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Evaluation of Microbiological Quality and Safety of Locally Produced Soya Beans Milk (Dage) Production in Kano State Metropolis

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Abstract*— This study assessed the microbial safety and quality of locally processed soya beans milk (Dage), identifying critical control points (CCPs) and characterizing isolates. The results indicated acidic pH (3.78–4.98) and varying viscosity (415.00–840.50 mPa·s). Mesophilic bacterial counts varied significantly ($p < 0.05$) among samples (7.12×10^2 to 2.72×10^5 CFU/ml), with Bacillus cereus, Staphylococcus aureus, Streptococcus thermophilus, and Actinomycetes detected. Fungal isolates included Mucor species, Penicillium maximae, and Aspergillus niger (1.08×10^2 to 1.06×10^3 CFU/ml). Molecular analysis confirmed sporulation genes in bacterial isolates and aflD gene in some fungal isolates, indicating potential aflatoxin production. CCP analysis revealed inadequate hygiene and sanitation practices as major contributors to contamination. 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. Conclusively the results highlight the need for quality control measures in traditional "dage" production to enhance safety, nutritional value, and consumer acceptability. Good Manufacturing Practices (GMPs), Hazard Analysis and Critical Control Points (HACCP) principles, handlers training on hygiene and sanitation, preodic testing of pathogens and toxins should be implemented.

Keywords*— soya beans milk (Dage) Physiochemical properties, Microbiological analysis, Critical control point, Morphological Characteristics, Sensory evaluation.

I. INTRODUCTION

Soybean (*Glycine max*), a leguminous crop (Mossie *et al.*, 2024). It's called "miracle plant" because of its high nutritional value (güzeler and yildirim 2016). A major source of plant proteins and oils (Liu *et al.*, 2020). It offers cost-competitive and versatile plant base-protein ingredient (Belobrajdic *et al*., 2023).

And the only highly desirable ingredient for producing meat alternatives with all the essential amino acids in amounts that can adequately meet human physiological requirements (Voora 2020). With potential of alleviating large scale protein malnutrition (Kamble 2021). It can help in the prevention of breast cancer when consumption starts during childhood (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).

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.

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To ensure the safety of Dage, it is essential to identify Critical Control Points (CCPs) in its production process. The HACCP concept permits a systematic approach to the identification of hazards and an assessment of the likelihood of an occurrence during manufacture, distribution and use of a food product, and defines measures for their control. In the concept, the term hazard refers to any agent in, or condition of, food that is unacceptable because it has the potential to cause an adverse health effect. The hazards include pathogenic microorganisms and/or their toxins, chemicals (carcinogens and allergens), and physical objects such as stones, bottles etc. that may injure the consumer (Daniel, *et al.*, 2024).

Therefore, the application of HACCP to food preparation permits the identification of practices that may be potentially hazardous and requires modification or practices that are critical for ensuring the safety of the food and requires specific monitoring (Gorman and Meeker, 2015). International association of food protection, (2009) also reported that HACCP studies of some fermented products have revealed that depending on the process and hygienic condition during preparation, some fermented foods might still pose a safety risk mainly due to post fermentation contaminations. The assurance that food will not cause harm/injury to the consumer when it is prepared and/or consumed according to intended use is referred to as food safety (US-FDA, 2020). Hazard Analysis and Critical Control Points (HACCP) has emerged as a systematic approach to identifying, evaluating, and controlling food safety hazards. Developed in the 1960s by the Pillsbury Company, NASA, and the US Army Laboratories, HACCP has since become a globally recognized preventive system for ensuring food safety (Mortimore and Wallace, 2018).

II. HACCP Concept

Hazard Analysis and Critical Control Point (HACCP) is a globally accepted program for ensuring food safety (Abdullahi, *et al.*, 2021). HACCP is a system which provides the framework for monitoring the total food system, from harvesting to consumption, to reduce the risk of foodborne illness (Faour-Klingbeil and Todd, 2020). The system is planned to establish and control potential difficulties before they occur. It is applied as a standard for the development of food safety guidelines by food regulatory organizations, and its application by food manufacturers and business operators is mandatory in many nations (Musaj *et al.*, 2012).

