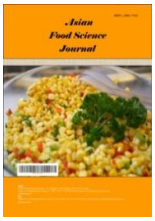

Asian Food Science Journal

17(1): 1-14, 2020; Article no.AFSJ.58931
ISSN: 2581-7752

Nutrient Composition and Microbiological Evaluation of Vended Street Foods in Parts of Lagos State, Nigeria

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Authors' contributions

This work was carried out in collaboration between both the authors. Author OGI designed the study, wrote the protocol and wrote the first draft of the manuscript. Author CBS performed the statistical analysis and the literature searches of the study. Both authors read and approved the final manuscript.

Article Information

DOI:10.9734/AFSJ/2020/v17i130181
Editor(s):
(1) Dr. Vijaya Khader, Acharya N. G. Ranga Agricultural University, India.
(2) Dr. Samaila James, Federal University of Technology, Nigeria.
Reviewers:
(1) Preeti Bora, Uttarakhand Open University, India.
(2) Fikadu Kumsa, Ambo University, Ethiopia.
(3) Joshita Lamba, Lady Irwin College, India.
Complete Peer review History: http://www.sdiarticle4.com/review-history/58931

Original Research Article

Received 03 May 2020
Accepted 09 July 2020
Published 10 July 2020

ABSTRACT

The presence of microbiological pathogens and proximate composition of vended street foods (VSF) in parts of Lagos State were investigated. The experiment was conducted along 3 local government areas of Lagos State (Marina, Apapa and Yaba) using two factorial design. Eight VSF products investigated were roasted (plantain, fish, yam, corn), suya, meat pie, egg roll and doughnuts, purchased from parts of Lagos State. The result for proximate analysis of VSF sourced from Marina, Yaba and Apapa showed that moisture content ranged from 4.81% to 28.56% for Suya from Yaba and roasted plantain from Apapa. Moisture content of roasted plantain from Apapa was significantly different ($P<0.05$) and higher than those from Yaba and Marina. Moisture content of roasted plantain, roasted fish, suya, meat pie and doughnut from the three different stations (Marina, Yaba and Apapa) were significantly different ($P<0.05$) with respect to food type. Ash, fat, protein, crude fibre and carbohydrate content ranged from 1.15% – 4.66%, 0.40% – 24.54%, 0.08 – 54.45%, 0.10 – 6.85% and 47.60 – 88.99%, respectively. Significantly higher

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protein value of 54.45% was seen in suya from Yaba. Suya samples from Apapa (SMA) gave high crude fibre of 6.85% while significantly (P<0.05) high carbohydrate of 88.99%, 87.85% and 87.51% were seen in roasted yam samples from Marina, Apapa and Yaba. Total bacteria count ranged from 3.05 log_{10}CFU/g as seen in egg roll from Apapa to 3.83 log_{10}CFU/g as noticed in roasted fish from Yaba. Total Fungi count ranged from 2.00 log_{10}CFU/g – 2.60 log_{10}CFU/g. Fungi load in roasted (plantain, fish and yam) sourced from Apapa were significantly (P<0.05) higher than those from Marina and Yaba. The energy value ranged from 255.27kcal/100g to 456.90kcal/100g, with suya sourced from Marina and Yaba were significantly different (P<0.05). The presence of high Bacteria and Fungi load in vended foods requires the attention of public health officers.

Keywords: Nutrient composition; microbial pathogens; energy value; vended street foods.

1. INTRODUCTION

The importance of foods and its availability, accessibility and affordability to the people of Lagos State was put on the balance and tested during the COVID-19 pandemic. The state decision to lockdown as one of the protocols to deter the spread of the deadly disease was faced with resistance and opposition after 48 hours due to the level of poverty occasioned by inability of most of the citizens to stock enough foods, hence the crisis and agitation for the Lagos State Government to ease and unlock the state. The Poverty level among the citizenry and the need to meet the nutritional requirements for survival has given them the prime opportunity to patronize hawkers of these vended street foods on a daily basis. The restriction on movement has placed on the hawkers' constraint to access most of their customers, especially those in Yaba and Marina area of Lagos State enroute the popular Balogun Market with several commercial banks and various businesses and commercial activities. For Apapa area, around the oil and gas installation facilities, one of the location for which this study was carried out, being part of the essential services, allowed free access and good patronage of vended street food by Hawkers. The nutritional and food safety requirements of these ready-to-eat food cannot be guaranteed. Thus, to guarantee this to take place nutritionally adequate diet should be biologically utilized so that adequate performance is maintained in growth, resistance or recovery from disease, pregnancy, lactation and or physical work, [1]. Street vended food has provided a link to satisfy availability, accessibility and affordability. However, the nutritional and microbiological quality of these ready- to-eat food is the subject of this study.

According to United Nations, [2]: food security is having adequate access to food in both quality and quantity. Street food consists of out-of-home food consumption and has old, historical roots with complex social-economic and cultural implications [3]. The World Health Organization (WHO), [4] defines street vended foods as foods and beverages prepared and/or sold by vendors in streets and other public places for immediate consumption or consumption at a later time without further processing or preparation [5,3,6,7]. Today, we are concerned about the nutritional and microbial composition of the vended street foods, as they are not only patronize by adults, but infants and school children respectively.

