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Food Safety and Quality Evaluation of Street Vended Meat Pies Sold in Lafia Metropolis, Nasarawa State, Nigeria

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***Abstract*—** Gastroenteritis coupled with the under reporting of food-borne disease outbreaks is a major challenge to health care in Nigeria. This study was carried out to critically appraise the food safety and quality of street vended meat pies sold in Lafia Metropolis – Nigeria. Thirty-five meat pie samples were obtained from street vendors randomly in five different locations within Lafia metropolis. The samples were subjected to chemical (proximate composition, fat quality indices, and acid values), microbiological (total plate, coliform, and fungal counts under ambient storage for three days and microbial enumeration and isolation), and sensory qualities assessment. Statistical analysis was done using Analysis of Variance (ANOVA). Results showed all the meat pies to be rich in protein, ash, carbohydrate, energy, and crude fibre. The storage quality indices such as total titrable acidity, PH, free fatty acid, peroxide value, were within permitted standards with the exception of water activity. The microbial count for fresh meat pies was within the recommended threshold limit and was fit for human consumption within two days of storage after which it became potentially hazardous and a threat to public health. The microbial isolates were distributed among five genera of bacteria and two genera of fungi of *Bacillus, Lactobacillus, Streptococcus, Staphylococcus, Escherichia, Aspergillus, and Penicillium*. The sensory scores showed no significant difference among the various samples. Conclusively, all the meat pies samples were high in nutritional content and safe for consumption within two days of production under non-refrigerated storage conditions.

Keywords— food safety, food quality, meat pie, contamination, street vended food, keeping quality, shelf life, Nasarawa State, Nigeria

I. INTRODUCTION

Food has long been recognised as one of the basic needs of life due to its ability to provide nourishment, health and vitality to the consumer. Despite the importance attached to food, it is now common knowledge that there is increase in the outbreak of food borne illness as a result of both risky food preparation and eating behaviour. Many discussions on food security have focused on providing food for nine billion people by 2050 with several world food and health organisations' policies focusing on increasing the production of food. However, the issue of food security goes beyond increasing production, supply and consumption of food as the production, distribution and consumption capacities are being threatened by poor food safety and quality. With the recent declaration of World Food Safety Day by the United Nations, safe food is now seen as one of the fundamental human rights because of its potential to promote sound health and improve productivity for poverty alleviation as veritable platforms for sustainable development. Therefore, to maintain a healthy human diet and optimum well-being, the quality and safety of food must also be taken into consideration. Hence, food safety can be seen as the level of assurance consumers' repose on the food being eaten to provide the intended vital nourishment without any form of health hazard or risk [1]. Similarly, [2] considered food safety "as the absence, or safe, acceptable levels of hazards in food that may harm the health of consumers".

Therefore, the issue of food safety has generated global attention considering the reported cases of global, regional and national food borne disease outbreaks and huge numbers of food recalls which have eroded consumer confidence in the safety of food supply and agrifood production and trade in recent times [3]. The World Health Organisation reported estimate of 600 million people in the world falling sick after eating contaminated food as a result of which, 420, 000 die every year. This figure could be worse in the developing world if all the food borne outbreaks and deaths associated with food borne diseases are reported and properly documented. Equally, over 800 million people in the world are chronically malnourished because of lack of access to sufficient safe and nutritious food [2]. The rapid deterioration of food system and increasing incidences of food borne diseases has been globally attributed to poor cleaning of food-machine contact surfaces, cross – contamination, poor decontamination of the hand before and after handling food, improper storage temperature and inadequate heat treatment as the basic media for transmission of food borne diseases [4].

Food safety is indispensably significant for healthy living and general wellbeing as lack of access to safe food leads to nutrition insecurity which in turns results in the double burden of malnutrition and food borne diseases. In Nigeria and other developing world, the problem of food safety goes hand-hand with poverty which makes access to safe nutritious food unrealistic and unaffordable. Hence, poverty and food insecurity are serious threats to food quality and safety in Nigeria and have contributed to regulatory agencies ineffectiveness. The desk study by [5] "found that the largest expense for most Nigerian households is food in which 57 percent of disposable income goes toward food consumed at home with factors—such as high rates of poverty, increasing food prices, and insufficiently developed and diversified livelihood opportunities—present risks to Nigerian families' ability to purchase food and nutrition-related services". Hence, the majority of street food vendors are very poor and uneducated, with no knowledge of food hygiene. These cuts across men and women of various ages pushing " their food-laden carts, wheel-barrows or specially-designed bicycles from one location to another to serve their customers" [6] while selling at relatively low prices thereby attracting the majority of low-income workers, shoppers, travellers on the highway and school children in an attempt to earn a living. "These consumers are often interested in money saving and time convenience than issues of safety, quality and hygiene" [7].