The HACCP system is used in food processing to identify certain hazards and control measures, in order to secure the safety of foods thereby preventing contamination (Rai *et al*., 2014). Its application in traditional food processing caused symbolic improvement in food safety (Abdullahi, *et al.*, 2021). HACCP system has been recognized as a productive and rational means of ensuring food safety from primary production to final consumption, using a “farm to table” methodology (El-Hofi *et al*., 2010).

There are obvious food safety challenges across West-African sub-region with specific emphasis on Nigeria with reported cases of foodborne diseases and outbreaks (Oguntoyinbo, 2014). The unhygienic conditions under which local production occurs include unclean processing environment, equipment contaminations, use of contaminated water from producers and poor storage (Abdullahi, *et al.*, 2021). This accounts for poor microbiological quality in many traditional foods and can pose grave risks to consumers (Omemu and Adeosun, 2010). Lack of economic resources, purchasing power, more complex food-handling practices, lack of technical expertise and limited personnel have all been cited as barriers to HACCP implementation in retail and catering sectors (Karaman *et al*., 2012).

III. Principles HACCP Seven

The seven HACCP principles are to conduct a hazard analyses, identify the critical control points (CCPs), establish critical limits for preventive measures associated with each identified CCP, establish CCP monitoring requirements, establish corrective actions to be taken when monitoring indicates there is a deviation from an established critical limit, establish verification procedures and establish record-keeping and documentation procedures (Abd El-Razik *et al*., 2016; Abdullahi, *et al.*, 2021). There is a need for every food been consumed to be subjected to HACCP system.

Fermented / dairy products have been long associated with the transmission of food-borne diseases (Anyanwu, 2019). Interestingly, the application of HACCP program in dairy (from animal and plant sources) processing significantly improves the microbial quality and safety of the finished products (Musaj *et al*., 2012). Critical control points (CCP) in fermented milk processing are raw milk, after pasteurization, mixing with other ingredients, fermentation, packaging, and storage (Musaj *et al*., 2012; Siddig and Barka, 2015).

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IV. Theoretical Framework On HACCP

The HACCP concept permits a systematic approach to the identification of hazards and an assessment of the likelihood of an occurrence during manufacture, distribution, and use of a food products, and defines measures for their control (Mortimore and Wallace, 2018). In the concept, the term hazard refers to any agent in, or condition of, food that is unacceptable because it has the potential to cause an adverse health effect. The hazards include pathogenic microorganisms and/or their toxins, chemicals (carcinogens and allergens), and physical objects such as stones, bottles etc. that may injure the consumer (Daniel, *et al.,* 2024).

Despite the dawn of science and technology in developing countries, most production of fermented foods may still largely be a traditional family art at home in crude manner. The foods are produced at household level and sent to relations abroad, whereas some are produced semi-commercially. In all this, hygiene and presence of chemicals and physical objects are a major concern. Therefore, the application of HACCP to food preparation permits the identification of practices that may be potentially hazardous and requires modification or practices that are critical for ensuring the safety of the food and requires specific monitoring (Gorman and Meeker, 2015). International association of food protection, (2009) also reported that HACCP studies of some fermented products have revealed that depending on the process and hygienic condition during preparation, some fermented foods might still pose a safety risk mainly due to post fermentation contaminations (Mortimore and Wallace, 2018). The assurance that food will not cause harm/injury to the consumer when it is prepared and/or consumed according to intended use is referred to as food safety (US-FDA, 2020). It is therefore the aim of the authors to identify possible hazards and CCPs in the production of some Nigerian fermented dietary foods in order to help reduce risks to health as a result of the consumption of these foods as well as to promote both local and international trade relations as some of these foods have been introduced into other parts of the country and some into the Diaspora where they are consumed by some members of the populace therein (Abdullahi, *et al.,* 2021).

In the dynamic landscape of the food and beverage industry, ensuring the safety of products is paramount. Hazard Analysis and Critical Control Points (HACCP) has emerged as a systematic approach to identifying, evaluating, and controlling food safety hazards.