There is also need for quantitative information on the nutrient content of street vended foods to assess the nutritional quality of different types of these foods and their contribution to the overall energy and nutrient intake of different population groups in order to help identify particular foods or ingredients that in terms of composition and consumption, may offer potential as vehicles for nutritional interventions [8]. In developing countries all over the world, street foods provide a wide range of nutrients, helping people to meet their nutritional needs. Desirable attributes of street foods such as ease of accessibility, variety in taste, choice and low cost make them an affordable option [9]. Despite the fact that street foods have been sold for many years and provide a source of livelihood to many households, there is little data regarding their contribution to the nutritional value of the consumers' diet, [10]. Micronutrient deficiencies remain major public health problems in developing countries in both rural and urban contexts with deficiencies of vitamin A, iron and iodine, for instance, being the most prevalent [11]. Some FAO investigations have shown street foods to be good sources of energy and protein available at a lower cost than pre-packaged processed foods [12]. Food as a prime necessity of life is key for the existence of man. Food and nutrition are the fuel, providing energy

for our bodies. We need to replace nutrients in our bodies with a new supply every day. Important component of nutrition are water, carbohydrates, proteins and fats. Key vitamins and minerals such as calcium and iron are also important to maintaining good health and immunity. The requirement of these macro and micro components in our diet change or needs to be altered according to the age, physiological demand and conditions of any individual, [13]. Vended street foods when source at affordable price has closed the gaps in nutritional requirement of the low income class.

Study from FAO [14] found that 67% of primary school children in Dares Salaam in Tanzania purchased street foods daily [15], while almost all (96%) elementary school children in Nigeria bought breakfast from street food vendors and 76% bought two street food meals per day [14]. A number of investigations have demonstrated that street foods immensely contributes to the diet of children and adults in developing countries, both in terms of the variety of food groups consumed and protein, energy and micronutrient intakes [16]. These foods account for a variable, but significant part of the daily diet and nutritional requirements through a wide range of ingredients and products [14,17,18]. For example, a study carried out in Indonesia reported that it was possible to obtain almost half the recommended daily allowance of protein, iron, vitamin A and vitamin C from a street food meal by spending US$ 0.2544. A similar study in Bangkok, Thailand, showed that street foods provided around 40%, 39% and 44% of total energy, protein and iron intake, respectively. The nutritional importance was even greater in children between 4 and 6 years old, who obtained 80% of their energy, protein, fat and iron intake from street foods [14]. As a result of their regularity and consistency in usage, street foods have been identified and recommended as a means of reducing problems of urban food insecurity and as a possible vehicle for micronutrient fortification to prevent nutritional deficiencies, often referred to as 'hidden hungers', among rural and urban dwellers in the developing countries [8,19].

According to Adegbola et al. [20]. Domestic food production is on the rise in Nigeria, but it is not enough to meet the national food demand, worst still losses of produced crops are on the rise because processing and storage of crops are not adequately done. Nutritious foods are limited by low income, and poverty; most nutritious food are often expensive, food intake and nutritional well-being of many households are of relatively low quantity, and are affected by their low economic status. Hunger has increased in many countries where the economy has slowed down or contracted, mostly in middle-income countries. Furthermore, economic shocks are contributing to prolonging and worsening the severity of food crisis caused primarily by conflict and climate shocks [21]. Considering all people in the world affected by moderate levels of food insecurity together with those who suffer from hunger, it is estimated that over 2 billion people do not have regular access to safe, nutritious and sufficient food, including 8 percent of the population in Northern America and Europe. Hunger is on the rise in almost all African sub-regions, making Africa the region with the highest prevalence of undernourishment, at almost 20 percent. Hunger is also slowly rising in Latin America and the Caribbean, although its prevalence is still below 7 percent. In Asia, Western Asia shows a continuous increase since 2010, with more than 12 percent of its population undernourished today [21].

In spite of the experiences gained from the significant food contamination occurrences at the years past, extremely numerous increments in food contamination still demonstrate a deterioration with respect to food business handlers and their representatives to follow essential standards of individual cleanliness and the methods for guaranteeing the processing foods that are liberated from all types of impurity and contagion [22]. There is no uncertainty that food safety is an issue which concerns everybody operating within food industry, manufacturers of food, food providing organization association's in the stock and supply chain, retailers and individuals who prepares food at home. In addition, latest enactment of laws presently requires food business administrators to put a food safety management system in place. For example, Hazard Analysis Critical Control Point (HACCP) with end goal of lessening the cost of death and sick well-being related with unsound food [23].

The global concern for the safety of the consumers of street vended foods has led to several research efforts to determine the hygiene of the preparation and vending as well as the microbial hazards associated with consumption of these foods [24,25]. The potential for the contamination of street foods with pathogenic microorganisms has been well documented and

several outbreaks of diseases have been traced to consumption of contaminated vended foods [26]. Foodborne bacterial pathogens commonly detected in street vended foods in developing countries include *Bacillus cereus*, *Clostridium perfringens*, *Staphylococcus aureus* and *Salmonella* spp [9]. These pathogens, among others, may result in foodborne infections and intoxications once contaminated food is ingested by the unsuspecting consumers. The risk of contamination usually varies with the type of street food and how the food is prepared.