Therefore, in Nigeria, while the demand for safe food is on the increase, the issue of safety has not been given the desired attention considering the lack of food safety surveillance and enforcement of relevant laws especially in the production, storage, distribution and marketing of street vended foods. Reference [8] reported that over 200,000 people die of food poison annually in Nigeria as a result of food contaminated through improper farming, processing, preservation and services. In addition, [9] identified poor cooking method and sanitary condition of cooking environment while [6] observed personal hygiene of food handlers as all potential sources of food borne diseases in Nigeria. Street foods are regarded as one of the potential sources of food borne illness because of their high susceptibility to microbial spoilage [10] due to poor storage temperature and mal-handling practices that expose them to contamination and cross contamination [11]. Hence, [12] reported that "the safety and shelf life of street food depends on the interaction of chemicals, physical and microbial agents as they are exhibited in open fields making them easily prone to be contaminated with dust, exchange fumes, insects, willing customer hands and rain". Despite consumers awareness of the food borne diseases associated with consumption of street food, majority disregard this health warning especially in developing countries such as Nigeria where consumers as a result of poverty are only interested in satisfying hunger with no regard to food safety and quality thereby resorting to optimistic bias and fate eating.

Meat and meat products have been integral part of man's diet before the dawn of civilizations [13]. Among ready to eat street foods, meat pie is the most popular choice as a result of its nutrients density and savoury ingredients. Meat pie is defined as " a savoury pie that cover contains filling meat and other savoury ingredients. It is a baked pastry usually made of flour dough that covers or contains filling of meat and vegetables" [12]. According to [14] "The Nigerian meat pie is similar to the Jamaican beef patty. It can be fried or baked and the fillings can be almost anything from corned beef (the most widely used) to just onions and tomatoes". However, meat pie owing to its meat filling tends to spoil easily especially in developing countries where access to cold storage and electricity are grossly unavailable. The nutrient dense quality of meat-pie makes it a suitable substrate for microbial growth and other forms of contamination as the meat based ingredient could be contaminated with spores of thermophilic bacteria such as Clostridium perfringes before filing except some form of hurdles are introduced at the point of processing.

Gastroenteritis coupled with the under-reporting of food-borne disease outbreaks is a major challenge to health care in Nigeria. Therefore, with the global rise in foodborne diseases outbreak and with the increasing demand for safe food by consumers, there is a need to evaluate the quality, safety, and keeping quality of street vended food within developing countries such as Nigeria that lack access to constant electricity supply, clean water and appropriate food storage/keeping facilities.

This paper is organized as follows: Section I contains the introduction of the background to the study on meat pie and food safety, Section II contain the related work on safety and quality of street vended foods, Section III explain the methodology employed in study design, sample collection and analysis, Section IV describes results and discussion of the safety and quality of meat pies, Section V contains the recommendation of the study and Section VI concludes the research work with future directions.

II. RELATED WORK

Different studies at various time and location have examined the contamination of street vended food [15, 12, 11, 16, 17, 18, 19, 20, 21, 22, 23]. With the constant implication of retailed and street vended food in food borne disease [21] outlined risk factors for contamination of ready to serve food to include "environmental and human factors such as seasonal changes, improper holding temperature, lack of proper ventilation systems, cross contamination and absence of clean and suitable outer garments, failure of food handlers to adhere to sanitation guideline rather than to unsanitary environment".

Although, some of the studies in Nigeria and abroad showed acceptable and tolerable level of microbial load as specified by International Commission on Microbiological Specification for Foods (ICMSF), the time of sample

collection varies significantly with the time the food products are produced and kept on display for consumers patronage which could give rise to increase in microbial load beyond acceptable and tolerable level. Most of the street vended snacks/food in developing countries are prepared before break of dawn and kept on display for sale till dusk. Within the time span and the rapid growth and replication of micro-organisms facilitated by lack of appropriate storage/keeping facilities, the food products are prone to contamination leading to food poisoning.

Most studies on street vended food such as meat pie focused on the microbial assessment, none has been conducted to critically evaluate the safety and nutritional quality of meat pies in Lafia, Nigeria. Hence the aim of this study is to critically appraised the nutritional quality, food safety and storage stability of meat pie sold in Lafia Metropolis, Nigeria with the goal/objective of assessing the threat or otherwise posed to consumers health in the locality in order to provide document and data on the chemical composition, food safety and keeping quality of street foods consumed in Nigeria.

III. METHODOLOGY

Study area

The research study was carried out within Lafia Local Government Area of Nasarawa state, Nigeria. The location was chosen because it is the state capital, the area composition is large with major activities for street food vending within the city center and it is the business hubs of the state. The area is an administrative and metropolitan capital with about 329,922 populations [24]. Nasarawa state is located at the center of middle belt region, the state shares borders with FCT Abuja on the west, Kaduna state on the North, Plateau and Taraba states on the East and Benue and Kogi states on the south. The area is agriculturally productive with varieties of foodstuffs; it has major bus stops, markets, shopping areas, construction sites and commercial areas which favour street food vending [25]. It a major gateway that connects the Northern part of Nigeria with it's Southern counterpart and hence a popular spot for road vended foods.

Samples Collection

For the purpose of this study, Lafia Metropolis which is the Captial City of Nasarawa Sate, Nigeria was mapped into five areas of the City Centre, Makurdi Road, Doma Road, Jos Road, and Shandam Road on the basis of population and commercial activities. Thirty five (35) meat pie samples were obtained from street hawkers randomly irrespective of their flavour, appearance and hygiene from each of the five (5) study areas. While collecting the samples, the researchers observed the personal and environmental hygiene and other serving practices of food safety of the hawkers. These included use of apron, covering of hair, and usage of gloves while serving. The samples were collected in the sterile sampling polythene bags and were immediately transported to Microbiology laboratory, College of Agriculture, Lafia-Nigeria.

