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EC MICROBIOLOGY
Research Article

Proximate Analysis and Mycological Evaluation of Mold Species in Grilled Meat (*Suya*) Sold in Ilorin, Kwara State, Nigeria

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Received: March 28, 2022; **Published:** April 18, 2022

Abstract

Background: Grilled meat (*Suya* or *Balangu*) is a protein-rich food delicacy usually consume among the elites during period of relaxation or events. Apparently, *Suya* can propagate source of infection as it can harbour fungal pathogens detrimental to human health due to unhygienic processing and packaging. However, there are meagreness of information on pathogenic fungal analysis of *Suya* sold within Ilorin metropolis, Kwara State, Nigeria.

Aim: This study determined the proximate proportion and mycological assessment of mold species in *Suya* sold at Ilorin metropolis, Kwara State.

Method: A total of twenty (24) samples were randomly collected from selected *Suya* spots at Ilorin metropolis and microbiologically analyzed. Total spores counts, identification of mold species and proximate analysis was determined using standard microbiological techniques.

Results: A total of six hundred and twenty two (622) mold species were isolated from all the *Suya* samples collected. The highest frequency of occurrence was shown by *Rhizopus* species (11.4%) while *Cladosporium* species had the lowest frequency of occurrence (6.1%). Proximate quantities showed the mean percentage of moisture as (28.31 - 47.76%), crude protein (8.80 - 16.88%), crude fiber (0.11 - 13.58%), fat (5.22 - 8.75%), carbohydrate (1.05 - 2.74%) and ash (24.00 - 48.00%) contents. This study showed the presence of *Sporotricus*, *Aspergillus*, *Alternaria*, *Fusarium*, *Absidium*, *Penicillium*, *Thamnidium*, *Rhizopus*, *Mucor*, *Cladosporium* and *Geotrichum* species in *Suya* samples assessed.

Conclusion: Apparently, *Suya* might to be contaminated with numerous mold species that could be detrimental to the well-being of consumers due to the poor personal hygiene of vendors. *Rhizopus* species are fast growing mold that absorbs all of the nutrients of meat products. Eating *Rhizopus* can cause indigestion, vomiting, nausea and the spores trigger anaphylactic shock in sensitive individuals. Proper sanitary environment, handling, use of good and clean packaging products and modern technology to preserve and process the *Suya* are recommended in Ilorin metropolis, Kwara state.

Keywords: *Rhizopus; Grilled Meat; Suya; Mold Species; Spores Count; Proximate Analysis*

Introduction

Currently, food borne illness is of global public health issues as a result of concomitant increase of microbial food contamination. In the United States, about 325, 000 people were hospitalized due to food borne diseases with 5, 000 mortality rate annually and 2, 429

