *et al*., 2014). The High moisture content of sample is an indication of the higher susceptibility to spoilage and low shelf life (FAO, 2003). The higher the moisture content of the sample the lower the shelf stability of products, hence, low moisture content ensures higher shelf stability in any products (Moore, 2020). Among the samples, the sample from Fage local had the lowest moisture content of 76.96%.

The fat content of all sample ranged from 3.55 – 4.38 % while control sample has the highest 4.38 % fat content. The higher fat and protein content of the sample is an indication of high antioxidant activity of the drink. This is in line with finding of Delgado-Andrade (2025), which stated that, the digested low-fat drink, with low level of protein content, showed the least antioxidant activity. The protein content of all the samples ranged from 5.30 – 7.36%, the protein content of the control samples 7.36%, was significantly ($p<0.05$) higher when compared with the other samples while samples from ungwaggo and Dala had the lowest protein contents of 5.90 and 5.96 respectively. The high protein content of the product is an important index of promoting growth and development and repair of worn-out tissues when such product was given to the children. According to Arnarson (2017), protein is one of the major components of body tissues and an essential nutrient for growth. Crude fibre content of the samples ranged from 2.10 to 2.88%. There is no significant different ($p< 0.05$) between control and Kumbotso, fagge and Nasarawa. And significant different observed between the other samples. Among all the samples Nasarawa had the highest crude fibre content with 2.88% and Kumbotso with the lowest 2.10% content. A lower fibre diet is a risk factor for chronic childhood constipation, (Soile 2011). While the high crude fibre content of the diet is due to the type of milling machine applied and the extent of extraction rate. Several research shows the significant role of dietary fibre on the human body i.e prevention of several diseases such as cardiovascular diseases, diverticulosis, constipation, irritable colon, cancer and diabetes (Slavin, 2005). The ash content of the sample ranged from 1.03 to 1.42. There is no significant different ($p< 0.05$) of ash content between the samples from fage– Tarauni, Dala-Nasarawa, and Gwale- Ungwaggo. While significant different ($p< 0.05$) observed between the other samples. The minerals content of the sample increases with extraction rate and can be determined by burning the sample to ashes (Scade,1975.) Ash is the inorganic (mineral) residue remaining after the combustion (Harris, 2017).

Table 1: Proximate Composition of *Dage* from Difference Locations of Kano State

SPL	%MOISTURE	%ASH	%FAT	%PROTEIN	%FIBRE	%NFE	ENG (KCAL)
Ctr	77.49 ± 0.01^e	1.09 ± 0.01^f	4.38 ± 0.01 b	7.36 ± 0.01^a	2.66 ± 0.00^b	7.04 ± 0.01^d	96.92 ± 0.04^a
DAL	78.40 ± 0.02^c	1.20 ± 0.02^d	3.88 ± 0.02 e	5.96 ± 0.06^g	2.57 ± 0.03^d	8.00 ± 0.05^b	90.73 ± 0.17^d
FGE	76.96 ± 0.02^f	1.14 ± 0.02^e	4.16 ± 0.02 d	6.49 ± 0.05^e	2.87 ± 0.04^a	8.36 ± 0.02^a	96.53 ± 0.25^b
GWL	79.08 ± 0.02^a	1.34 ± 0.01^c	3.99 ± 0.01 e	6.64 ± 0.04^d	2.27 ± 0.03^g	6.69 ± 0.02^e	89.17 ± 0.15^g
KBT	78.98 ± 0.02^b	1.03 ± 0.03^g	3.55 ± 0.02 g	6.26 ± 0.02f	2.10 ± 0.02^h	8.08 ± 0.02^b	89.57 ± 0.32^f
KMC	78.77 ± 0.02^d	1.42 ± 0.02^b	4.20 ± 0.01 c	6.96 ± 0.02^c	2.44 ± 0.03^f	6.21 ± 0.03^f	90.51 ± 0.16^e
NSR	77.58 ± 0.02^e	1.19 ± 0.02^d	3.90 ± 0.02 e	6.59 ± 0.01^e	2.88 ± 0.02^a	7.88 ± 0.02^c	92.86 ± 0.17^c
TRN	80.05 ± 0.02^a	1.12 ± 0.03^e	4.03 ± 0.01 e	7.10 ± 0.02^b	2.34 ± 0.01^g	5.36 ± 0.04^g	86.14 ± 0.19^h
UGG	78.69 ± 0.02^d	1.33 ± 0.02^c	3.79 ± 0.02^f	5.90 ± 0.02^g	2.47 ± 0.02^e	7.83 ± 0.04^c	88.95 ± 0.07^g