Inclusion and Exclusion Criteria

The inclusion and exclusion principles were used to select the meat pies for the study. Only meat pies which are openly traded on the streets were included. However, branded meat pie and meat pie sold in standard restaurants and enclosed eating environment were not included in this study.

Evaluation of the Proximate Composition of Meat pies

Moisture, ash, crude fibre, fat and crude protein of the samples were determined by the methods of the Association of Official Analytical Chemists [26].

Nitrogen content was determined using the micro-Kjeldahl procedure. Zero point five gram (0.5 g) meat pie sample was weighed, heated and digested using concentrated tetraoxosulphate (iv) acid with the aid of catalyst mixture. The digest was neutralized with alkali and distilled into a boric acid solution. The borate anions formed were titrated with standardized acid, which was converted to nitrogen in the sample and calculated by the formula below:
(1ml of 0.1MHcl = 0.014gN).

$$\% \, Protein = \% \, Nitrogen \times 6.25$$

Where
Titer = Final burette reading - Initial burette reading
N = Normality of acid
DF = Dilution factor

The moisture was determined using the oven method and calculated using the formula:

$$\% \, Moisture \; Content = \frac{Weight \; loss}{Weight \; of \; sample} \times \frac{100}{1}$$

The ash was determined using the muffle furnace. The ash was calculated using the formula:

$$\% \text{ Ash Content} = \frac{C-A}{B-C} \times \frac{100}{1}$$

Where,
A = Weight of empty dish
B = Weight of empty dish + sample before ashing
C = Weight of dish + ash

Soxhlet method was used to determine fat content. It was calculated as:

$$\% \, Fat \; Content = \frac{C-B}{A} \times \frac{100}{1}$$

Where,
A = Weight of Sample
B = Weight of empty flask
C = Weight of flask + oil

The crude fiber was determined according to the procedure of AOAC, Method 7.504. Samples were defatted with petroleum ether and digested with tetraoxosulphate (vi) acid solution; it was filtered and washed with water. The residue was then boiled with NaOH solution to saponify the fat components. The washed residue was incinerated,

cooled and weighed. The crude fibre was calculated using the formula:

$$\% \text{ Crude Fibre} = \frac{W1 - W2}{\text{Weight of sample}} \times \frac{100}{1}$$

The carbohydrate content was calculated by difference as described by [27] using the formula:

$$\text{Carbohydrate} = 100 - (\% \text{ Moisture, Protein, Fibre, Fat and Ash})$$

All the proximate results were reported as % dry weight. The energy values were calculated by adding up the values obtained for carbohydrates (x 17 kJ), crude protein (x 17 kJ) and crude fat (x 37 kJ) for each of the samples.

Physicochemical Analysis

Free fatty acid, peroxide values and water activity were determined as described by [26]

Microbial Evaluation of Meat pies

Ten grams portion of each sample of meat-pies were macerated in 90 ml of sterile 0.1% peptone water as diluents. To make a 1:10 dilution, further ten-fold serial dilution were made and examined by means of the pure plate method as described by [28]. The plates were marked for easy identification and I ml of the dilution used for the inoculation and incubated.

***Microbial Enumeration and Isolation*:** Total fungi and bacteria count were determined by pour plate techniques using standard methods. The total bacterial count was obtained by incubation aerobically at 37 ^{0}C for 24 h. Total coliform count was determined by MPN index method using 3-3-3 regimen. MacConkey broth was used and positive result was associated with acid and gas production on incubation at 37 ^{0}C for 48 h. Morphological features and biochemical reactions patterns were used for the identification of microbial isolates. Dilution with 25-250 colonies were selected and counted. The number of colony forming unit per gram (Cfu/g) were calculated by multiplying the number of microbes by the dilution.

Sensory Evaluation of the Meat Pie

A preference test was used to determine the sensory attributes of meat pie samples. The sensory evaluation was conducted in the sensory evaluation laboratory of the Department of Home and Rural Economics, College of Agriculture, Lafia, Nigeria. A panel consisting of 30 Judges who regularly ate meat pie were asked to indicate their preference for appearance, texture, aroma, colour, mouth feel, and overall acceptability using a 9-point hedonic scale as described by [29], with values dislike extremely=1, dislike very much=2, dislike moderately=3, dislike slightly=4, neither like nor dislike=5, like slightly=6, like moderately=7, like very much=8, like extremely=9.

Statistical Analysis

Samples were tested at least in triplicate. Statistical analysis was done using the Analysis of Variance (ANOVA) and in cases where there was significant difference, means were separated using the Duncan's multiple range test.

IV. RESULTS AND DISCUSSION

Results

Thirty five (35) samples of meat pie collected from different street vendors at different locations in Lafia Metropolis were utilised in this study for food quality and safety studies in terms of proximate compositions, physiochemical attributes, microbial qualities, shelf stability, and organoleptic qualities.