food-borne outbreaks in England from 1992 to 2008 [1]. In Nigeria, there is paucity of reliable data on food borne diseases due to the challenges of scientific reporting system [2]. Raw meat is obtained from animals such as camel, ram, cattle, sheep, cow, pig, goat, turkey or chicken. And may be grilled into various meat products such as *Suya* or *Balangu* for human consumption in Nigeria [1]. Grilled meat is traditionally known as "*Suya"* or "*Balangu"* in Hausa language. *Suya* is one of the protein - rich food in Kwara State. *Suya* is usually grilled, roasted and spiced with ingredients such as grinded groundnut cake with red pepper, vegetable oil, salt, carrots, cabbage, onion, maggi and peanut [3]. *Suya* contain fatty acids, amino acids, minerals and vitamins which are essential for human growth and development [4]. Meat and meat products make valuable supplements to diets of many countries due to its high nutritional profiles [5]. Meat products such as *Suya* can generate income and provide employment to the population in developing countries [4]. Meat production has become a major economic activity in Mali, Chad Republic, Cameroon, Nigeria, Senegal and other developed countries [4]. *Suya* has high nutritional contents which can be easily spoiled if adequate preservation method is not used [1]. The most important factors for preserving the quality of meat and meat products from spoilage is determine by microbial growth and holding temperature capacity [1]. Processing of meat to *Suya* facilitates the distribution, packaging, marketing, and handling of the meat products [6]. In Nigeria, *Suya* is one of contaminated meat products hawked on the street. Contamination route may be physical, environmental or chemical which poses serious public health problems to consumer's health. However, there are different ways of preserving meat and its products. One of the methods is processing the fresh meat to a delicious ready to eat form of meat such as *Suya*. *Suya* is one of the palatable forms of meat processed and roasted with different tasty spices and slanted boneless mostly in Northern part of Nigeria [6]. However, the consumption of *Suya* has been extended to other parts of geographical zones of Nigeria [3]. The rate of fungal contamination is being suspected to be considerably higher due to the unhygienic processing of meat, unsterilized utensils and the environment. Moreover, there are some sporadic occurrences of gastroenteritis and microbial food infection caused after consumption of *Suya* which indicates that the meat product is unsafe to eat [7]. Studies revealed that some mold species has been isolated from grilled meat such as *Mucor* species, *Aspergillus* species, *Penicillium* species and *Geomyces panorus* [8]. Potential pathogens such as *Bacillus cereus*, *Staphylococcus aureus*, *Salmonella* species and aflatoxigenic molds has been isolated from contaminated utensils, water, spices, raw meat and meat processing slabs [9]. Grinded groundnut spices used in the preparation of *Suya* may contain high contamination rate of mold species which may cause health hazard conditions like food poisoning [4]. Fungi can be present in most domiciles and has been reported to be the cause of food spoilage and illness [10]. Filamentous fungi such as *Rhizopus*, *Aspergillus*, *Penicillium*, *Mucor* and *Fusarium* have been isolated from vended food on the street [4]. These fungi may cause food spoilage, reduce food nutritional value and introduce toxic metabolites to prevent other organisms from eating by poisoning the food products [10]. The presence of pathogenic fungi in grilled meat may render it toxic for human consumption [11]. Food safety is significant due to increase in public health issues in the developed and developing countries presently. Meat and meat products are highly nutritious eaten by most of individuals, contaminated meat is a high risk route of fungi to thrive and can cause food borne diseases [12].

Figure 1: *Processing Chart of Grilled Meat (Suya) in Ilorin metropolis.*

Material and Methods

Study area

The study was carried out in Ilorin metropolis, the capital of Kwara State in Nigeria, West Africa. Ilorin is located on the globe which lies between latitude 8°30̍ N and longitude 4°33̍ E. Ilorin has a tropical savannah climate and estimated as 777, 667 in population, 2011. Ilorin's central location with an area of 765 Km^2 and density of 1,188/ Km^2 makes it easily accessible from all parts of the country.

Sample collection

Survey and random sampling were conducted to mark and select twelve (12) selling spots of *Suya* in Ilorin metropolis. A total of twenty four (24) *Suya* samples were collected from 12 randomly *Suya* spot located in Ilorin namely, Henry George Hotel/Adewole Junction (HGHAJ), Upper Ibrahim Taiwo Road/General Hospital Junction (UITRGHJ), Kwara Hotel Area/Government House Junction (KHAGHJ), R and S Hotel Fate/Shoprite Junction (RSHFSJ), Maraba Area/Maternity Junction (MAMJ), Zango Area/National Open University Junction (ZANOUJ), Surulere Area/Agbo-Oba Junction (SAAOJ), Oja Oba/Emir Palace Junction (OOEPJ), Gada Area/Opo-Malu Junction (GAOMJ), Oke Suna Area Primary School Junction (OSAPSJ), Gaa-Akanbi Junction (GAJ), and Agbabiaka Junction (AJ). All samples were collected using sterile hand gloves. All *Suya* samples were aseptically wrapped in a sterilized wrapping papers and aluminium foil to avoid further contamination and transported immediately to the laboratory of Medical Microbiology and Parasitolgy, University of Ilorin, Ilorin, Nigeria, and kept in a refrigerator at 4°C until mycological examination. The *Suya* samples were collected from January, 2022 to February, 2022.

Isolation and enumeration of molds count

The Grilled meat samples collected were smashed in a sterile laboratory mortar and pestle. Two gram of smashed meat sample was weighed and aseptically introduced into 10 ml of sterile distilled water, and shaken after which a five-fold dilution was conducted in different test tubes. One millimeter of each of the dilution factor was pipetted and introduced into new petri dishes. Sterile potato dextrose agar was poured into the sterile petri dishes which were left to solidify. The plates were then incubated at 25 °C for 3 - 7 days. The spores were enumerated on each agar plates for determination of total fungal counts. Spores were observed morphologically and then sub-cultured onto new prepared potato dextrose agar to obtain pure cultures. The isolates were stored on potato dextrose agar slants at 4 °C for further mycological examination.