Developed in the 1960s by the Pillsbury Company, NASA, and the US Army Laboratories, HACCP has since become a globally recognized preventive system for ensuring food safety (Mortimore and Wallace, 2018).

V. Statement Of Problem

The local processing soya bean products such as soya bean milk (Dage) in Kano Metropolitan faces significant challenges due to the lack of adequate sanitary measures, poor hygienic environment and lack of adherence to Good Manufacturing Practices (GMPs), as well as limited understanding of food safety hazards, inadequate processing and storage facilities. Insufficient regulatory oversight. These factors contribute to the risk of contamination, compromising the health and well-being of consumers. The soya milk is consumed as one of the major beverages in Kano metropolis especially during the hot season which may lead to cereal outbreaks if not properly handled, therefore there is a need to develop a CCP in the processing units from the raw materials to the point of consumption.

VI. Justification

This study aims at addressing the knowledge gap in identifying CCPs in "Dage" soya bean milk locally beverage to ensure the safety and quality of this widely consumed product by developing a CCP as a model for the producers as well as to determine the microbiological, physicochemical and heavy metal content of samples. This research intern to inform the local producers on critical control points to improve food safety, enhance regulatory oversight and enforcement, Protect public health by reducing foodborne disease risk and outbreak, contribute to the development of evidence-based food safety policies among the producers.

VII. Methodology

Sample Collection

The samples of locally produced soyabeans drinks (Dage) were selected at random from different locations withing the local governments area 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.

VIII. 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

IX. Microbiological Analysis Of "DAGE" Samples

Enumeration Of Aerobic Bacteria

Serial dilution method was used to enumerate the appearance of the colony of each isolate on the agar media was studied as described by Phumudzo *et al*., (2013). Characteristics observed include shape, edge, colour, elevation and texture.

Isolation And Identification Of Bacteria From Soya Bean Milk Samples

The colour, size, shape and microscopy, surface elevation and margin of different colonies developing on the plates will be observed. Representative colony of the various morphological types were picked and transferred to a fresh prepared, sterilized and solidify nutrients agar and will be incubated at 35^0C for 24 hours to obtain pure culture of the organisms, (Pundir *et al*., 2013)

Isolation Of Escherichia Coli From Samples

A portion of each of the isolate will be inoculated for sub-culture in to BGLB broth by means of a 3mm loop. These tubes were incubated at 35^0C ± 0.5 for 24 hours. A small portion from the positive BGLB tubes that shows gas within 24 hours will be streaked with aid of a 3mm loop onto previously prepared eosin methylene blue agar. The plates will be incubated at 44^0C for 48 hours. Colonies appearing as green metallic sheen on Eosine methylene blue agar were identified primarily as *E. coli.* (Pundir *et al*., 2013).

Isolation of Staphylococcus Aureus Staphylococcus Epidermis's

This was done according to the method described by Pundir *et al*., (2013), with some modifications. A portion of each of the Isolate was streaked onto the surface of previously dried duplicate plate of Manitol salt agar. The plates were incubated at 35^0C for 48 hours. Opaque Colonies, 1-2mm in diameter appearing yellow and light pink on Manitol salt agar will primarily be identified as *Staphylococcus aureus* and *staphylococcus epidermis's* respectively

Isolation Of Salmonella Spp And Shigella SPP

Desoxycholate Citrate Agar (DCA) (Park Scientific Limited, Moultan Park, and Northampton) was used for the isolation and of Salmonella and Shigella spp. The DCA plates were streaked with the isolates and incubated at 37^oC overnight. Typical colonies with black centers were identified *as Salmonella spp* on DCA according to Macfaddin (2000). Pinkish colonies were identified presumptively as Shigella on DCA and subjected to further biochemical testing (Pundir *et al*., 2013).

Isolation Of Pseudomonas Aeruginosa And Klebsiella SPP.