The patronage of street-vended foods over the years has been on the increase, this is due to the emergence of increased poverty and unemployment, urbanization, growth in population. This trade type provides means of livelihood to traders as income is generated for trader and family, [27]. World Health organization, [4] recorded that annually, a ton of about a million number of people have been infected while consuming foods that has suffered contamination and this has been a major widespread of diseases in the modern-day society, [28] A research by Manguiat and Fang, [29] showed that a large presence of coliform, *E. coli* and *Staph.* aureus which poses great health risks and makes such foods unsatisfactory. Although there has not been enough data availability on incidents of food-borne diseases, and incidence often not put into investigation, the reoccurrence of incidences of food-borne diseases with gastrointestinal distress symptoms like diarrhea, vomiting, abdominal cramp and nausea has been a great effect on mortality and morbidity in Nigeria, [30].

According to Ekanem, [31]. Microbiological foodborne diseases have been widely reported to immensely influence the economies of both developing and developed countries in a negative way, which has necessitated street foods safety to remain a principal priority for most governments**.** Most of the outbreaks have been closely linked to a number of factors including use of microbiologically poor quality raw materials in food preparation, improper handling of prepared foods and unsound vendor hygiene practices among others [32]. The story is even worst in most developing countries such as Nigeria-Apapa as vended street foods are prepared under unhygienic conditions very close to flooded low plan areas characterize with human and municipal waste that provide favorable breeding sites for insects and rodents which can easily contaminate the foods. In most cases also, basic provisions such as running potable water, washing facilities, toilets and organized waste disposal are often unavailable at the retail sites, [33] which can put consumers health at risk of microbial foodborne illnesses, [25], In many cases, street food vendors are uneducated and untrained in basic food hygiene and pre- requisite systems, such as the good manufacturing practices and good hygiene practices, [34].

In another study, Akinnibosun and Airiohuodion, [35] reported that most of the vended foods are not protected from flies which may carry food borne pathogens like *Bacillus sp, Staphylococcus sp, E. coli, Clostridium sp, Vibrio sp, Campylobacter sp, Listeria sp* and *Salmonella sp.* World Health organization, [4] reported that every year, several people from various part of the world are known to suffer from food poisoning and related illness resulting from the patronage and consumption of roadside foods that have suffered contamination. This menace resulting from unhealthy food habit has caused many health complications people are facing currently in the public health sector, [28]. Indeed, ready-to-eat food instead of nourishments have regularly been associated with bowel sickness and other food borne diseases among road traveler. In a few third world nations with Nigeria inclusive, the perceptions on the rate of vended street food borne pathogens are not totally or promptly accessible, in any case, the high prevalence of diarrhea, especially in babies and small kids in these nations means that a fundamental food safety issue exist [36]. According to De Sousa *et al*., [37]. High counts of *Escherichia coli* and total coliform (TC) in foods usually indicates lack of hygiene in handling and production operations, inadequate storage and post-process contamination. Therefore, *E. coli* and TC enumeration are used as a food-quality parameter.

Studies in food safety have increased in relevance in the public health sector to help curb, control and contain food-borne health issues. Worldwide, food-borne diseases have a toll on the morbidity and mortality witnessed. This has led to the implementation of strategies and mechanisms to improve safety of foods by governments, [38]. Customers to street-food vendors are becoming more concerned about the quality and safety of their meals; seeking better delivery in terms of hygiene and quality, [39]. Therefore, this study examined the nutrient

components and presence of microbiological pathogens in selected ready- to-eat foods in three local government areas of Lagos State.

2. MATERIALS AND METHODS

2.1 Study Area

Lagos is a large port city in the southwestern Nigeria. Lagos is on Latitude and longitude coordinates are**:** 6.465422, 3.406448. Lagos's 2020 population is now estimated at 14,368,332. Lagos has grown by 2,129,126 since 2015, which represents a 3.26% annual change, [40]. The Study was conducted in three local Government areas of Lagos State along the following sampling points: Marina, Yaba and Apapa respectively.

2.2 Methods

2.2.1 Experimental design

The study was done using complete randomized design in a factorial experiment. Two factorials were used (Factors A and B); factor A represented Location and B StreetVended food samples given as 3×8 factorials. The vended foods are as shown in Table 1,[41].

2.2.2 Sample collection

A total of 24 (Twenty four) food samples consisting of roasted fish, roasted plantain, roasted yam, meat pie, roasted corn, suya meat, Egg-roll and Doughnut were purchased from roadside food vendors and hawkers along Marina , Yaba and Apapa respectively. Eight (8) samples each were collected along the three (3) different locations for two (2) days. They were wrapped in an aluminum foil, placed in an iced cooler and taken to Odun Environmental Laboratory located at Block 81. Plot 71 G, Freedom Way Lekki, Lagos, Nigeria same day for analysis, from which sub-samples were obtained for the determination of Proximate Compositions and Microbiological pathogens. The samples were stored at 4°C prior to analysis.

2.2.3 Proximate analysis

The analytical method described by AOAC**,** [42] was used to determine the moisture, ash, crude fibre, protein and fat contents. Determination of the crude protein content followed the method by AOAC, [42] using the Kjeldahl method with the total %Nitrogen x 6.25 as a conversion factor. The Ash content was determined using the method of AOAC, [42]. Fat content was determined by Soxhlet extraction method in ethyl ether. Crude fiber (method 7.070) according to AOAC, [43] procedures. Carbohydrate content was determined (by difference) i.e. 100 – (% + % Ash + % Fat + % crude protein + % fibre). The proximate compositions were carried out in triplicate samples and calculated in percentages.