Table 1: Proximate Compositions of Meat-Pie Sold in Lafia Metropolis, Nigeria (% Dry Weight Basis)

Parameter	***Crude Protein***	***Moisture***	***Ash***	***Crude Fat***	***Crude Fibre***	***Carbohydrates***	***Energy (Kcal)***
Makurdi Road	16.77±0.01^b	10.03±0.01^a	9.11±0.01^b	6.91±0.01^c	8.96±0.00^e	48.52±0.00^e	1365.60±0.00^e
City Centre	15.99±0.01^c	9.26±0.00^b	9.69±0.01^a	6.36±0.01^e	8.05±0.01^c	50.95±0.03^c	1373.30±0.00^d
Doma Road	15.03±0.01^d	8.70±0.01^c	9.11±0.01^b	7.98±0.01^a	8.70±0.01^b	50.80±0.01^d	1414.37±0.00^c
Shandam Road	14.03±0.01^e	7.37±0.01^e	9.03±0.00^c	6.62±0.01^d	7.87±0.01^d	55.39±0.00^a	1425.08±0.00^b
Jos Road	16.96±0.01^a	8.27±0.01^d	7.69±0.01^d	7.37±0.00^b	8.72±0.01^b	51.29±0.00^b	1432.94±0.00^a
LSD	0.027	0.026	0.029	0.027	0.027	0.034	0.024

Values are means of triplicate determinations. Mean values with same superscript in a column are not significantly different ($p \geq 0.05$).

Table 1 shows the proximate quality of the Meat pies samples. The meat pies were generally high in crude proteins (14.03 to 16.96%), ash (7.69 to 9.69%), carbohydrate (48.52 to 55.39%), energy (1365 to 1432.94kcal) and crude fibre (7.87 to 8.96%) and moisture (7.37 to 10.03%) contents; but low in fat (6.36 to 7.98%).

The meat pie samples from the different location reveal that Jos road sample has the highest protein content (16.96%),and energy (1432.94 Kcal) but with the lowest ash value (7.69%). Makurdi road meat pie followed having protein content (16.77%), and the highest moisture (10.03%) and crude fibre (8.96%) contents. Analysis of Variance (ANOVA) revealed significant differences in the proximate composition among the meat pies from different locations ($p>0.05$).

Table 2: Physiochemical Compositions of Meat-Pie Sold in Lafia Metropolis, Nigeria (% Dry Weight Basis)

Parameter	*Free Fatty Acid*	*Peroxide value*	*Total Titrable Acidity*	*Water Activity, a_w*	*PH*
Makurdi Road	1.36 ± 1.42^{a}	8.17 ± 0.01^{a}	0.33 ± 0.01^{a}	0.962 ± 0.03^{c}	6.43 ± 0.01^{a}
City Centre	0.29 ± 0.01^{d}	6.36 ± 0.00^{b}	0.35 ± 0.01^{a}	1.020 ± 0.02^{a}	6.48 ± 0.04^{a}
Doma Road	0.58 ± 0.02^{b}	6.10 ± 0.01^{d}	0.29 ± 0.02^{b}	0.984 ± 0.00^{b}	6.00 ± 0.06^{c}
Shandam Road	0.15 ± 0.01^{e}	6.15 ± 0.01^{c}	0.33 ± 0.01^{a}	0.993 ± 0.01^{b}	6.36 ± 0.02^{b}
Jos Road	0.43 ± 0.01^{c}	6.19 ± 0.01^{c}	0.36 ± 0.00^{a}	1.050 ± 0.02^{a}	6.39 ± 0.02^{b}
LSD	1.63	0.03	0.34	0.85	0.09

Values are means of triplicate determinations. Mean values with same superscript in a column are not significantly different ($p \geq 0.05$).

Physiochemical quality of the meat pies vary significantly ($p < 0.05$) in their percentage free fatty acid (0.15 to 1.36%), peroxide values (6.10 to 8.17%), titrable acidity (0.29 to 0.36%), Water activity (0.962-1.050%) and PH values (6.00 to 6.48%)as Tabulated in Table 2.

Table 1: Proximate Compositions of Meat-Pie Sold in Lafia Metropolis, Nigeria (% Dry Weight Basis**)**

Parameter	***Total Viable Count (cfu/g)***	***Total Fungi Count (cfu/g)***	***Total Coliform Count (cfu/g)***
Makurdi Road	$(1.73\pm0.01^{b}) \times 10^{4}$	$(1.22\pm0.00)^{c} \times 10^{3}$	$(1.75 \pm 0.02) \times 10^{6}$
City Centre	$(1.44\pm0.02^{c}) \times 10^{3}$	$(1.12\pm0.00)^{d} \times 10^{2}$	$(1.28\pm0.01) \times 10^{4}$
Doma Road	$(1.13\pm0.01^{d}) \times 10^{4}$	$(1.72\pm0.00)^{b} \times 10^{3}$	$(1.45\pm0.00) \times 10^{4}$
Shandam Road	$(1.22\pm0.00^{d}) \times 10^{3}$	$(1.03\pm0.01)^{d} \times 10^{2}$	$(1.30 \pm 0.01) \times 10^{6}$
Jos Road	$(3.32\pm0.00)^{a} \times 10^{4}$	$(8.43\pm0.00)^{a} \times 10^{3}$	$(1.62\pm0.02) \times 10^{5}$
LSD	0.04	0.11	0.08

Values are means of triplicate determinations. Mean values with same superscript in a column are not significantly different ($p \geq 0.05$).

