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Article

Microbiological Profile of Peanut Muamba: A Quality and Food Security Study in Luanda, Angola

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Abstract: The peanut (Arachis hypogaea L.) is widely consumed for its oily characteristics and high nutritional value. It is used in the production of oil and muamba, a creamy peanut paste, and is of great economic importance. Its contamination is common due to its high moisture content. Although widely consumed, little data are available on the microbiological profile of the peanut muamba produced and consumed in Luanda, the capital of Angola. This study aimed to evaluate the microbiological profile of peanut muamba at the National Institute of Quality Control (INACOQ). This was a retrospective study conducted with 25g of 25g of peanut muamba at INACOQ, in Luanda, Angola, between 8 and 12 August 2024. All peanut muamba samples were free from Salmonella spp. in 25 g of product. Thermotolerant coliform counts were below 10 CFU/g. Mould and yeast counts were below 100 CFU/g. The average count of mesophilic aerobic bacteria was 1,600 CFU/g. The muamba of peanut samples showed good microbiological quality, with no presence of Salmonella spp. and low levels of indicator microorganisms. These results indicate adequate sanitary practices during production and reinforce the importance of hygienic-sanitary control to ensure food safety and protect public health.

Keywords: Arachis hypogaea L.; Muamba of peanut; microbiological analysis; food safety; Angola

1. Introduction

Peanut cultivation (*Arachis hypogaea L.*) in Angola has long been intertwined with traditional agricultural practices and cultural expressions, reflecting its deep-rooted significance in the national food system (Ferrão, 2013). In several communities, peanut farming is embedded within ceremonial activities and harvest festivals, which underscore its sociocultural relevance (Tavares, Oliveira, & Mendes, 2019).

Annual peanut production in Angola exhibits considerable variability, primarily influenced by climatic conditions, agricultural techniques, and market dynamics (Gil, 2019). Estimates suggest that national output fluctuates between 100,000 and 150,000 tonnes per year. However, adverse factors such as drought, pest infestations, and plant diseases frequently compromise yields (Alvarenga, Da Silveira, & Buainain, 2023), as demonstrated in governmental or institutional agricultural reports is advisable (FRESAN, 2024).

Peanut cultivation in Angola is primarily concentrated in provinces such as Uíge, Malanje, Kwanza Sul, and Huíla, where environmental conditions favour its growth (Paim, 2016). The crop

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holds both cultural and economic value, being used extensively in local gastronomy, either as roasted seeds or as a core ingredient in various dishes and also serves as animal feed (Gondim & Rolim, 2024). Introduced to Africa from South America during the colonial period, Arachis hypogaea has demonstrated strong adaptability to the diverse agroecological zones across the continent, including Angola (Souza & Menezes, 2023).

In addition to its nutritional importance, peanut production contributes meaningfully to rural livelihoods and food security, serving as a source of income for smallholder farmers (Ngale & Zidora, 2024). Nonetheless, the processing and commercialisation of peanut-derived products, such as the muamba, pose potential public health risks due to microbial contamination at various stages of the value chain (Oliveira et al., 2019). The quality of peanut muamba is determined by several parameters, including physical, chemical, nutritional, sensory, and microbiological attributes.

Despite the crop's prominence, scientific research on the microbiological safety and quality of peanut-based products in Angola remains limited. Addressing this knowledge gap, the present study aimed to evaluate the microbiological profile of peanut muamba samples collected and analyzed at the Central Laboratory of the National Institute for Quality Control (INACOQ) in Luanda, the capital city of Angola, in order to underscore the role of hygienic-sanitary measures in ensuring food safety and mitigating public health risks in Angola.

2. Materials and Methods

2.1. Study Design and Settings

This was a retrospective study conducted with 25g of peanut muamba at the National Institute of Quality Control (INACOQ), located in Luanda, the capital city of Angola, between 8 and 12 August 2024. The study protocol was reviewed and approved by the general, technical and scientific management of INACOQ (nr. 96/DG.INACOQ-MINDCOM/2025, dated April 30, 2025).

2.2. Sample Collection and Laboratory Processing

2.2.1. Analysis of Total and Thermotolerant Coliforms

Quantification of total and thermotolerant coliforms was performed using the Most Probable Number (MPN) method, a widely accepted technique for estimating microbial density in water and food samples. This method is based on the statistical probability of bacterial presence in a series of dilutions. For this analysis, serial dilutions of peanut samples were prepared and inoculated into the chromogenic substrate Colilert® (IDEXX Laboratories), following the manufacturer's instructions. The inoculations were distributed into three sets of five tubes each, allowing a robust estimation at different concentration levels. The inoculated tubes were incubated at a controlled temperature of 35°C for 24 hours. After incubation, the tubes were examined for colour changes as an indicator of bacterial activity. A change in colour from the original clear or slightly yellowish hue to a distinct yellow was interpreted as a positive result for the presence of total coliforms. This colour change occurs due to the enzymatic hydrolysis of chromogenic substrates by coliform enzymes, indicating metabolic activity consistent with the presence of these bacteria. This method is particularly useful in food microbiology, as it combines simplicity, reliability and sensitivity, making it suitable for routine quality control.