Identification of mold isolates

Pure fungal isolates were identified based on their colonial morphology and microscopic examination. The isolates were also characterized based on their septation of hyphae, size, pigmentation, texture, and shape. The microscopic examination was obtained by using the lacto-phenol cotton blue stain method. This was done by carefully picking a small portion of mycelial growth using sterile inoculating needle and spread evenly in a drop of the lacto-phenol cotton blue stain on a clean glass slide. The clean slide was covered gently with a cover slip to expel air bubbles and observed under microscope using x10 and x40 objective lenses. Identification was done by comparing the mold morphological features with a fungal atlas [13].

Proximate composition analysis

The ash, crude fiber, protein and moisture contents were evaluated as described by AOAC [14].

Moisture content determination

The moisture content was determined following the method of AOAC [14], in which 2 grams of the sample was dried in a hot air oven at 100°C for 24 hours. The loss in weight represents the moisture content in equation one below.

$$\% \text{ Moisture} = \frac{W_1 - W_2}{W_1} \times 100 \ (1)$$

Where, W_1 = Initial weight of the sample; W_2 = weight of the dried sample

Ash content determination

The ash content was evaluated by dry ashing method [14]. This was done by measuring two grams of each of the samples into a porcelain crucible of known weight. The samples were burnt into ash in a muffle furnace at 550°C for 12 hours. It was then transferred to a desiccator where it was allowed to cool. The weight of the ash was finally evaluated after weighing. The percentage ash content is given by equation two below.

$$\% \text{ Ash} = \frac{W_1 - W_2}{W_1} \times 100 \ (2)$$

Where, W_1 = Initial weight of the sample; W_2 = weight of the dried sample after ashing.

Determination of protein content

Kjeldahl method was used to determine the crude protein content [14]. Two grams of the samples was introduced into a digestion flask, followed by 25 milliliters of concentrated sulphuric acid, ten grams of sodium sulphate and copper sulphate. The flask was put in the digestion block in a fume cupboard and heated until frothing stops producing a light blue coloration that was clear. The mixture was left to cool after which it was diluted with distilled water until it reached the mark of a 25 milliliters volumetric flask. The mixture 10 milliliters was poured into the distillation apparatus and 10 milliliters of 40% sodium hydroxide solution was added. Ammonia gas was given off after which boric acid 10 milliliters was added to the mixture and observed for color change from green to purple. The percentage protein content was calculated using equation three below.

% Crude protein = % N 6.25 (3)

The nitrogen content of the sample can be calculated from equation four below.

$$\% \text{ N} = \frac{T_v \times N_a \times 0.014 \times V_1}{GV_2} \times 100 \ (4)$$

Where, T_v = Titre value of the acid (cm^3); N_a = Concentration normality of the acid; V_1 = Volume of distilled water used for distilling the digest; V_2 = Volume of aliquot used for distillation.

Crude fiber determination

The crude fiber was evaluated by using the method of AOAC [14]. Five grams of the *Suya* sample was defatted with petroleum ether using Soxhlet extractor. The defatted sample was boiled in 150 milliliters of 1.25% H_2SO_4 solution for 30 minutes under reflux. The process was repeated three times under the same conditions. The sample was transferred to a crucible and dried using acetone. The sample in the crucible was incubated at 550°C for 3 hours to burn off the carbonaceous content thus leaving ash as crude fiber in the crucible. The percentage crude fiber was determined using equation five below.

$$\% \text{ Crude fiber} = \frac{W_1 - W_2}{W} \times 100 \ (5)$$

Where, W = Weight of the sample; W_1 = Weight of sample; and crucible before ashing; W_2 = Weight of crucible and ash.

Statistical analysis

Data obtained from mold species isolated and proximate evaluation of grilled meat from different *Suya* spots in this study were analyzed using descriptive statistics.

Results and Discussion

Results

Table 1 shows the total number of spores counted on each plate after 4 - 10 days of incubation range from 6.0 10^4 - 2.0 10^5 Sfu/ml from different *Suya* spots in Ilorin, Kwara State, Nigeria. Samples from Zango Area/National Open University Junction (ZANOUJ) and Oke Suna Area Primary School Junction (OSAPSJ) had the highest total spores counted of 2.0 10^5 while the least total spores counted 6.0 10^4 were observed for the samples collected from R and S Hotel Fate/Shoprite Junction (RSHFSJ).

