



Knowledge and self-reported food safety practices among meat consumers in Ilorin, Nigeria

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ARTICLE INFO

Keywords:

Food safety
Knowledge
Practices
Meat
Consumption
Nigeria

ABSTRACT

As an imperative source of protein to man, meat could also serve as a source of infections when processed poorly. This research studied consumers' knowledge and self-reported food safety practices among 869 meat consumers of different socioeconomic statuses. We summarized the data obtained using descriptive and inferential statistics. Two outcome variables were developed to determine satisfactory knowledge and practices. The knowledge and practice scores were determined through a numeric scoring system based on the respondents' correct responses to knowledge and practices questions. These outcome variables were further categorized into binary variables based on a cut-off point (mean + 1 SD of the scores) with scores greater and lower than the cut-off points considered satisfactory (acceptable/appropriate) and unsatisfactory, respectively. The respondents are predominantly female (54.9%) within the age range of 19–25 years (54.2%) and were unmarried (71.1%). Less than half (46.4% and 40.0%) of the respondents have adequate knowledge and practice levels of food safety. Most meat consumers have identified various challenges to food safety and hazards related to unsafe food safety practices. Important socioeconomic variables of the meat consumers such as occupation, age, and marital status, were significantly ($p < 0.05$) associated with food safety knowledge. Meat consumers with higher age categories and educational levels were more likely to have good food safety knowledge than those of the 15–18 years age category and primary educational level, respectively. Respondents with higher levels of education were more likely to demonstrate satisfactory food safety practices than those of primary education status, while males (OR = 1.34; 95% CI: 1.02, 1.76; $p = 0.043$) were significantly more likely to report satisfactory food safety practices. In conclusion, this study emphasized the need for an improvement in consumers' food safety practices.

1. Introduction

Foodborne diseases (FBDs) are ailments that occur due to the consumption of infected food or beverages [1,2]. FBDs are responsible for approximately 600 million morbidities in people, nearly one in every ten globally, and about 420,000 mortalities every year [3]. This represents an alarming annual loss of 33 million years of healthy life (i.e., disability-adjusted life years or DALYs), which is comparable to the burden of major infectious diseases (such as tuberculosis, malaria, and HIV/AIDS) [1]. The global burden of illnesses caused by FBDs is disproportionately burdened on the populations of low- and middle-income nations in the Asian and African continents, with children being the most severely impacted, likely contributing to high child malnutrition rates [4]. For context, evidence from epidemiological data highlights that at least 70% of

diarrheal-associated pathogens in children are contracted via contaminated food [5]. The numbers are incredibly higher in sub-Saharan Africa [6]. Therefore, it is becoming increasingly essential to trace food along the production chain worldwide, especially in sub-Saharan Africa [7].

Furthermore, FBDs negatively impact food and nutrition security, incurring extra costs to the food economy and the public health system by negatively impacting the labor workforce. For developing nations, productivity losses from foodborne sickness are estimated at \$95.2 billion yearly. In comparison, treatment costs for these illnesses run as high as \$15 billion annually, according to a 2018 World Bank assessment [8]. In Nigeria, an estimated 200,000 people die annually due to foodborne diseases. The annual economic cost of foodborne infections is estimated to accrue to about US \$3.6 billion in total [9]. FBDs cover a wide spectrum of illnesses and are known to be of public health importance worldwide, with children under

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five severely affected [3]. Pathogen-contaminated foods can result in FBDs, which may lead to long-term impairments or even death [10]. The foods that pose the greatest danger include contaminated meat and fish products, fruits, and vegetables [11]. Food contamination with biological agents such as bacteria, viruses, fungi, protozoa, and helminths undoubtedly constitutes the major etiology of FBDs with varying severity, ranging from mild infection to chronic disease manifestation [2].

Foodborne diseases are usually a result of food safety shortfalls in the food chain. Thus, enhancing the consumer's knowledge of safety rules would minimize bacterial contamination of commonly consumed foods such as meat and meat products. Much attention has been given to investigating the knowledge and self-reported food safety practices among meat consumers worldwide [12], with scarce reports observed in some developing countries like Nigeria. These reports have focused on the food safety knowledge and practices among animal handlers and meat processors [13–15]. Food safety assurance and education are needed to reduce the incidence of FBDs. Raw meat could serve as a vehicle for spreading diseases carried by slaughtered food animals because it is because it is inherently rich in nutrients that could promote microbial growth and proliferation [16]. These diseases are seldomly reported, especially in underdeveloped countries with limited trace-back mechanisms [17]. To avoid FBDs, precautions while handling, preparing, and storing meat have been emphasized [18]. It is critical to provide safe food to safeguard human health and improve quality-of-life. Food safety is crucial, whether food is produced and eaten domestically, imported, or exported.