Microbial quality of the meat-pie as presented in Table 3 revealed that all the meat pies samples were contaminated with varying level of bacterial count ranging from 1.73×10^{4} cfu/g to 3.32×10^{4} cfu/g and total fungi count ranging from 1.03×10^{2} cfu/g to 8.43×10^{3}cfu/g. The total coliform count in the meat pie samples ranged from 1.45×10^{4} cfu/g to 1.30×10^{6} cfu/g. The mean bacterial counts of meat pie samples from the different location reveal that Jos Road samples were the most contaminated, having a mean total aerobic count of 3.32×10^{4} cfu/g and total fungi count 8.43×10^{3} cfu/g. Samples from Makurdi road (1.73×10^{4} cfu/g), fungi count (1.22×10^{3} cfu/g) and City Centre (1.44×10^{2} cfu/g) had the lowest mean total aerobic count and lowest total coliform count (1.28×10^{4}). However, contamination with coliforms was highest in meat pie samples from Makurdi road (1.75×10^{6} cfu/g) and Shandam road (1.30×10^{6} cfu/g). The rate of contamination between the locations were statistically significant ($p>0.05$).

Table 4: Changes in Microbial Quality of Meat-Pie Sold in Lafia Metropolis, Nigeria During Storage

		Parameter			
Samples	**Time**	*Total Viable Count(cfu/g)*	*Grand Mean*	*Total Fungi Count (cfu/g)*	*Grand Mean*
	0hrs	$(1.73\pm0.01^{b}) \times 10^{4}$		$(1.22\pm0.00)^{c} \times 10^{3}$	
	24hrs	$(3.43\pm0.01^{c}) \times 10^{4}$		$(1.83\pm0.01^{c}) \times 10^{4}$	
	48hrs	$(4.63\pm0.01^{b}) \times 10^{5}$	3.78×10^{5}	$(2.24\pm0.02^{b}) \times 10^{5}$	2.10×10^{5}
Makurdi Road	72hrs	$(5.33\pm0.01^{a}) \times 10^{7}$		$(3.12\pm0.00^{a}) \times 10^{6}$	
LSD		0.04		0.04	
	0hrs	$(1.44\pm0.02^{c}) \times 10^{3}$		$(1.12\pm0.00)^{d} \times 10^{2}$	
	24hrs	$(2.13\pm0.01^{c}) \times 10^{3}$		$(1.55\pm0.04^{c}) \times 10^{3}$	
	48hrs	$(2.55\pm0.04^{b}) \times 10^{4}$	2.59×10^{4}	$(2.02\pm0.00^{b}) \times 10^{4}$	1.83×10^{4}
City Centre	72hrs	$(4.23\pm0.00^{a}) \times 10^{5}$		$(2.63\pm0.01^{a}) \times 10^{5}$	
LSD		0.06		0.05	
	0hrs	$(1.13\pm0.01^{d}) \times 10^{4}$		$(1.72\pm0.00)^{b} \times 10^{3}$	
	24hrs	$(2.14\pm0.02^{c}) \times 10^{4}$		$(2.08\pm0.08^{c}) \times 10^{3}$	
	48hrs	$(2.56\pm0.06^{b}) \times 10^{5}$	2.52×10^{5}	$(2.52\pm0.10^{b}) \times 10^{4}$	2.29×10^{4}
Doma Road	72hrs	$(4.24\pm0.01^{a}) \times 10^{6}$		$(2.82\pm0.02^{a}) \times 10^{5}$	

LSD		0.09		0.11	
Shandam Road	0hrs	$(1.22\pm0.00^{d}) \times 10^{3}$		$(1.03\pm0.01)^{d} \times 10^{2}$	
	24hrs	$(1.53\pm0.01^{c}) \times 10^{3}$		$(1.42\pm0.00)^{c} \times 10^{2}$	
	48hrs	$(2.12\pm0.00^{b}) \times 10^{4}$	1.85×10^{4}	$(1.72\pm0.00)^{b} \times 10^{3}$	1.58×10^{3}
	72hrs	$(2.55\pm0.01^{a}) \times 10^{6}$		$(2.15\pm0.01)^{a} \times 10^{4}$	
LSD		0.01		0.020	
Jos Road	0hrs	$(3.32\pm0.00)^{a} \times 10^{4}$		$(8.43\pm0.00)^{a} \times 10^{3}$	
	24hrs	$(1.83\pm0.01^{c}) \times 10^{5}$		$(1.23\pm0.01)^{d} \times 10^{4}$	
	48hrs	$(1.93\pm0.01^{d}) \times 10^{5}$	2.33×10^{5}	$(1.54\pm0.01)^{c} \times 10^{5}$	3.23×10^{5}
	72hrs	$(2.24\pm0.01^{b}) \times 10^{6}$		$(1.74\pm0.01)^{b} \times 10^{6}$	
LSD		0.04		0.03	

Values are means of triplicate determinations. Mean values with same superscript in a column are not significantly different ($p \geq 0.05$).

The results of the storage stability of the meat pie samples stored at ambient temperature for three days (72 hours) as presented in Table 4 revealed that there were obvious outward sign of bio-deterioration on the meat pies after three days. When the interior of the meat pies were examined it was discovered that they had offensive odours. The significant spoilage odour normally associated with spoilt foods was absent in meat pies stored within two days when physically examined. It was also noticed that the meat filling and the potato topping had become sticky. The results of the total plate counts of fresh meat pies obtained from the five sampling locations revealed that the samples from Makurdi Road had the highest aerobic count of 3.78 x 10^{5}while sample from Shandam road recorded the least mean aerobic plate count of 1.85 x 10^{4}. The highest viable bacterial counts of stored meat pies were obtained in meat pies stored at ambient temperature for three days while the least viable bacterial counts were obtained from fresh meat pies.