S/N	Locations	Samples	No. Samples	Dilution factor	No. of spores	Total spores count (Sfu/ml)
1	Henry George Hotel/Adewole Junction (HGHAJ)	*Suya*	2	10^4	8	8.0 X 10^4
2	Upper Ibrahim Taiwo Road/General Hospital Junction (UITRGHJ)	*Suya*	2	10^5	17	1.7 X 10^5
3	Kwara Hotel Area/Government House Junction (KHAGHJ)	*Suya*	2	10^5	14	1.4 X 10^5
4	R and S Hotel Fate/Shoprite Junction (RSHFSJ)	*Suya*	2	10^4	6	6.0 X 10^4
5	Maraba Area/Maternity Junction (MAMJ)	*Suya*	2	10^4	8	8.0 X 10^4
6	Zango Area/National Open University Junction (ZANOUJ)	*Suya*	2	10^5	20	2.0 X 10^5
7	Surulere Area/Agbo-Oba Junction (SAAOJ)	*Suya*	2	10^5	11	1.1 X 10^5
8	Oja Oba/Emir Palace Junction (OOEPJ)	*Suya*	2	10^5	12	1.2 X 10^5
9	Gada Area/Opo-Malu Junction (GAOMJ)	*Suya*	2	10^4	7	7.0 X 10^4
10	Oke Suna Area Primary School Junction (OSAPSJ)	*Suya*	2	10^5	20	2.0 X 10^5
11	Gaa-Akanbi Junction (GAJ)	*Suya*	2	10^4	9	9.0 X 10^4
12	Agbabiaka Junction (AJ)	*Suya*	2	10^5	12	1.2 X 10^5

Table 1: *Total molds viable count of Suya sold at different locations in Ilorin Metropolis.*

A total of 622 species of fungi were isolated from all the *Suya* samples collected. These include *Sporotricus* species, *Aspergillus* species, *Alternaria* species, *Fusarium* species, *Absidium* species, *Penicillium* species, *Thamnidium* species, *Rhizopus* species, *Mucor* species, *Cladosporium* species and *Geotrichum* species. *Rhizopus* species was the most prevalent fungus isolated from the samples exhibiting the highest occurrence of 11.4% while *Cladosporium* species were the least isolates with the percentage occurrence of 6.1% as shown in table 2 and figure 2.

S/N	Isolates	Frequency	% Frequency
1	*Sprotricus* species	59	9.5
2	*Aspergillus* species	52	8.4
3	*Alternaria* species	66	10.6
4	*Fusarium* species	51	8.2
5	*Absidium* species	52	8.4
6	*Penicillium* species	64	10.3
7	*Thamnidium* species	58	9.3
8	*Rhizopus* species	71	11.4
9	*Mucor* species	57	9.1
10	*Cladosporium* species	38	6.1
11	*Geotricum* species	54	8.7
	Total	**622**	**100**

Table 2: *Frequency of mold isolates from different locations in Ilorin Metropolis.*