Values are Mean ± Standard Deviation of the Determinations. Values with Different Superscripts in a Column are Significantly Different at $p<0.05$. SPL = Sample, NFE = Nitrogen Free Extract, = ENG = Energy, Ctr= control, DAL= Dala, FGE = Fage, GWL = Gwale, KBT = Kumbotso, KMC= Kano Municipals, NSR= Nasarawa, TRN= Tarauni, UGG= Ungwaggo

Table 2 shows the phytochemical contents of the sample. Anti-nutrients such as Phytate and Oxalate are the key factor, which reduce the bioavailability of various components of the cereals and legumes (Samtiya *et al*., 2020). From the results the; the phytate contents of all the beverages samples ranged from 148.15 – 289.83 (mg/100L). This shows no significant difference between samples from Fagge and Ungwaggo (188.53 ± 0.28^f and 190.78 ± 0.03^f), Kumbotso and Tarauni (225.68 ± 0.03^b and 255.28 ± 0.13^b). Control sample had the lowest phytate content of 148.15 (mg/100L). From the table the oxalate content of samples ranged 15.94 -31.05 ((mg/100L)), were sample from Dala Local government area were significantly ($p< 0.05$) higher than the other samples, and the control samples with the lowest 31.05% oxalate content. The lower content of oxalate and phytate content of the control sample could be due to pre-processing treatment applied to the seed. Previous studies have also shown that processing techniques such as cooking, dehulling, soaking, fermentation and germination, improves the nutritional quality of food products by reducing or eliminating the anti-nutrient composition of the food product. Which is in line with finding of Samtiya *et al*., (2020) which confirmed that anti-nutritional factors reduce the nutritional value of foods and can be reduced/eliminated by the use of traditional food preparation methods such as fermentation, cooking, soaking and puffing. Samtiya *et al*., (2020) further, stated that: milling, soaking and fermentation technique removes anti-nutrients (e.g. phytic acid and tannins), which are present in the bran of grains.

The flavonoid contents of the samples ranged from 0.22 – 0.59 (mg/100L), there is no significant difference in the flavonoid contents of the samples fram (Dala, Gwale and

Nasarawa) and sample from (Fagge and Ungwaggo) local government area. Control sample had the lowest flavonoid content of 0.22 (mg/100L). the higher flavonoids contents of the sample indicate the level of antioxidants contents of that particular sample. Antioxidants are substances or compounds that have free radical scavenging capacity while inhibiting oxidative progression Rahaman *et al*., (2020). Furthermore, the finding described by Flieger *et al.*, (2021), stated that; Antioxidants act by delaying or preventing the oxidation of other chemicals. There were a lot of literatures that provides ample data to support the antioxidant capacity of beverages. The health benefit of locally produced beverages is mainly attributed to the presence of bioactive compounds such as polyphenols and flavonoid (Nowak and Gośliński, 2020).

Table 2: Phytochemicals Content of *Dage* from Difference Locations of Kano State

SAMPLE	OXALATES (mg/100L)	PHYTATE (mg/100L)	FLAVONOIDS (mg/100L)
CONTROL	15.94 ± 0.06^{h}	148.15 ± 0.25^{h}	0.22 ± 0.01^{g}
DALA	31.05 ± 0.01^{a}	205.30 ± 0.30^{c}	0.44 ± 0.01^{c}
FAGE	27.42 ± 0.02^{c}	188.53 ± 0.28^{f}	0.59 ± 0.01^{a}
GWALE	19.58 ± 0.03^{g}	195.73 ± 0.28^{e}	0.45 ± 0.01^{c}
KBT	22.93 ± 0.02^{f}	225.68 ± 0.03^{b}	0.37 ± 0.02^{e}
KMC	25.31 ± 0.02^{d}	180.52 ± 0.02^{g}	0.40 ± 0.01^{d}
NSR	28.75 ± 0.03^{b}	289.83 ± 0.18^{a}	0.44 ± 0.01^{c}
TRN	27.87 ± 0.03^{c}	255.28 ± 0.13^{b}	0.49 ± 0.01^{b}
UGG	20.75 ± 0.03^{g}	190.78 ± 0.03^{f}	0.54 ± 0.01^{a}

Values are Mean ± Standard Deviation of Three Determinations. Values with Different Superscripts in a Column are Significantly Different at p<0.05. SPL = Sample,, KBT = Kumbotso, KMC= Kano Municipals, NSR= Nasarawa, TRN= Tarauni, UGG= Ungwaggo