Table 5: Microbial Isolates from Meat-Pie Sold In Lafia Metropolis, Nigeria stored at ambient Temperature for 72 Hours

Parameter	***Fresh Meat-Pies***	***Stored Meat-Pies***
Makurdi Road	Lactobacillus, Bacillus	Staphylococcus, Aspergillus Spp, Bacillus
City Centre	Staphylococcus, Bacillus	Lactobacillus, Bacillus,
Doma Road	Bacillus, Staphylococcus Spp,	Escherichia coli, Aspergillus, Penicillum
Shandam Road	Staphylococcus, Bacillus	Streptococcus, Aspergillus Spp, Penicillum Spp
Jos Road	Staphylococcus, Bacillus	Bacillus, Staphylococcus

The microbial isolates are presented in Table 5. Microscopic examination of gram stained smears prepared from each meat pie sample showed extensive growth of gram positive cocci, gram positive bacilli, a few gram negative rods and some fungi species. The isolated organisms were distributed among five genera of bacteria and two genera of fungi. They included *Bacillus, Lactobacillus, Streptococcus, Staphylococcus, Escherichia, Aspergillus and Pencillium. Bacillus* had the highest percentage frequency of occurrence (89.3%), followed by Streptococcus (82%) while E. coli (18%) had the least percentage frequency of occurrence (Table 5).

Table 6: Sensory Scores of Meat-Pie Sold in Lafia Metropolis, Nigeria (% Dry Weight Basis)

Parameter	***Appearance***	***colour***	***Crumb***	***Crust***	***Flavour***	***Taste***	***General Acceptability***
Makurdi Road	7.77a	6.90a	6.70a	6.77a	6.83a	6.83a	7.43a
City Centre	7.03a	6.90a	6.50a	7.50a	6.50a	6.77a	6.83a
Doma Road	7.17a	6.83a	7.03a	7.30a	6.50a	7.30a	7.10a
Shandam Road	6.90a	7.10a	6.97a	6.57a	7.03a	7.50a	7.50a
Jos Road	6.83a	6.90a	7.43a	7.03a	7.17a	7.30a	7.70a
LSD	1.02	0.95	0.94	0.92	0.96	1.03	0.98

Values are means of triplicate determinations. Mean values with same superscript in a column are not significantly different ($p \geq 0.05$).

The meat pie samples were evaluated for sensory qualities for colour, appearance, flavour, crumb, crust, taste, general acceptability by panel members at room temperature as displayed in Table 6. All the parameters of the sensory evaluation indicated that there was no significant different ($p \geq 0.05$) in the sensory scores among the meat pies samples from different locations within the metropolis.

Discussion

The meat pies samples were generally high in protein, energy, carbohydrates, fibre and ash. This ley credence to the ability of the products to contribute to nutritional intake of the local dwellers, showing them to be good sources of concentrated energy and protein thereby combating protein-energy (PEM) malnutrition. The high protein content is as a result of inclusion of meat and other vegetables. Similar protein profile in baked food was obtained by [30] on the addition of pumpkin seed milk to bread and correlates with the work of [31].The overall content of protein, carbohydrate and fat make the meat pies samples to be high in calorie equivalent to the recommended daily energy intake of an adult (1255 kcal/100g) [31].The high fibre content could be attributed to the vegetable fillings which is of great nutritional significance as it aids in the digestion of the baked foods in the colon and reduce constipation often associated with baked products produced from refined wheat flour [32] as cited in [31]. The fat contents in meat-pie are indispensable, as it contribute to the pleasant creamy or oily mouthful, and the ability to solubilize many taste and aroma constituents of food. The low fat extract is of advantage as it reduces the ability of the meat pie to go rancid thereby prolonging the shelf life of the meat pie. This finding agrees with the study of [33] for fast foods consume in Nigeria.

Moisture content in the meat pies samples plays a significant role in the overall quality and safety of the product. The complex physical and chemical interactions of moisture with the nutrient such as proteins, polysaccharides, lipids, and salts inherent in the fundamental ingredients of meat-pies contributes significantly to the texture, making it greasy. However, excess moisture content predisposes food product to microbial spoilage. The moisture contents of various meat pies samples in this study are within the acceptable range for baked products as reported by [30] and significantly lower than that reported by [34] for fried chicken meat. This could be attributed to the high temperature of dry heat applied during baking of meat pie compared to the moist heat of deep frying in which the moisture is locked in by fat.

While moisture content look at the overall water content of a product, water activity is the measure of the free water available for both physiochemical and biochemical interactions. The water activity obtained in this study were well above the recommended storage stability of aw between 0.2 and 0.4 range which could obviates the need for preservatives against microbial spoilage and biochemical reactions. Hence Water activity (aw) as a fundamental determinant of food quality and safety influences the storability of foods because according to [35] "free water in products is jointly responsible for the growth of undesirable organism such as bacteria or fungi, which produce "toxins" or other harmful substances and also chemical/biochemical reactions (e.g. the maillard reaction) increasingly take place and possibly change the microbiological stability, chemical stability, content of proteins and vitamins, color, taste and nutritional value, storage and packing, solubility and texture". Therefore, decreased water activity retards the growth of microorganisms and slows enzyme-catalyzed reactions (particularly involving hydrolyses).