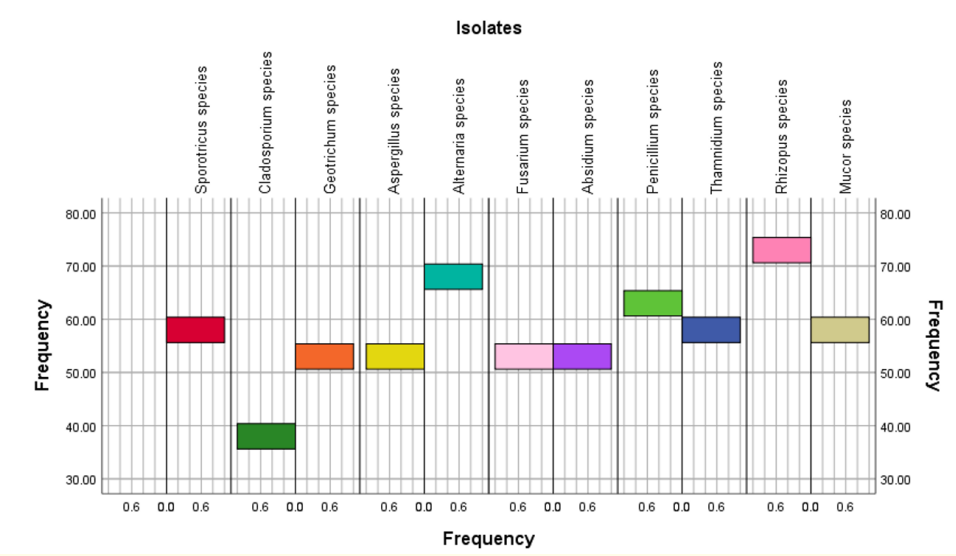

Figure 2: *Frequency distribution of mold species from all sample locations in Ilorin metropolis.*

Similarly, eleven (11) mold species were recorded in all Suya samples as *Sporotricus* species, *Aspergillus* species, *Alternaria* species, *Fusarium* species, *Absidium* species, *Penicillium* species, *Thamnidium* species, *Rhizopus* species, *Mucor* species, *Cladosporium* species and *Geotrichum* species as presented in table 3. Based on the locations of samples centers Gaa-Akanbi Junction (GAJ) 13.8% had the highest mold count, followed by Agbabiaka Junction (AJ) 11.3%, Gada Area/Opo-Malu Junction (GAOMJ) 10.9%, Maraba Area/Maternity Junction (MAMJ) 8.7%, Zango Area/National Open University Junction (ZANOUJ) 8.5%, Oja Oba/Emir Palace Junction (OOEPJ) 8.5%, Oke Suna

Area Primary School Junction (OSAPSJ) 8.5%, R S Hotel Fate/Shoprite Junction (RSHFSJ) 7.2%, Kwara Hotel Area/Government House Junction (KHAGHJ) 7.1%, Henry George Hotel/Adewole Junction (HGHAJ) 5.8%, Upper Ibrahim Taiwo Road/General Hospital Junction (UITRGHJ) 5.2%, and Surulere Area/Agbo-Oba Junction (SAAOJ) 4.5% which had the lowest molds incidents as showed in table 3.

Isolates	HGHAJ	UITRGHJ	KHAGHJ	RSHFSJ	MAMJ	ZANOUJ	SAAOJ	OOEPJ	GAOMJ	OSAPSJ	GAJ	AJ
Sprotricus species	1	1	3	1	4	9	1	5	9	2	11	12
Aspergillus species	8	1	11	3	2	6	3	3	8	5	2	0
Alternaria species	1	2	2	12	8	6	2	1	11	4	9	8
Fusarium species	2	4	1	2	3	6	0	7	12	5	3	6
Absidium species	4	1	0	1	6	0	4	5	11	3	9	8
Penicillium species	3	0	7	7	4	8	0	4	4	6	12	9
Thamnidium species	0	4	5	2	9	9	6	0	4	7	12	0
Rhizopus species	9	11	3	9	3	4	7	4	2	3	5	11
Mucor species	3	3	7	3	3	0	2	12	3	6	6	9
Cladosporium species	1	1	3	1	5	4	2	3	2	8	8	0
Geotricum species	4	4	2	4	7	1	1	9	2	4	9	7
Total	**36**	**32**	**44**	**45**	**54**	**53**	**28**	**53**	**68**	**53**	**86**	**70**
Percentage (%)	**5.8**	**5.2**	**7.1**	**7.2**	**8.7**	**8.5**	**4.5**	**8.5**	**10.9**	**8.5**	**13.8**	**11.3**

Table 3: *Number and percentage distribution of mold isolated from Suya based on sample locations.*

Sample spots

The proximate analysis revealed the percentage of ash, moisture, crude protein, fat, crude fiber and carbohydrate content in table 4. The ash and moisture were high compared with other proximate profiles.