Table 3. shows the result of the Physicochemical properties of the soyabeans (Dage) samples, Physicochemical properties further elucidate the fermentation status and technological quality of dage beverages, the pH of ranged from 3.78 – 4.98 indicating the low acidic content of the samples, moreover the pH value of control sample was significantly (p< 0.05) higher than the other samples with 4.98 indicating the high acidic content of all the Dage samples. Microbial load of the samples decreased with decreases in the pH, which is in agreement with Adeola and Aworh, (2010) which stated that acidity inhibits the growth of surviving heat-resistant microorganisms. Furthermore, these values are characteristic of acidic, fermented soy beverages, where lactic acid bacteria such as Streptococcus thermophilus and other fermenters convert sugars into organic acids, lowering pH and increasing titratable acidity (Okur *et al*., 2025). It has been reported that fermented foods with low pH have some antimicrobial activities. total titratable acidity (TTA) of the sample ranged from 0.38–0.89%, °Brix between about 19.97 and 23.02, and viscosity from 415.00 to 840.50 mPa·s. Comparable acidic pH and TTA values have been documented in fermented soymilk, yogurt-type soy products, and other traditional soy foods, often associated with improved digestibility and development of desirable flavours. However, the wide range of viscosity and °Brix values among the Kano samples reflects substantial variation in solids content, sugar utilization, and possible syneresis or phase separation during storage. Some studies report that properly fermented soymilk should have a smooth, moderately viscous texture and stable soluble solids content; excessive thinning or thickening can signal either over-dilution or uncontrolled fermentation, including exopolysaccharide production or protein denaturation (Peng *et al*., 2023). The present data suggest that only a subset of producers consistently achieves the physicochemical profile associated with high-quality, stable fermented soy beverages.

Table 3: Physicochemical Properties of *Dage* from Difference Locations of Kano State

SAMPLE	PH	% BRIX	% TTA	VISCOSITY MPa.s
CNTRL	4.98 ± 0.02^{a}	22.50 ± 0.02^{b}	0.89 ± 0.01^{a}	720.00 ± 8.00^{d}
DALA	4.68 ± 0.02^{c}	21.59 ± 0.01^{f}	0.76 ± 0.01^{b}	652.50 ± 2.50^{f}
FAGE	4.58 ± 0.02^{d}	23.02 ± 0.01^{a}	0.59 ± 0.01^{d}	650.00 ± 35.00^{f}
GWALE	3.95 ± 0.05^{h}	20.91 ± 0.01^{h}	0.51 ± 0.02^{e}	512.50 ± 4.50^{h}
KBT	4.65 ± 0.00^{c}	21.01 ± 0.01^{g}	0.68 ± 0.02^{c}	415.00 ± 6.00^{i}
KMC	4.23 ± 0.02^{f}	21.22 ± 0.01^{g}	0.39 ± 0.01^{g}	607.00 ± 8.00^{g}
NSR	4.48 ± 0.02^{e}	22.43 ± 0.00^{c}	0.51 ± 0.01^{e}	730.50 ± 11.50^{c}
TRN	3.78 ± 0.02^{i}	19.97 ± 0.03^{i}	0.38 ± 0.02^{g}	840.50 ± 15.50^{a}
UGG	3.93 ± 0.07^{h}	21.88 ± 0.02^{e}	0.44 ± 0.01^{f}	798.50 ± 6.50^{b}

Values are Mean ± Standard Deviation of three Determinations. Values with Different Superscripts in a Column are Significantly Different at p<0.05. SPL = Sample, TTA= Titratable Acidity, KBT = Kumbotso, KMC= Kano Municipals, NSR= Nasarawa, TRN= Tarauni, UGG= Ungwaggo

Table 4. reports concentrations of heavy metals and micro-elements (Ca, Fe, K, Mg, Cd, Ni, and Pb) to expand the nutritional assessment. Calcium levels, for instance, ranged from about 3.71 mg/L in some samples to 24.40 mg/L in control, while potassium levels varied widely, reaching up to around 785.4 mg/L in control and lower values in several market samples. Iron and magnesium also exhibited significant differences among samples. These findings are consistent with the idea that standardized processing preserves mineral content better than informal methods, where repeated dilutions, losses into soak water, and variation in bean-to-water ratios can reduce the final concentrations per unit volume. In general, the presence of these micro-elements at nutritionally relevant levels confirms that *dage* can

contribute to micronutrient intake, especially in populations with limited access to animal-based sources of Ca and Fe (Faour-Klingbeil and Todd, 2020).