However, food quality and food safety depends on pH, acidic value and water activity (aw) in food environment. Although the water activity in this study was high, the pH and titrable acidic value are within the range that prevent the meat pies from spoiling easily. This is in agreement with report of [35] who state that "for a food to have a useful shelf life without relying on refrigerated storage, it is necessary to control either its acidity level (pH) or the level of water activity (aw) or a suitable combination of the two". This can effectively increase the product's stability and make it possible to predict its shelf life under known ambient storage conditions [36]. Also, the low TTA obtained in this study is an indication that the products have better keeping quality because the acidity could prevent or delay the growth of spoilage microbes. Similar finding was reported by other researchers [37, 38, 39].

The peroxide and free fatty acid values are quality indicators of fat and oil in food that determine the predisposition of food to rancidity. The wide variation of peroxide and free fatty acid values obtained in this study could be attributed to the variation of the quality of the fat and oil used by the various street vendors. An increment in the amount of FFA in a sample of food indicates hydrolysis of triglycerides. The peroxide and free fatty acid agrees with the study of [31].

The microbial result of the fresh meat pies samples revealed varying degree of microbial contamination with some samples showing acceptable level of microbial load of $< 10^4$ cfu/g but the total coliform count exceeded the recommended safe level (< 100 coliform/g). The Total Viable Count is an indicator of quality, not safety, and cannot directly contribute towards a safety assessment of ready-to-eat food but can be used as part of a general quality assessment including that of extended shelf-life foods. Microbial criteria regulation varies across countries. [40] Considers TVC in the range of $0\text{-}10^3$ cfu/g, $10^4\text{-}10^5$ cfu/g and $>10^6$ cfu/g as acceptable, marginally acceptable (tolerable), or unacceptable respectively. On the other hand, [41] and [42] are more stringent stating that RTE foods with TVC exceeding 10^5 cfu/g are of objectionable quality and therefore unfit for consumption. Based on the microbiological standards used, meat pies sold at several locations in Lafia Metropolis – Nigeria were deemed

acceptable for sale. The findings of this study differs from similar earlier work [43,44,15,12,16,17,18,19,45,46]. The significant difference in microbial load recorded in this study could be attributed to difference in location population in terms of humans and vehicular densities. For instance, microbial contamination in this study is significantly lower than that reported by [12] for Lagos main land meat pie showing heavy contamination of bacteria ranging from 0.2×10^9 cfu/g to 8.0×10^9 cfu/g. Lagos is high dense metropolitan city with heavy vehicular and human movement that increase the rush and hustle by street vendors to service their clients hereby leading to heavy contamination of food product unlike Lafia where life is slower with little rush and hustle. The acceptable level of microbial contamination found in this study agrees with similar work of [13] and [11] for meat pie sold in Ochanja market, Onitsha and Yenagoa Metropolis which attest to both human and vehicular densities difference in terms of contamination.

Also, meat-pies are manually handled extensively with its curry filling either fried or baked in small batches. Factors such as the slow cooling of the curry, subsequent exposure to contaminants via food handlers, utensils, the environment, and the rich medium contribute to the increased microbial loads of the samples [47]. However, high aerobic counts alone do not make a food unsafe but do indicate poor handling, storage, or inadequate general hygiene [48]. However, the isolation of bacteria and fungi in all the street meat-pie samples and the unacceptable total coliform count of > 102 Cfu/g indicate contamination level of potential health significant. The bacterial load recorded in this study are mainly due to the unsanitary and unhygienic nature of the food production and services areas. Foods are good indicators of the state of the environment in which they are prepared or served. Majority of the street centers are located beside waste disposal points and dusty roads or streets with human and vehicular traffic which encouraged multiple contaminations due to the deposition of bioaerosol on exposed food products, transfer of from dirty hands and utensils and flies as reported by [43, 49]. This is equally aggravated by lack of safe and affordable water supply, inefficient waste management system, open air or outdoor preparation and epileptic power supply in Nigeria that prevent the use of modern storage facilities for meat-pies and appropriate sanitation practice in the study area that will make for much lower count that will not be significantly detrimental to public health. Similar observations have been made by other researchers [44]; [22].

A critical examination of the meat-pie samples stored at ambient temperature or air preserved for three (3) days shows a remarkable shelf stability. This could be attributed to the physiochemical quality of the meat-pies samples. Based on the specification of [40] for ready-to-eat foods of 0-10^3 (Acceptable), 10^4-10^5 (Tolerable) and above 10^5 (Unsatisfactory or Unacceptable), the street vended meat-pies air stored for 2 days in this study were found to be fit for human consumption as they recorded total bacterial and fungal count between 10^2 – 10^5cfu/g within 48 h of storage. This agrees with the findings of [50] who reported the mean microbial load of 10^4 cfu/g for standard eatery meat-pies air preserved for two (2) days. However the ambient storage result obtained here differ from that of [44] that recorded as high as 10^7 to 10^9 total aerobic count for meat-pies air preserved for 2 days. Hence, the meat-pies provided to residents of Lafia metropolis by street vendors are acceptable and tolerable microbiological quality within 2 days of production. Beyond two days, the products will become a potentially hazardous and threat to public health owning to the rich nutritious inner fillings of minced meats that provide the optimum medium for rapid microbial growth and replication.