S/N	Locations	Ash (%)	Moisture (%)	Crude Protein (%)	Fat (%)	Crude Fibre (%)	Carbohydrate (%)
1	Henry George Hotel/Adewole Junction (HGHAJ)	48.00	40.22	12.11	6.06	0.99	1.20
2	Upper Ibrahim Taiwo Road/General Hospital Junction (UITRGHJ)	35.00	28.31	16.34	5.76	3.11	1.11
3	Kwara Hotel Area/Government House Junction (KHAGHJ)	24.00	43.00	10.77	5.77	7.32	2.45
4	R and S Hotel Fate/Shoprite Junction (RSHFSJ)	24.00	34.98	9.99	6.81	8.22	1.98
5	Maraba Area/Maternity Junction (MAMJ)	31.00	43.76	8.21	7.21	1.32	2.00
6	Zango Area/National Open University Junction (ZANOUJ)	29.00	43.19	12.72	5.25	3.25	2.18
7	Surulere Area/Agbo-Oba Junction (SAAOJ)	33.00	42.07	16.88	5.22	2.11	2.11
8	Oja Oba/Emir Palace Junction (OOEPJ)	31.00	34.65	14.23	7.11	3.33	1.05
9	Gada Area/Opo-Malu Junction (GAOMJ)	48.00	34.33	13.99	5.88	4.29	1.33
10	Oke Suna Area Primary School Junction (OSAPSJ)	44.00	45.19	12.22	8.75	0.11	2.21
11	Gaa-Akanbi Junction (GAJ)	46.00	47.76	8.80	8.71	13.58	2.74
12	Agbabiaka Junction (AJ)	48.00	40.44	10.11	8.11	3.75	1.05

Table 4: *Proximate mean values of Suya samples from different locations in Ilorin Metropolis.*

Discussion

The result of mold species count in this study revealed that the processing stages of grilled meat (*Suya*) was found to be unhygienic and contaminated with numerous species of molds. The species of molds identified in this study include *Sporotricus* species, *Aspergillus* species, *Alternaria* species, *Fusarium* species, *Absidium* species, *Penicillium* species, *Thamnidium* species, *Rhizopus* species, *Mucor* species, *Cladosporium* species and *Geotrichum* species. This is consistent with the findings of Mohammed., *et al*. [15] who isolated mold species such as *Mucor* species, *Penicillium* species, *Aspergillus* species, *Fusarium* species, and *Rhizopus* species from *Suya* sold in Minna metropolis, Niger State, Nigeria. Hassan., *et al*. [2014] reported the presence of mold species in barbecue meat such as *Aspergillus* species, *Mucor* species, *Penicillium* species, *Trichoderma* species and *Rhizopus* species. Apparently, molds are found to be predominantly present in the processing stages of *Suya* in combination with tasty spices, groundnut cake, onions, carrots, cabbage and other ingredients added which were openly display to insects, flies, dust and contaminated air thereby encouraging molds to thrive. This agrees with the findings of Hungaro., *et al*. [17], that, meat as perishable foods favors mold species to thrive because of its high water activity and concentrations of nutrients. This study agrees with the research conducted by Keta., *et al*. [18], who isolated related mold species in his study. The *Suya* samples from Zango Area/National Open University Junction (ZANOUJ) and Oke Suna Area Primary School Junction (OSAPSJ) had the highest total spores count of 2.0 10^5 while the least total spores count 6.0 10^4 were observed for the samples collected from R and S Hotel Fate/Shoprite Junction (RSHFSJ) in spore forming unit per milliliter (Sfu/ml). Its total spore count ranged from 2.0 10^5 - 6.0 10^4 Sfu/ml (Table 1). This agrees with the findings of Albert., *et al*. [1], who also reported high range of fungi in a study conducted in Kabuga, Kano State, Nigeria. However, this study agreed with Boziaris and Parlapani [19], that, meat spoilage is due to the specific spoilage organisms dominant form metabolites and alter the organoleptic features of raw meat and its products, making it detrimental to consumers health. The present of mold isolates in *Suya* might be essential to economic profit losses for both retailers and producers. The presence of *Mucor* species in *Suya* could be as a result of contamination with utensils use, unwashed hands, packaging wrappers, spicy use, and direct touching of *Suya* with hands in the packaging process. This agrees with the study conducted by Umoh [20], that, contamination of meat by *Mucor* species could be from contaminated packaging wrappers, spices and other ingredients before serving the customers. *Alternaria* species isolated from *Suya* in this study could be found during the air circulation or dust because *Alternaria* species are airborne fungi. Weinhold [21] revealed in his study that *Alternaria* species are ubiquitous mold that can be found everywhere. *Suya* is commonly display in an open place for consumers to see and patronize their product. *Penicillium* species isolated from *Suya* might be from the dust or air circulation during processing. This study agreed with the finding of Pairs [22], who revealed that *Penicillium* species are present in the dust and air of indoor building. *Penicillium* is able to syntheses the Mycotoxin to assess the risk factors due to Cyclopiazonic acid on meat and meat products. The *Cladosporium* species isolated from *Suya* may be due to unhygienic method of processing, handling, transportation and sales. This study agreed with the finding of Pairs [22], who revealed that *Cladosprium* species are usually found in contaminated materials with soil or plant. *Cladosporium* species are not human pathogen except in some cases of immune system disorder. *Aspergillus* species have potential ability to produce mycotoxins (aflatoxins) which are toxic to human health thus their prevalent in *Suya* are hazardous. According to this study of proximate analysis recorded in table 4, the highest mean values of ash, were found to be 48.00% in Henry George Hotel/Adewole Junction (HGHAJ), Gada Area/Opo-Malu Junction (GAOMJ), and Agbabiaka Junction (AJ) respectively. The highest mean values of moisture content was found to be 47.76% in Gaa-Akanbi Junction (GAJ), crude protein was found to be 16.88% in Surulere Area/Agbo-Oba Junction (SAAOJ), fat was found to be 8.75% in Oke Suna Area Primary School Junction (OSAPSJ), crude fibre was found to be 13.58% in Gaa-Akanbi Junction (GAJ), and carbohydrate was found to be 2.74% in Gaa-Akanbi Junction (GAJ). The high mold species counts as observed in this study could be as a result of high protein contents (12.72% and 12.22%) and high moisture contents (43.19% and 45.19%) in *Suya* samples collected from Zango Area/National Open University Junction (ZANOUJ) and Oke Suna Area Primary School Junction (OSAPSJ). The mean values obtained in this study for moisture content (28.31 - 47.76%) was within the mean value (24.64 - 40.57%) obtained by Albert., *et al*. [1]. Emaka-Ike *et al*. [23], reported the high moisture content of meat and that can facilitate high prevalent of mold species in *Suya.*