A portion of each isolate will be streaked onto the surface of previously dried duplicate plate of Mac Conkey agar and CLED agar. The plates were incubated at 37^0C for 48 hours. Colonies which had green appearance on CLED agar was primarily identified as *Pseudomonas aeruginosa*; while large mucoid pink colonies on Mac Conkey agar were primarily identified as *Klebsiella spp.* (Pundir *et al*., 2013).

GRAM'S Reaction

The isolated organisms will be subjected to Gram's staining techniques as described by Leboffe, (2014). The Gram staining involved the preparation of smear of 24 h culture of an organism on clean grease-free glass slide. The smear was heat fixed by passing the reverse side of slide slightly over flame three times. The heat fixed smear of cells was stained with 0.20% crystal violet staining reagent for 60 seconds. The slide was then flooded with Lugols iodine (a mordant) and left for 30 seconds before it was washed off with distilled water. The slide was decolorized again with 95% (vol/vol) ethanol for 10 seconds and flushed with distilled water to prevent excessive discolouration and then counter-stained with 0.25% safranin solution for 1 minute, washed off with water and allowed to dry.

A drop of immersion oil was added to the stained slide and examined under the oil immersion objective lens of the microscope as described by Leboffe, (2014).

Biochemical Tests

The isolated organisms were subjected to biochemical tests such as: Catalase test, Coagulase, Indole test, Methyl red- voges Proskauer, Citrate test, Motility test, Carbohydrate fermentation and Urease test as described by Cheesebrough (2000).

Isolation And Identification Of The Moulds

The colonies on each plate were counted and recorded, after which each type of fungal colony was sub cultured onto fresh medium (PDA) to obtain pure culture in PDA slants.

The technique of James and Natalie (2001) was adopted for identification of the unknown isolated fungi using cotton blue in lacto-phenol stain. The identification was achieved by placing a drop of the stain on clean slide with the aid of a mounting needle, where a small portion of the mycelium from the fungal cultures was removed and placed in a drop of lacto-phenol. The mycelium was spread very well on the slide with the aid of the needle. A cover slip was gently applied with little pressure to eliminate air bubbles. The slide was then mounted and observed with x10 and x40 objective lenses respectively. The species encountered were identified in accordance with Cheesbrough (2000).

DAGE Local Northern Nigerian Traditional Food

One of the basic necessities of life is Food. Every country is bequeathed with a host of traditional foods and beverages made from rich provisions of raw food materials. These local foods are a part of street vended foods in the country. It has been documented that four out of every five Nigerians frequently buys street foods at least once a day (Wogu *et al.,* 2011). Therefore, Food safety management systems such as, HACCP have been enforced to prevent contamination of food and food borne diseases and infections (Kim *et al*., 2020)

Dage, a popular soya beans milk beverage, is widely consumed in Nigeria, particularly in Kano Metropolitan. Local producers / manufacture Dage used 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. To ensure the safety of Dage, it is essential to identify Critical Control Points (CCPs) in its production process.

"DAGE" Soya Milk Drink

The local processing soya bean products such as soya bean milk (Dage) in Kano Metropolitan faces significant challenges due to the lack of adequate sanitary measures, poor hygienic environment and lack of adherence to Good Manufacturing Practices (GMPs), as well as limited understanding of food safety hazards, inadequate processing and storage facilities. Insufficient regulatory oversight (Karaman *et al*¸2012). These factors contribute to the risk of contamination, compromising the health and well-being of consumers. The soya milk is consumed as one of the major beverages in Kano metropolis especially during the hot season which may lead to cereal outbreaks if not properly handled, therefore there is a need to develop a CCP in the processing units from the raw materials to the point of consumption (Joseph, 2015).

This review identifies available literature and focuses on addressing the knowledge gap in identifying CCPs in "Dage" made from soya bean milk locally beverage to ensure the safety and quality of this widely consumed product by developing a CCP as a model for the producers as well as to determine the microbiological (Joseph, 2015), This research intern to inform the local producers on critical control points to improve food safety, enhance regulatory oversight and enforcement, protect public health by reducing foodborne disease risk and outbreak, contribute to the development of evidence-based food safety policies among the producers (Karaman *et al*¸2012).