Among the various microorganisms isolated from the meat-pies, Bacillus species and Staphylococcus species are predominate. Other bacterial species such as *Escherichia coli, Streptococcus* and *Lactobacillus* ,were isolated. However, a study by [13] isolated high percentage of Escherichia coli (39%), while *Bacillus cereus* (26%) was the least for meat pie samples sold within Ochanja Main Market. The meat-pie samples were considered fit for human consumption since the distributions of the bacteria isolates were below standard threshold limit as found in this study. Besides the bacterial species, species of fungi such *Aspergillus* and *Penicillium* of food spoilage significant were equally isolated. Other researchers [13, 22, 11, 44, 16, 45, 50, 20] isolated similar micro-organisms on meat pies and other meat products. The presence of these microbial isolates in the meat pies are due to various factors such as their opportunistic nature and ability to thrive under harsh environment [11], use of dirty processing equipment/materials, contaminated water, poor hygiene and food safety practices of the food processors.

Most of these isolates are both medical and public health significant due to their pathogenic nature. *Bacillus* species are environmental contaminants found in the air, water and withstanding harsh weather condition thereby contaminating "vended snacks as they are vending activities take place in busy-crowded environment" [22]. Being mesophilic bacteria, Bacillus species produce heat-resistant endospores which on injection produces heat-labile toxic that causes diarrheal illness accompanied with abdominal pain. The most favourable factor that promote the growth of bacillus and subsequent food borne infection and intoxication is wrong hot processing and holding temperatures of prepared food items. Meat pies fillings are minimally processed with the internal temperature not reaching the recommended core temperature of 145 oF and the street vended/hawked meat-pies are without any form of hot holding device that could maintain the holding temperature of 140 ^oF of the products. This keep the meat-pies within the "the temperature danger zone" of 140 ^oF to 41 ^oF leading to proliferation of bacillus and other co-opportunistic bacteria.

Staphylococcus bacteria exist as normal skin flora of animals and humans and their presence in meat-pies suggest poor hygienic practices of both the processors and vendors such as the use of dirty hands, clothing and the practices of mouth blowing of air into packaging materials in an attempt to open them [11]. *Staphylococcus* bacteria in foods are considered worrisome as they are known to tolerate high concentration of sodium chloride and secretion of thermal stable enterotoxins which causes diarrhea and vomiting on ingestion [20]. Equally, *E.coli* is a normal intestinal micro flora with the enteropathogenic strains implicated for causing travelers diarrheal and hemorrhagic colitis [20]. Although, the percentage of *E.coli* in meat pie samples in this study was not significant, its presence shows serious contamination by human or animal faecal matter from water sources utilized during the preparation of the meat meat-pie. *Penicillium* and *Apergillus* are fungi species of food spoilage significance. Their presence could be attributed to environmental and packaging materials contamination [22].

All the parameters of the sensory appraisal indicated that there was no significant different ($p \geq 0.05$) in the sensory scores among the meat pies samples from different locations within the metropolis. This could be due to the similar ingredients and processing methods employed by the vendors.

V. CONCLUSION AND FUTURE SCOPE

This study examined the food safety and quality of meat-pies vended in Nigeria metropolitan town of Lafia. The result shows that the nutritional qualities of street vended meat pie are compromised by high microbial contamination of public health significance. All the evaluated meat pie samples were nutritionally viable and safe for human consumption. The proximate data indicated the potential of the meat pies to the meet the protein-energy needs of the local dwellers. The meat pie samples were generally high in protein, energy, carbohydrates, fibre, and ash content. The researchers observed that, the inclusion of meat and other vegetables were responsible for high nutritive profile of the products.

Microbiologically, the meat pies were contaminated to various degrees by microbes. This could be attributed to factors such as poor sanitary nature of food preparation and service environment, food vendors' unhygienic practices, poor water quality and inappropriate storage facilities. However, the microbial count for the products within two days of non-refrigerated (ambient) storage were within threshold limit for human consumption according to local and international standards/regulations. Beyond two days, the products become potentially hazardous and threat to public health owning to the rich nutritious inner fillings of minced meats that provide the optimum medium for rapid microbial growth and replication.

Therefore, our findings outline the necessity for routine surveillance, public enlightenment and training on food safety hygienic food preparations and distribution. This calls for public health departments and other food safety regulators in Nigeria such as Food and Drug Administration and Control (NAFDAC) to double effort in aggressive food safety education as it is currently done in the prevention of Covid-19, Ebola, Lasser Fever, and endemic diseases. It is also important for the National Agency for Food and Drug Administration and Control (NAFDAC) to establish and enforce safety standards for street vended foods in Nigeria that could be enforced by state and local public health department that will aid in safeguarding the public health of residents. The outcome of this study should be addressed circumspectly considering the attended sampling and testing limitations. Further studies should be carried out to assess heavy metals and aflatoxin safety of street vended meat-pies in Nigeria.

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