2.2.4 Microbial analysis

Twenty four (24) food samples were prepared for microbial quality determination for Total Heterotrophic bacterial counts and Total heterotrophic Fungal counts following the method of Ojokoh, [44]. The sterilization of all glass wares used for the analysis were done through autoclaving at 121^{o}C for 15 minutes and cooled to 45^{o}C. The twenty four (24) food samples were cultured on nutrient agar and potato Dextrose Agar. Plates were incubated at 37°C for 24 hrs. Bacterial count was done using conventional methods as reported by Weaver and Tatum**,** [45]. Quantitative analysis of heterotrophic plate count, the pour plate method was used for determining the heterotrophic plate count (HPC) of bacteria and Fungi in Twenty four (24) food samples after dilution. They were inoculated on Nutrient Agar Media (NAM) for total heterotrophic count and Potato Dextrose Agar (PDA) with chloramphenicol for total fungal count. They were incubated for 48 hrs. at 37±°C. After incubation all discrete colonies on NAM, and PDA were counted using a Techmel and Techmel colony counter and expressed as cfu/g. Bacterial and Fungal isolates were identified on the basis of cultural morphology and biochemical tests according to Bergey's Manual of Determinative Bacteriology, [46] and fungal isolates were identified on the basis of their macroscopic and microscopic characteristics [47].

2.2.5 Energy value calculation

Energy value (kcal per 100 g) was estimated using the Atwater conversion factor, [48]. Energy (kcal per 100 g) = [9 × Lipids% + 4 × Proteins% + 4 × Carbohydrates%].

2.3 Data Analysis

Data obtained from this study were subjected to Analysis of Variance (ANOVA) using Statistical Package for Social Sciences (SPSS) version 21. All experiments and analysis were carried out in Triplicates.

Table 1. Experimental design: Locations and food samples

MARINA	YABA	APAPA
RPM	RPY	RPA
RYM	RYY	RYA
SMM	SMY	SMA
MPM	MPY	MPA
RCM	RCY	RCA
ERM	ERY	DN3
DNM	DNY	DNA
RFM	RFY	RFA

Legends:RPM = roasted plantain from Marina, RPY = roasted plantain from Yaba, RPA = roasted plantain from Apapa, RFM = roasted fish from Marina, RFY = roasted fish from Yaba, RFA= roasted fish from Apapa, RYM = roasted yam from Marina, RYY = roasted yam from Yaba, RYA = roasted yam from Apapa, SMM = suya meat from Marina, SMY = suya meat from Yaba, SMA = suya meat from Apapa, MPM = meat pie from Marina , MPY = meat pie from Yaba, MPA = meat pie from Apapa, RCM = roasted corn from Marina, RCY = roasted corn from Yaba, RCA = roasted corn from Apapa, ERM=egg roll from marina, ERY= egg roll from Yaba, ERA= egg roll from Apapa, DNM= dough nut from Marina, DNY= dough nut from Yaba, DNA= dough nut from Apapa

3. RESULTS AND DISCUSSION

The study was designed to investigate the nutritional composition and microbiological quality of some vended street foods in selected Local Government areas of Lagos State.

3.1 Proximate Composition of Vended Street Foods Sourced from Three Locations in Lagos State, Nigeria

Analysis of the proximate composition of vended street foods sourced from Marina, Yaba and Apapa presented the nutrient content of food with respect to moisture, ash, fat, crude fibre, protein and carbohydrate content,[49]. Moisture content ranged from 21.45% for roasted fish from Apapa (RFA) to 28.56% shown in roasted plantain also sourced from Apapa (RPA). Moisture content of roasted plantain from Apapa was significantly different ($P<0.05$) and higher than those from Yaba (RPY) and Marina (RPM), with values of 25.03% and 7.23%, respectively. Moisture content of roasted plantain, roasted fish, suya meat, meat pie and dough nut from the three different stations (Marina, Yaba and Apapa) were significantly different ($P<0.05$) with respect to food type. There was no significant difference ($P>0.05$) in the moisture contents of roasted corn from Yaba and Apapa. The difference in moisture content of egg roll sourced from Marina and Yaba were not statistically significant ($P>0.05$). Low moisture content is a better indicator of product potential to have longer shelf life, [50]. The higher the moisture contents of food the lower the shelf life stability [51]. Ash, fat, protein, crude fibre and carbohydrate content of the vended street foods ranged from 1.15% – 4.66%, 0.40% – 24.54%, 0.08 – 54.45%, 0.10 – 6.85% and 5.51 – 88.99%, respectively. Ash content of roasted fish, roasted plantain and dough nut from the different locations were significantly ($P<0.05$) different. High ash contents of suya meat and roasted plantain from the three locations showed that the food samples are rich in essential minerals, as the ash content of food is simply a measure of its mineral content, [52,53]. The fat content of each food type from specific locations were significantly different ($P<0.05$) except for roasted plantain from Marina and Apapa. Fats are essential in diets as a source of energy, it also increase the palatability of foods by absorbing and retaining their flavor, [54], fats also help in the transportation of nutritionally essential fat-soluble Vitamins. Significantly higher protein value of 54.45% was seen in suya meat sourced from Yaba. Protein is a major nutrient needed as building blocks for the body, necessary for growth and for the repair of damaged tissues, [55]. The high protein content of these vended street foods collaborate with work of Clara et at.,[56], who reported that due to high protein value of vended street foods most adolescents depends on these foods for supply of most nutritional requirements. Already, 25% and 50% of energy and protein respectively are from street foods. It appears that the children patronage of vended street food provided an alternative to protein intake from the home despite the cost implications, [56].