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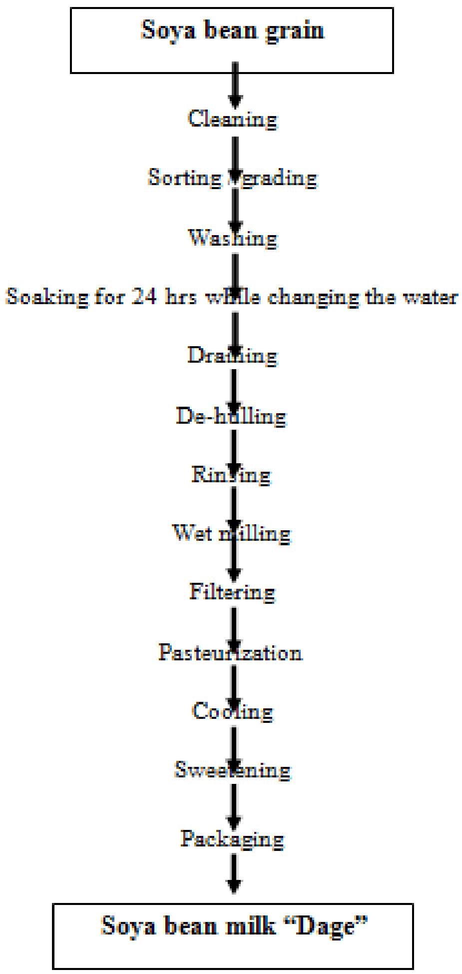

Fig. 1: Flow-Chart for the preparation of 'Dage' soya bean milk

X. Statistical Analysis

All determinations were carried out in triplicates measures for the analysis. The data generated were analyzed using Minitab 17, Statistical software for data analysis. Means and standard deviation were calculated among the samples from values obtain from the analysis as described by Onwuka, (2018).

Analysis of variance (ANOVA) result were used to compare the values obtain and the level of significance were considered significant at ($P \leq 0.05$) using mean separate by turkeys' test as described by (Onwuka, 2018).

XI. Results And Discussion

The findings demonstrate that locally processed soya beans milk (*dage*) in Kano metropolis is a nutritionally valuable but microbiologically vulnerable product, with clear critical control points required to ensure safety and consistent quality. Across the objectives, the study links high mesophilic loads, presence of pathogenic and toxigenic microorganisms, variable composition and sensory quality, and identifiable failures in hygiene and process control to the informal nature of production and sale, while also showing that, under controlled conditions, *dage* can meet acceptable microbiological and sensory standards.

The significant differences ($p < 0.05$) in counts among locations indicate heterogeneity in hygiene practices and process control within the metropolis. For example, samples from Kano Municipal and Fagge, which recorded among the highest bacterial loads, may be produced in more crowded, high-throughput environments where rapid turnover and limited infrastructure hinder implementation of good manufacturing practices (GMP). Conversely, samples with relatively lower counts (e.g., control and some other locations) illustrate that, when soaking, grinding, boiling, and fermentation are conducted under more controlled and hygienic conditions, microbial loads can be kept at levels more consistent with safe consumption (Okur *et al.*, 2025). This aligns with literature on blanching and optimized heat treatments, which reports that sufficient heating can markedly reduce initial microbial loads in soymilk, though such benefits are quickly lost if subsequent handling is unhygienic or the product is stored at ambient temperatures for extended periods. Similar conclusions have been reported for street-vended and traditionally fermented soymilk products in Nigeria and other developing regions, where informal production systems often lack standardized controls (John *et al.*, 2023; Ikegwu *et al.*, 2024).

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TABLE 1.
PHYSICOCHEMICAL PROPERTIES

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 1. 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 achieve the physicochemical profile associated with high-quality, stable fermented soy beverages.