2.2.2. Microbiological Analysis

Microbiological analysis was performed following the methodology proposed by Silva et al. (2007), with the necessary adaptations to the context of this study. The culture medium used was Plate Count Agar (PCA) for the enumeration of mesophilic aerobic bacteria. Each sample was identified and labelled from A1 to A3 to maintain traceability throughout the analytical process. Under aseptic conditions, 1 g of each peanut muamba sample was accurately weighed inside a sterile laminar flow hood to minimise the risk of environmental contamination. The weighed sample was

 doi:10.20944/preprints202505.0876.v1

then transferred to a sterile test tube containing 9 ml of buffered peptone water. This primary suspension was homogenised, and a 1 ml aliquot was removed and spread on sterile Petri dishes containing PCA. All inoculations were performed in duplicate to ensure analytical reliability and reproducibility. The plates were incubated in an inverted position at 37°C for 48 hours in a controlled bacteriological incubator. After incubation, the colonies that developed were counted manually using a standard colony counter. The final result for each sample was calculated by averaging the duplicate counts and expressed in colony-forming units per gram (CFU/g). This methodological approach ensures the accurate quantification of mesophilic bacteria, which are key indicators of overall microbiological quality and hygienic handling throughout the peanut muamba production and processing chain.

2.2.3. Analysis of *Salmonella* spp.

Detection of Salmonella spp. was performed on a 250 g portion of each sample using an enzyme-linked immunosorbent assay based on the VIDAS® system (bioMérieux, France). This method uses an enzyme-linked fluorescence assay (ELFA) technique, which allows rapid and specific identification of Salmonella antigens. Prior to analysis, samples underwent a pre-enrichment phase in buffered peptone water, followed by selective enrichment and transfer to the test device. The automated Mini-Vidas system was used to process and interpret the results, providing reliable and standardised detection.

2.2.4. Mould and Yeast Count

The plate count methodology recommended by the American Public Health Association (2001) was used, with specific adaptations based on the procedures described by Taniwaki et al. (2001). All sample handling and processing steps were conducted under aseptic conditions, using sterilised instruments to preserve the integrity and reliability of the microbiological analyses. In a laminar flow hood, 5 grams of each peanut swab sample were accurately weighed on an analytical balance. The samples were then macerated in a sterile porcelain mortar and pestle. From the homogenised mass, 1 g was transferred to sterile test tubes containing peptone saline solution for serial dilution, resulting in dilutions of 10^{-1} and 10^{-2}. The suspensions were thoroughly mixed to ensure complete homogenization. Of each dilution, 1 ml was inoculated in duplicate onto sterile Petri dishes containing Potato Dextrose Agar (PDA), a medium commonly used for the cultivation of yeasts and fungi. The inoculum was evenly distributed over the agar surface with a sterile Drigalski spatula, previously disinfected by flaming in 70% ethanol. The plates were incubated at a temperature and duration appropriate to allow fungal growth. After incubation, colony-forming units (CFUs) were counted manually to estimate the concentration of yeasts and moulds present in the original samples.

2.3. Statistical Analysis

Descriptive statistical analyses were conducted to summarise the data, including the calculation of means for quantitative variables. All statistical procedures were performed using the Statistical Package for the Social Sciences (SPSS), version 29.

3. Results

Table 1 presents the quantitative results of the microbiological analyses performed on peanut muamba samples, using standardised plate count methodologies, following ISO international protocols. The results are expressed in colony-forming units per gram (CFU/g), except for Salmonella spp., which is reported as presence or absence in 25 g of sample. Thermotolerant coliforms were quantified using the ISO 4832:2010 method and presented values below 10 CFU/g, a value well within the acceptable limit of 10^3 CFU/g established by the Angolan microbiological standard (NA-13, 2013). Mesophilic aerobic bacteria, determined by ISO 4833:2010, presented an average count of 1,600 CFU/g. Although there is no specific limit for this group in Angolan legislation, the observed count

 doi:10.20944/preprints202505.0876.v1

is within acceptable international reference limits, indicating general microbiological quality and reflecting sanitary practices. For Salmonella spp., tested according to ISO 6579-1:2017, all samples were negative at 25 g, meeting the strict legal requirement of absence. Moulds and yeasts, analysed according to ISO 21527-1:2008, were detected at levels below 100 CFU/g. Although the NA-13 standard does not establish a mandatory limit, a reference value of 10^2 CFU/g is often adopted in similar standards.

Table 1. Microbiological quality parameters of peanut muamba samples based on standardised plate count methods.