Suya meat samples from Apapa (SMA) gave high crude fibre of 6.85%. High crude fibre slows down the release of glucose into the blood and decreases inter-colonic pressure hence reducing the risk of colon cancer, [57] Significantly

(P<0.05) high carbohydrate of 88.99%, 87.85% and 87.51% were seen in roasted yam samples from Marina, Apapa and Yaba, respectively. The study revealed that roasted fish, suya meat, pie and egg -roll has become a substitute for high protein meal supply among children and adults alike.

3.2 Energy Value of Vended Street Foods in Parts of Lagos State, Nigeria

The energy value of vended street foods in selected parts of Lagos State was calculated. The energy value ranged from 255.27kcal/100 g to 456.90kcal/100g, with suya meat sourced from Marina and Yaba giving significantly (P<0.05) higher values of 456.90kcal/100g and 439.71kcal/100g, respectively. This was followed by egg roll sourced from Yaba and Apapa, with values of 435.49kcal/100g and 432.31 kcal/100 g, respectively. Significantly higher energy value noticed in suya meat is probably due to its high fat content and contribution from protein-energy concentration. Energy value was estimated from the contributions of protein, fat and carbohydrate, taking into account the digestibility of each and their heat of combustion, [58]. The energy level of roasted yam in Marina was 372.68 kcal/100g and this was in agreement with the work of Pikuda and Illaboye**,** [59], though a higher value, had roasted yam in Mushine area of Lagos State recorded 223.97kcal/100g. Yam is known for high carbohydrate level and a key nutritional source for energy level requirement. Carbohydrates are distinct and key source of food energy around the universe. They constituted about 40-80% of total food energy intake, depending on local and cultural considerations or the economic status, [60]. Energy is very important in the human body; it is required for every physical activity. According to Jose et al.,[61] FAO, [62], the energy needs of each person is the amount of food energy required to compensate for energy expenditure when the size, body composition and level of physical activity are compatible with a lasting state of good health and the maintenance of physical activity that is economically necessary and socially desirable. Thus, deficiency in calories is as much a cause of malnutrition as protein deficiency, [63]. High energy value is desired especially in famine and in distressed locations were the next meal is not easy to come by [64]. High-energy foods tend to have a protective effect in the optimal utilization of other nutrients, [55]. According to (USDA recommendation, USDA, [65]. Serving size for suya meat and fish = 3.0 oz. (ounce) = 85.05g. Serving size for roasted yam, plantain, corn, = 4.23oz = 120g .Serving size for meat pie, egg roll and doughnut = 3.52oz = 100g. Thus average serving size (size per meal) for the street-vended foods was for convenient taking as 100g. When all these vended foods are taking in their proper servings, the nutritional requirements will be met. The study confirmed Suya meat, Meat Pie, egg-roll and yam as a veritable energy source for human use and therefore recommended to meet the nutritional gaps in children and adults of low income capacity.

3.3 Microbiological Quality of Vended Street Foods Sourced from Three Locations in Lagos, State, Nigeria

The study showed that Total bacteria count ranged from 3.05 $\log_{10}$CFU/g as seen in egg roll from Apapa to 3.83 $\log_{10}$CFU/g as noticed in roasted fish from Yaba. Total Fungi count ranged from 2.00 $\log_{10}$CFU/g – 2.60 $\log_{10}$CFU/g. Fungi load in roasted plantain, roasted fish and roasted yam sourced from Apapa were significantly (P<0.05) higher than those from Marina and Yaba.

The presence of high microbial load in these foods across the locations may be attributed to the food handling processes, vending location, waste disposal techniques, utensils, storage and reheating temperature, packaging materials as well as the hygiene conditions of the food vendor or hawkers themselves. According to Barro et al,[66],and Bryan et al., [67] Most of these food vendors are known to operate under poor conditions for food preparations and selling such as cooking in the open space, setting up canopies for selling by the road side with blocked drainage. The food is prepared either at home or at stalls, which are located on the street side and are made up of wood, polythene bags, tin, etc. The place of preparation is not always clean, well-lit and not far from source of contamination. Preparation surfaces used by some vendors have remains of foods prepared earlier that can promote cross contamination. Most of these foods are not covered and are exposed to flies and dust, which may harbor foodborne pathogens. In 70–90% of the cases, presence of animals, insects and liquid wastes in food preparation areas have been reported, [68] The two major sources from where the contaminants can enter the preparation area are: Improper food handling and waste disposal. The Total Heterotrophic bacterial Count (THBC) of roasted