The detection of heavy metals such as cadmium (Cd), nickel (Ni), and lead (Pb), albeit at low levels, has significant food safety implications. This is in line with Goldhaber (2003), which stated that, the risk assessment of essential trace elements such as copper, iron, manganese e.t.c examines that, high intakes result in toxicity and low intakes resulting in nutritional deficiencies. The control sample typically showed lower heavy metal concentrations than many market samples, indicating that environmental contamination such as (water quality, soil contamination of beans/contact surfaces e.g., metallic grinding equipment, storage and serving containers) occurs (Anyanwu, 2019). Similarly, Rahaman and Singh (2019), confirmed that, certain heavy metals such as cadmium (Cd), chromium (Cr), and Lead (Pb) are non-threshold toxins and can exert toxic effects at very low concentrations moreover, they are known as most problematic heavy metals as well as toxic heavy metals. Furthermore, Lead and nickel exposure even at low levels, is associated with neurotoxicity, nephrotoxicity, and other adverse health outcomes (Siddig and Barka, 2015). Although the present work does not directly compare measured levels to regulatory limits, the fact that some samples showed higher Pb and Ni than the control underscores the need for systematic monitoring of raw materials, water sources, and equipment, as well as adherence to national and international standards for contaminants in foods and beverages.

Table 4: Micro-Elements and Heavy Metal Concentration of *Dage* from Difference Locations of Kano State

SPL	Ca mg/L	Fe mg/L	K mg/L	Mg mg/L	Cd mg/L	Ni mg/L	Pb mg/L
CTL	24.40 ± 0.039[a]	3.088 ± 0.051[a]	785.4 ± 12.8[a]	1.298 ± 0.006[a]	0.017 ± 0.004[a]	0.130 ± 0.002[c]	0.007 ± 0.001[d]
DAL	23.36 ± 0.058[a]	1.023 ± 0.023[c]	518.4 ± 8.23[b]	1.254 ± 0.007[a]	0.014 ± 0.001[c]	0.158 ± 0.005[a]	0.049 ± 0.014[a]
FGE	8.63 ± 0.045[c]	1.076 ± 0.022[c]	756.8 ± 11.92[a]	0.780 ± 0.049[b]	0.015 ± 0.002[b]	0.161 ± 0.002[a]	0.029 ± 0.034[c]
GWL	11.42 ± 0.101[b]	0.583 ± 0.029[d]	554.2 ± 4.24[b]	0.143 ± 0.013[d]	0.016 ± 0.002[a]	0.157 ± 0.002[a]	0.009 ± 0.034[d]
KBT	5.38 ± 0.039[e]	1.689 ± 0.035[c]	228.2 ± 11.19[e]	0.459 ± 0.015[c]	0.016 ± 0.001[a]	0.168 ± 0.004[a]	0.053 ± 0.025[a]
KMC	11.06 ± 0.031[b]	2.949 ± 0.043[a]	460.6 ± 12.46[c]	0.435 ± 0.022[c]	0.015 ± 0.002[b]	0.161 ± 0.002[a]	0.024 ± 0.015[b]
NSR	5.26 ± 0.033[e]	1.300 ± 0.037[c]	308.5 ± 10.11[d]	0.210 ± 0.014[d]	0.016 ± 0.001[a]	0.141 ± 0.008[b]	0.025 ± 0.054[b]
TRN	3.71 ±0.057[f]	2.449 ± 0.037[b]	360.7 ± 5.64[d]	0.863 ± 0.050[b]	0.016 ± 0.001[a]	0.149 ± 0.006[b]	0.014 ± 0.011[c]
UGG	6.92 ± 0.041[d]	0.308 ± 0.024[d]	377.5 ± 18.05[d]	1.172 ± 0.018[a]	0.015 ± 0.001[b]	0.174 ± 0.006[a]	0.041 ± 0.014[a]

Values are Mean ± Standard Deviation of Three Determinations. Values with Different Superscripts in a Column are Significantly Different at p<0.05. SPL = Sample, = Ctr= Control, DAL= Dala, FGE = Fage, GWL = Gwale, KBT = Kumbotso, KMC= Kano Municipals, NSR= Nasarawa, TRN= Tarauni, UGG= Ungwaggo

The sensory evaluation in Table 5, provides a consumer-level perspective on how these compositional and process differences manifest. The control sample (CTL) achieved the highest scores for colour (8.10 ± 0.96[a]), taste (8.05 ± 1.19[a]), flavour (8.10 ± 1.17[a]), aftertaste (7.95 ± 1.10[a]), and overall acceptability (8.35 ± 0.81[a]), indicating that a well-controlled, hygienically produced *dage* is highly acceptable to consumers. Market samples such as DAL and NSR showed good but slightly lower scores (overall acceptability around 7.8 and 7.15, respectively), demonstrating that some traditional processors produce *dage* that approaches the sensory quality of the lab control. In contrast, samples like KBT and TRN scored significantly lower for colour (≈5.48–6.44), flavour (≈5.70–6.11), and overall acceptability (≈6.18–6.55), suggesting that inconsistencies in raw material quality, fermentation control, or hygiene contribute to off-colours, off-flavours, or undesirable mouthfeel (Anya *et al.*, 2024).