Standardised plate count			
Parameters	**Results expressed (CFU/g)**	**Methodology**	**Standard (Angolan standard, 2013)**
Thermotolerant coliforms	<10	ISO 4832:2010	103
Mesophilic aerobes, mean	1600	ISO 4833:2010	---
Salmonella spp.	Absent in 25	ISO 6579-1:2017	Absent
Moulds and yeasts	<100	ISO 21527-1:2008	102

4. Discussion

The microbiological quality of food products is a critical aspect of food safety, particularly in traditional or artisanal preparations such as peanut muamba, which often lack standardised processing protocols (FAO/WHO, 2009).

The detection of thermotolerant coliforms at concentrations below 10 CFU/g in our samples is consistent with good hygiene practices during processing and handling. These organisms, particularly Escherichia coli, are indicators of faecal contamination and inadequate sanitation (Jay et al., 2005). Their low levels in all samples suggest that effective cleaning and disinfection protocols were implemented for equipment, surfaces, and water used in processing. In addition, low levels of coliforms reinforce the likelihood that handlers maintain adequate personal hygiene, which is particularly important in environments where manual contact with food is frequent. In future studies, the identification of coliform species could help refine the understanding of the sources and pathways of contamination in the production environment.

The mean aerobic mesophilic bacteria count of 1,600 CFU/g is within acceptable limits according to international guidelines (ICMSF, 2011), although NA-13 does not define a specific limit for this group. These organisms are not necessarily pathogenic but are used as general indicators of microbiological quality and hygienic processing. Elevated levels may indicate poor handling practices, equipment contamination or environmental exposure during processing. In this study, the moderate levels observed suggest that although the production process maintained acceptable standards, there is room for improvement. Introducing routine environmental monitoring (e.g. surface sampling and air sampling) may help identify critical control points and reduce the potential for microbial build-up in the production environment.

The absence of Salmonella spp. in all samples tested in this study is a significant finding. This pathogen is among the most common causes of foodborne illness worldwide (Scallan et al., 2011), and its presence in ready-to-eat foods poses serious public health risks. Compliance with NA-13, which requires the absence of Salmonella in 25 g of the product, suggests that the sanitary conditions under which the muamba samples were processed were generally adequate. In addition, it also indicates that contamination prevention measures, such as adequate cooking temperatures, hygienic handling practices, and control of cross-contamination, were likely observed. However, this result should not lead to complacency as the intermittent nature of Salmonella contamination means that continuous monitoring remains essential, especially in decentralised or small-scale production settings (EFSA, 2019).

 doi:10.20944/preprints202505.0876.v1

Moulds and yeasts are common spoilage organisms in food products with moderate to high moisture and fat content, which represent the two key characteristics of peanut muamba. The observed mould and yeast counts (below 100 CFU/g) do not raise immediate food safety concerns. However, they warrant continued vigilance, as certain mould species are capable of producing mycotoxins, such as aflatoxins and ochratoxins, which pose long-term health risks, including carcinogenicity and hepatotoxicity (Pitt & Miller, 2017). Given that peanuts are known to be susceptible to Aspergillus contamination, particularly in tropical climates with poor post-harvest drying and storage conditions, even low mould counts should be assessed with caution. Aflatoxin contamination is particularly relevant in African contexts and has been associated with inadequate drying and storage practices (Williams et al., 2004). Therefore, it is recommended that future studies incorporate mycotoxin screening as part of the quality control process.

This study has some limitations. First, the sample size was limited to only three peanut muamba samples, which may not fully represent the microbiological variability of the product across different regions or production methods in Angola. Furthermore, as a retrospective analysis based on samples collected over a short time and from a single institution (INACOQ), the results may not capture seasonal or regional fluctuations in contamination patterns. The study also focused on selected microbial indicators, excluding other relevant pathogens and chemical contaminants. Therefore, further longitudinal and geographically diverse studies to expand the results are needed. Despite this, the study contributes significantly to food safety monitoring in Angola by providing crucial microbiological data on peanut muamba that can support sanitary control actions and public health policies in Angola.

5. Conclusions

The microbiological assessment of muamba de amendoim samples revealed no contamination by Salmonella spp., and levels of thermotolerant coliforms, mesophilic aerobic bacteria, moulds, and yeasts were within acceptable limits according to Angolan and international reference standards. These results suggest that the sampled products are microbiologically safe for consumption. However, the detection of low levels of spoilage and indicator organisms highlights the need for continued vigilance in hygiene and sanitary control. Given that peanut muamba is often produced in artisanal settings with variable control over processing conditions, further studies are necessary to develop standardised production guidelines. Such efforts should aim to enhance food safety, support regulatory oversight, and protect public health, particularly in informal market environments. Also, future research should include a broader sampling scope, seasonal variation analysis, and advanced testing for mycotoxins and other chemical hazards. Strengthening producer education and public awareness, alongside regulatory enforcement, will be essential for ensuring the safety and sustainability of this culturally important food product.

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