fish in Yaba and Apapa are 3.83 log_{10}CFU/g and 3.78 log_{10}CFU/g respectively, these two locations where the study was carried out was very close to oil and gas facilities Truck Park and Market in Lagos State. The sanitary condition of these location is a major source of concerns, as drivers and associates are seen urinating and passing fecal matters during early hours of the day and used the open drains as toilet pits. This situation continues unabated, despite the provision of functional toilets. Therefore, unsanitary handling of street foods by some of the vendor has been commonly found to be the source of contamination,[69]. Most pathogens such as Escherichia coli, Salmonella, Shigella, Campylobacter and S. aureus are freely transferred via the hands of these vendors or hawkers of street vended foods to the consumers. According to WHO, [70] the hands of the food handlers are the most important vehicle for the transfer of organisms from faeces, nose and skin to the food. The finding that Salmonella, non-typhi salmonellae, Campylobacter and E. coli can survive on finger tips and other surfaces for varying periods of time [71]. The presence of high heterotrophic bacterial and fungal load makes these vended street foods unsafe for human consumption and it is a source of public health concern, as many pathogenic (disease-causing) bacteria are heterotrophs.

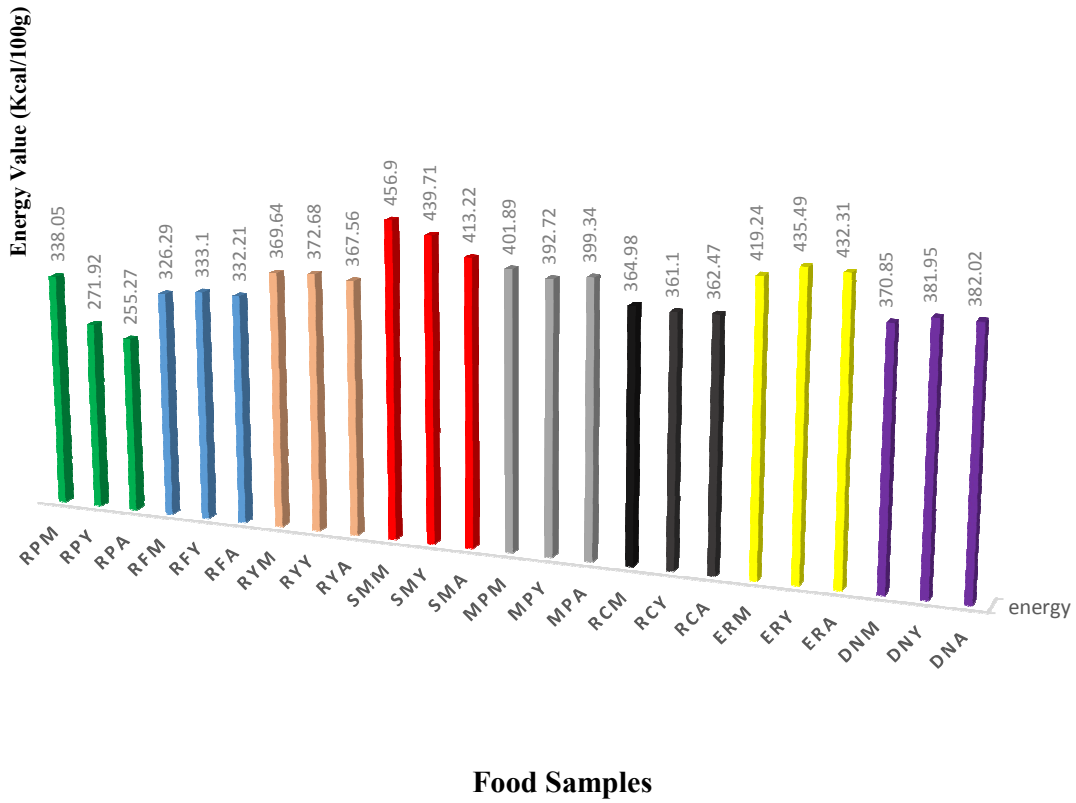

Fig. 1. Energy Value of Vended Street Foods in Parts of Lagos State, Nigeria (Energy value per serving size, calculated as kcal/100 g)

Key: RPM = roasted plantain from Marina, RPY = roasted plantain from Yaba, RPA = roasted plantain from Apapa, RFM = roasted fish from Marina, RFY = roasted fish from Yaba, RFA= roasted fish from Apapa, RYM = roasted yam from Marina, RYY = roasted yam from Yaba, RYA = roasted yam from Apapa, SMM = suya meat from Marina, SMY = suya meat from Yaba, SMM = suya meat from Apapa, MPM = meat pie from Marina , MPY = meat pie from Yaba, MPA = meat pie from Apapa, RCM = roasted corn from Marina, RCY = roasted corn from Yaba, RCA = roasted corn from Apapa, ERM=egg roll from marina, ERY= egg roll from Yaba, ERA= egg roll from Apapa, DNM= dough nut from Marina, DNY= dough nut from Yaba, DNA= dough nut from Apapa