TABLE 2.
MESOPHILIC BACTERIAL AND FUNGAL COUNTS OBTAINED SAMPLES OF SOYBEANS MILK

S/N	Sample ID	Bacterial counts (CFU/ml)	Fungal counts (CFU/ml)	Isolates
1.	A	7.12×10^{2a}	1.73×10^{2a}	*B. cereus, S. aureus*
2.	B	2.10×10^{4b}	8.86×10^{2b}	*S. aureus, Strep. thermophilus*
3.	C	1.97×10^{5c}	1.08×10^{2a}	*B. cereus, S. aureus, Aspergillus* spp.
4.	D	2.08×10^{4b}	4.88×10^{2c}	*B. cereus, Strep. thermophilus*
5.	E	3.05×10^{4b}	4.40×10^{2c}	*Strep. thermophilus, S. aureus*
6.	F	2.72×10^{5c}	8.60×10^{2b}	*S. aureus, Actinomycetes, Aspergillus* spp.
7.	G	3.12×10^{4b}	1.06×10^{3a}	*Aspergillus* spp., *B. cereus, S. aureus*
8.	H	2.01×10^{5c}	4.90×10^{2a}	*S. aureus, Strep. thermophilus Aspergillus* spp.
9.	I	4.16×10^{4b}	5.66×10^{2c}	*B. cereus, Strep. thermophilus, Aspergillus* spp.

Values are Mean of triplicate determination ± S.D Different superscripts on the same row are significantly different (p≤ 0.05) according to Duncan Multiply range test Keys; A – Lab (Control), B – Dala, C – Fagge, D – Gwale, E – Kumbotso, F – Kano municipal, G – Nasarawa, H – Tarauni, I – Ungoggo, Values having similar superscript letter in a column are not significantly different (p<0.05).

Table2. 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)***.

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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 reduces 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 are mainly attributed to the presence of bioactive compounds such as polyphenols and flavonoid (Nowak and Gośliński, 2020).

TABLE 3.
PHYSICOCHEMICAL PROPERTIES

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 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 achieve the physicochemical profile associated with high-quality, stable fermented soy beverages.

TABLE 4.
MICRO-ELEMENTS AND HEAVY METAL CONCENTRATION

SPL	Ca mg/L	Fe mg/L	K mg/L	Mg mg/I	Cd mg/L	Ni mg/L	Pb mg/L
CTL	24.40 ± 0	3.088 ± 0	785.4 ± 1	1.298 ± 0	0.017 ± 0	0.130 ± 0	0.007 ± 0.001^{d}
DAL	23.36 ± 0	1.023 ± 0	518.4 ± 8	1.254 ± 0	0.014 ± 0	0.158 ± 0	0.049 ± 0.014^{a}
FGE	8.63 ± 0.0	1.076 ± 0	756.8 ± 1	0.780 ± 0	0.015 ± 0	0.161 ± 0	0.029 ± 0.034^{c}
GWL	11.42 ± 0	0.583 ± 0	554.2 ± 4	0.143 ± 0	0.016 ± 0	0.157 ± 0	0.009 ± 0.034^{d}
KBT	5.38 ± 0.0	1.689 ± 0	228.2 ± 1	0.459 ± 0	0.016 ± 0	0.168 ± 0	0.053 ± 0.025^{a}
KMC	11.06 ± 0	2.949 ± 0	460.6 ± 1	0.435 ± 0	0.015 ± 0	0.161 ± 0	0.024 ± 0.015^{b}
NSR	5.26 ± 0.0	1.300 ± 0	308.5 ± 1	0.210 ± 0	0.016 ± 0	0.141 ± 0	0.025 ± 0.054^{b}
TRN	3.71 ±0.0	2.449 ± 0	360.7 ± 5	0.863 ± 0	0.016 ± 0	0.149 ± 0	0.014 ± 0.011^{c}
UGG	6.92 ± 0.0	0.308 ± 0	377.5 ± 1	1.172 ± 0	0.015 ± 0	0.174 ± 0	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

Table 4. extends the nutritional assessment by reporting micro-element and heavy metal concentrations (Ca, Fe, K, Mg, Cd, Ni, Pb). 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 results 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 5.
SENSORY ANALYSIS

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]
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*

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).

XII. Conclusions And Recommendations

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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