Conclusion

The results of this study showed that all *Suya* samples collected from different spots were contaminated with molds species such as *Sporotricus* species, *Aspergillus* species, *Alternaria* species, *Fusarium* species, *Absidium* species, *Penicillium* species, *Thamnidium* species, *Rhizopus* species, *Mucor* species, *Cladosporium* species and *Geotrichum* species that could be detrimental to consumer's health and causes food borne diseases. These molds species found in Gaa-Akanbi Junction (GAJ) and Agbabiaka Junction (AJ) could results into serious health issues such as gastro-intestinal disorders, urinary tract infections, diarrhea, genital infection and other diseases when concomitantly eating *Suya* in those spots. *Suya* as a protein, is needed for body building and repair of worn out tissue in human. The mold species isolated from all *Suya* spots showed that the vendors have inadequate knowledge on standard preparation and preservation techniques which has been practice for many years ago. Poor personal, handling and processing hygiene practices displayed by the vendors could cause severe health risk such as food poisoning. The presence and proportion of mold species in grilled meat in this study is an indication of serious food borne diseases to consumer's health in the study area, Ilorin Metropolis.

Recommendations

1. Proper and hygienic method of transportation, handling and storage of meat and its products should be taken into consideration in Ilorin metropolis.

2. The grilled meat should be kept close to the fire frequently in order to inhibit fungal growth in all explored spots.

3. Quality control unit should be established in meat processing areas and *Suya* spots so that to reduce mold species contamination, food poisoning and spoilage of meat products in Ilorin metropolis.

4. All equipment used in the processing of *Suya* should be properly washed using clean water or to be sterilize especially in Ga-Akanbi and Agbabiaka *Suya* spots junction.

5. Hygienic slaughter of animals, portable and safe drinking water, frequent meat inspection, proper storage of meat and meat products, proper meat transportation and animal husbandry should all be employed to reduce fungal contamination in Ilorin Metropolis.

6. Educating vendors and consumers on good sanitary practices on *Suya* processing display and the possible danger of fungal contamination should be considered in all *Suya* spots junction.

7. Mold species contaminations could be reduced via the awareness of Hazard Analysis Critical Control Points (HACCPs) system in the processing *Suya* spots in Ilorin metropolis.

Conflicts of Interest

The authors declare no conflict of interest.

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