Table 2. Proximate composition

Samples	Moisture (%)	Ash (%)	Fat (%)	C. Protein (%)	C. Fiber (%)	Carbohydrate (%)
RPM	7.23^{m}±0.001	3.31^{c}±0.011	0.49^{u}±0.000	3.65^{n}±0.030	5.66^{c}±0.000	79.76^{d}±0.000
RPY	25.03^{b}±0.000	3.17^{d}±0.000	0.40^{v}±0.000	3.51^{o}±0.001	4.32^{e}±0.000	63.57^{i}±0.000
RPA	28.56^{a}±0.000	3.02^{e}±0.000	0.51^{u}±0.002	3.40^{o}±0.001	5.24^{d}±0.000	59.27^{l}±0.000
RFM	22.08^{c}±0.020	1.70^{m}±0.000	5.17^{n}±0.000	45.89^{e}±0.000	1.31^{i}±0.000	24.05^{q}±0.000
RFY	21.85^{cd}±0.070	1.89^{l}±0.000	6.78^{l}±0.000	47.07^{d}±0.001	1.40^{h}±0.000	20.95^{r}±0.010
RFA	21.45^{d}±0.008	1.15^{r}±0.007	5.65^{m}±0.011	50.31^{c}±0.012	1.41^{h}±0.000	20.03^{s}±0.000
RYM	7.24^{m}±0.012	1.45^{no}±0.012	1.48^{t}±0.011	0.09^{p}±0.010	0.76^{j}±0.012	88.99^{a}±0.000
RYY	7.90^{k}±0.000	1.41^{op}±0.012	2.48^{o}±0.000	0.08^{p}±0.000	0.68^{k}±0.010	87.51^{c}±0.080
RYA	8.12^{j}±0.010	1.45^{no}±0.012	1.76^{q}±0.010	0.08^{p}±0.011	0.69^{k}±0.010	87.85^{b}±0.011
SMM	5.78^{n}±0.010	4.45^{b}±0.000	24.54^{a}±0.011	53.50^{b}±0.010	6.20^{b}±0.000	5.51^{v}±0.000
SMY	4.81^{p}±0.000	4.66^{a}±0.010	20.51^{c}±0.011	54.45^{a}±0.010	6.20^{b}±0.000	9.33^{u}±0.000
SMA	5.85^{o}±0.021	4.60^{a}±0.000	16.54^{e}±0.000	53.45^{b}±0.010	6.85^{a}±0.00	12.64^{t}±0.000
MPM	14.37^{g}±0.030	2.02^{jk}±0.010	13.93^{f}±0.010	10.02^{g}±0.010	0.51^{l}±0.000	59.11^{m}±0.000
MPY	15.04^{g}±0.021	1.98^{k}±0.010	12.52^{h}±0.010	9.88^{i}±0.000	0.46^{lm}±0.010	60.13^{k}±0.010
MPA	13.97^{i}±0.021	2.08^{hij}±0.010	13.02^{g}±0.010	10.01^{g}±0.010	0.39^{n}±0.011	60.53^{j}±0.011
RCM	7.01^{n}±0.010	2.06^{ij}±0.010	2.02^{p}±0.010	7.12^{k}±0.000	2.21^{f}±0.010	79.58^{e}±0.000
RCY	7.44^{l}±0.000	2.13^{h}±0.000	1.54^{s}±0.000	7.05^{l}±0.000	2.05^{g}±0.071	79.76^{d}±0.000
RCA	7.35^{l}±0.010	2.11^{hi}±0.000	1.71^{r}±0.000	6.98^{m}±0.000	2.08^{g}±0.000	79.79^{d}±0.000
ERM	16.02^{f}±0.000	2.60^{f}±0.000	18.92^{d}±0.000	12.03^{g}±0.000	0.22^{o}±0.010	50.21^{n}±0.000
ERY	15.99^{f}±0.010	2.59^{f}±0.010	22.09^{b}±0.000	11.57^{h}±0.000	0.18^{o}±0.010	47.60^{p}±0.012
ERA	14.99^{g}±0.010	2.48^{g}±0.010	20.51^{c}±0.000	12.31^{f}±0.011	0.10^{p}±0.000	49.62^{o}±0.000
DNM	16.76^{g}±0.011	1.28^{q}±0.010	8.93^{k}±0.000	8.01^{j}±0.010	0.43^{mo}±0.010	64.61^{h}±0.000
DNY	14.84^{h}±0.001	1.51^{n}±0.011	9.91^{j}±0.000	8.05^{j}±0.070	0.52^{l}±0.010	65.14^{f}±0.000
DNA	15.05^{g}±0.070	1.35^{p}±0.010	10.06^{i}±0.000	7.87^{j}±0.010	0.64^{k}±0.010	65.00^{g}±0.000

Values are means ± standard deviation of triplicate samples; Mean values bearing different superscript in the same column differ significantly (P=.05)Key: RPM = roasted plantain from Marina, RPY = roasted plantain from Yaba, RPA = roasted plantain from Apapa, RFM = roasted fish from Marina, RFY = roasted fish from Yaba, RFA= roasted fish from Apapa, RYM = roasted yam from Marina, RYY = roasted yam from Yaba, RYA = roasted yam from Apapa, SMM = suya meat from Marina, SMY = suya meat from Yaba, SMM = suya meat from Apapa, MPM = meat pie from Marina , MPY = meat pie from Yaba, MPA = meat pie from Apapa, RCM = roasted corn from Marina, RCY = roasted corn from Yaba, RCA = roasted corn from Apapa, ERM=egg roll from marina, ERY= egg roll from Yaba, ERA= egg roll from Apapa, DNM= dough nut from Marina, DNY= dough nut from Yaba, DNA= dough nut from Apapa

Table 3. Microbial quality ($Log_{10}CFU/g$)