These results align well with reports that consumer acceptance of fermented soy beverages is strongly influenced by flavour, absence of "beany" notes, and smooth texture. Fermentation with appropriate starter cultures and careful control of time–temperature conditions are known to reduce beany flavour, increase sweetness and umami through hydrolysis of proteins and carbohydrates, and enhance overall palatability (Oluwakemisola, 2025). Where uncontrolled microflora dominates or where contamination occurs post-processing, defects such as sourness, rancidity, or sedimentation may arise, undermining acceptability. Thus, the pattern observed in Table 4.8—high acceptability for the lab control and selected market samples, but notably lower scores for others—corroborates the physicochemical and microbiological evidence of process variability and points to the need for training and standardized guidelines for *dage* producers to achieve both safety and consumer satisfaction (Felberg *et al.*, 2024).

Table 5: Sensory Analysis of *Dage* from Difference Locations of Kano State

SPL	Colour	Texture/mouth feel	Taste	Flavour	After taste	Overall Acceptability
CTL	8.10 ± 0.96[a]	7.75 ± 1.21[b]	8.05 ± 1.19[a]	8.10 ± 1.17[a]	7.95 ± 1.10[a]	8.35 ± 0.81[a]
DAL	7.04 ± 1.30[c]	7.35 ± 0.99[b]	7.89 ± 1.33[b]	7.80 ± 2.0[b]	7.55 ± 1.88[b]	7.82 ± 0.90[b]
FGE	6.88 ± 1.91[d]	7.0 ± 0.99[c]	6.75 ± 1.11[c]	7.00 ± 0.90[c]	7.25 ± 1.40[b]	7.25 ± 1.00[c]
GWL	8.01 ± 1.75[a]	6.88 ± 1.12[d]	7.55 ± 1.44[b]	7.49 ± 0.88[b]	7.41 ± 1.25[b]	7.35 ± 0.95[c]

SPL	Colour	Texture/mouth feel	Taste	Flavour	After taste	Overall Acceptability
KBT	5.48 ± 2.06^{e}	6.51 ± 1.55^{d}	6.66 ± 1.33^{c}	5.70 ± 0.55^{e}	6.20 ± 0.90^{d}	6.55 ± 1.15^{e}
KMC	7.58 ± 1.27^{c}	7.48 ± 0.70^{b}	7.89 ± 0.89^{b}	6.75 ± 0.94^{c}	6.04 ± 0.39^{d}	6.25 ± 1.05^{e}
NSR	7.98 ± 2.11^{b}	8.01 ± 0.41^{a}	7.70 ± 1.04^{b}	7.40 ± 0.51^{b}	7.08 ± 0.40^{c}	7.15 ± 1.30^{d}
TRN	6.44 ± 3.00^{a}	5.94 ± 1.22^{e}	6.05 ± 0.78^{c}	6.11 ± 0.97^{d}	5.98 ± 0.87^{e}	6.18 ± 1.14^{e}
UGG	7.58 ± 1.81^{c}	6.85 ± 1.35^{d}	7.59 ± 0.91^{b}	7.66 ± 1.35^{c}	7.11 ± 0.75^{c}	7.38 ± 2.0^{c}

Values are Mean ± Standard Deviation of three Determinations. Values with Different Superscripts in a Column are Significantly Different at $p<0.05$. SPL = Sample = Ctr= Control, DAL= Dala, FGE = Fage, GWL = Gwale, KBT = Kumbotso, KMC= Kano Municipals, NSR= Nasarawa, TRN= Tarauni, UGG= Ungwaggo

CONCLUSIONS

This study underscores the need for quality control measures in traditional "dage" production to enhance safety, nutritional value, and consumer acceptability. Standardization of processing methods is recommended to improve product quality and public health outcomes. The variability in composition and quality highlights food safety and nutritional concerns. Standardized processing is needed to ensure consistent quality and minimize contamination risks. Implementation of Good Manufacturing Practices (GMP) and Hazard Analysis and Critical Control Points (HACCP) for "dage" production.

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