Samples	THBC		THFC	
RPM	3.19^{t}	±0.000	2.00^{o}	±0.000
RPY	3.30^{p}	±0.000	2.00^{o}	±0.000
RPA	3.35^{n}	±0.001	2.09^{m}	±0.003
RFM	3.77^{c}	±0.001	2.32^{j}	±0.001
RFY	3.83^{a}	±0.000	2.42^{f}	±0.002
RFA	3.78^{b}	±0.000	2.47^{d}	±0.002
RYM	3.30^{p}	±0.002	2.00^{o}	±0.000
RYY	3.33^{o}	±0.001	2.34^{l}	±0.001
RYA	3.28^{r}	±0.002	2.39^{h}	±0.001
SMM	3.68^{d}	±0.001	2.30^{k}	±0.000
SMY	3.59^{f}	±0.002	2.02^{n}	±0.006
SYA	3.48^{i}	±0.000	2.30^{k}	±0.000
MPM	3.48^{i}	±0.000	2.51^{b}	±0.002
MPY	3.40^{l}	±0.000	2.40^{g}	±0.002
MPA	3.41^{k}	±0.002	2.49^{c}	±0.001
RCM	3.46^{j}	±0.001	2.00^{o}	±0.000
RCY	3.51^{h}	±0.001	2.27^{l}	±0.000
RCA	3.36^{m}	±0.001	2.09^{m}	±0.005
ERM	3.60^{e}	±0.000	2.60^{a}	±0.000
ERY	3.55^{g}	±0.001	2.51^{b}	±0.002
ERA	3.32^{o}	±0.000	2.43^{f}	±0.002
DNM	3.05^{u}	±0.000	2.45^{e}	±0.000
DNY	3.26^{s}	±0.000	2.32^{j}	±0.000
DNA	3.30^{q}	±0.000	2.32^{j}	±0.000

Values are means ± standard deviation of triplicate samples, Mean values bearing different superscript in the same column differ significantly (P=.05), THBC= Total Heterotrophic bacterial Counts.THFC= Total Heterotrophic Fungal Counts, Key:RPM = roasted plantain from Marina, RPY = roasted plantain from Yaba, RPA = roasted plantain from Apapa, RFM = roasted fish from Marina, RFY = roasted fish from Yaba, RFA= roasted fish from Apapa, RYM = roasted yam from Marina, RYY = roasted yam from Yaba, RYA = roasted yam from Apapa, SMM = suya meat from Marina, SMY = suya meat from Yaba, SMM = suya meat from Apapa, MPM = meat pie from Marina , MPY = meat pie from Yaba, MPA = meat pie from Apapa, RCM = roasted corn from Marina, RCY = roasted corn from Yaba, RCA = roasted corn from Apapa, ERM=egg roll from marina, ERY= egg roll from Yaba, ERA= egg roll from Apapa, DNM= dough nut from Marina, DNY= dough nut from Yaba, DNA= dough nut from Apapa

In a similar study by Mensah et al, [72] and Cardinale et al., [73]. The serving utensils used at the vending site are often contaminated with Micrococcus spp. and Staphylococcus spp. which may have originated from the vendors hands when they touched the food preparation areas, dishcloths, or the water during dish washing or hand washing which indicates cross contamination between dishwater, food preparation surfaces, and the food itself. It is reported that bacteria from dirty dish washing water and other sources adhere to the utensil surface and can constitute a risk during the food vending process. Microbiological analysis of utensils surface and knives have shown the presence of Salmonella and Shigella, [66], It is also reported that during the preparation of food, the raw material is cut and chopped using the same knife without in between cleaning and such knives are often invaded by flies resulting to cross contamination,[72] and thus making the food a source of contamination to the consumers.

4. CONCLUSION

The study demonstrated significant different for values of proximate composition of vended street food purchased from the same local Government area, but the location has no significant effect on the proximate composition of each vended street food. However, this is not true for the microbial load, as the food sampling point in each local Government area has a significant different on the pathogens distribution. For instance Fungi load in roasted (plantain, fish and yam) sourced from Apapa were significantly (*P*=<.05) higher than those from Marina and Yaba respectively. The energy value of suya sourced from Marina and Yaba were significantly different (*P*=<.05)

The study confirmed Suya meat, Meat Pie, egg-roll and yam as a veritable energy source for human use as well as sources of foods to support growth and maintain life and therefore recommended to meet the nutritional gaps in children and adults of low income capacity.

The presence of high Bacteria and Fungi load in vended foods is capable making food unfit for human consumption and therefore, requires the attention of public health officers. The call for urgent awareness program to enable both food vendors and consumers understand the health implications of these pathogens will help to reduce exposure to the Nigerian populace including children and adults respectively. There is need for government to review the economic value add of this sector in Nigeria and draw up a legal frame work of providing enabling environment for the sustainability of this food sector.

ACKNOWLEDGEMENTS

The study was carried as part of personal development program and the author OGI provided the funding, design the study, participated in sample collection, Laboratory analysis and interpretation of data; and in the writing of the manuscript. Author CBS, anchored the statistical analysis and interpretation of data and also previewed the manuscript. We wish to specially appreciate the staff of Odun Environmental Laboratory located at Block 81. Plot 71 G, Freedom Way Lekki, Lagos, Nigeria who participated in the field work and also assisted in the laboratory analysis.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
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