Furthermore, the manufacturing of healthy foods is a potential source of revenue and economic integration. The food chain paradigm has been an important step in ensuring food safety from production to consumption in the past decades. This approach requires the commitment of all players in the food chain, involving producers, traders, processors, distributors, competent authorities, and consumers.

Certain diseases are spread through meat consumption or handling by humans. These diseases are considered zoonotic, caused by various bacterial, viral, fungi, and parasitic agents. These pathogens have been detected along the Nigerian meat processing chain from the slaughterhouse to the retail market, especially in Ilorin, Nigeria [14,15,19–21]. There is a regular increase in the number of zoonotic diseases. One of the reasons for this steady increase is the inadequate knowledge and poor practices demonstrated by slaughterhouse workers and consumers on animal hygiene and meat processing. Improper cooking of meat increases the risk of foodborne illnesses [22]. Hence, meat is prone to contamination by pathogens at any point along the processing chain until the consumers' cooking stage. Consequently, a better understanding of safety knowledge and practices by meat consumers is an important research priority. Therefore, we examined meat consumers' knowledge and self-reported food safety practices in Ilorin, Nigeria.

2. Material and methods

2.1. Study area

This study was carried out among meat consumers in Ilorin, Northcentral Nigeria. Ilorin is a large ancient city (land area of 765km²) on GPS coordinates of 8° 30' 0.0000" N and 4° 32' 60.0000" E. Ilorin is a nodal city serving as an access settlement linking the southern and northern parts of the country. The Ilorin metropolis comprises four local government areas (LGAs): Asa, Ilorin East, Ilorin South, and Ilorin West. Currently, the population figure of Ilorin stands at 814,192, ranking as the 11th most populous city in Nigeria [23].

2.2. Study design

A cross-sectional study design of meat consumers in Ilorin metropolis was used in this research. This study design was employed as it is commonly used to provide detailed information regarding food safety

practices, recruit many participants, and generate targeted and valid responses [24–26].

2.3. Sample size and sampling

The number of the questionnaire distributed in this study was determined using the sample size formula for cross-sectional surveys [27] calculated by adopting: $n = Z_{\alpha}^2 P(1 - P) \div d^2$. The absolute precision (d) and the proportion of consumers with satisfactory knowledge/practices (P) were taken as 0.04 and 50% [28], respectively. We included attrition of 20% to give the minimum number of respondents as 720. A total of 869 participants were surveyed from the studied population through a multi-stage sampling technique. First, the Ilorin metropolis (comprising the four LGAs) was identified from Kwara State, Nigeria. Then, at least two meat markets were selected and sampled from each of the four LGAs. Respondents at each meat market location were chosen utilizing a non-intentional sampling technique, whereby consenting respondents were invited after purchasing meat. Sampling was carried out between 8:00 am and 4:00 pm during the day (Monday to Saturday) for ten weeks (between November 30, 2019, and January 15, 2020). The questionnaire was administered to each respondent within 10 min.

2.4. Ethical consideration

Participants in this survey gave written informed consents before the questionnaire was administered. We explained the research objective to the respondents before completing the survey tool. Only meat consumers (at least aged 15 years old) who prepare and consume meat at least once a week were sampled. Meat consumers were as previously defined [15]. We excluded non-meat consumers and visitors to the city during the survey period. The Ethical Review Committee of the Faculty of Veterinary Medicine, University of Ilorin, Nigeria, endorsed this study with approval number: FVER/UG/001/2019.

2.5. Questionnaire design and pre-test

The questionnaire (Supplementary file 1) was developed with mostly closed-ended questions that eliminate differences and discrepancies to improve reliability and data processing rigor. Questions included in the survey instrument were generated from a literature search [10,12,29–32] and from previous observations of common practices employed by meat consumers when handling and processing meat. The questions were grouped into five sections. The first section focused on the socioeconomic information of the meat consumers and included five inquiries (gender, age, educational status, occupation, and marital status). Questions detailing the meat types and frequency of meat consumption were included in the second section.

Furthermore, section three of the questionnaire contained questions revealing the consumers' knowledge of food safety. We asked ten relevant questions in the fourth section of the questionnaire to assess food safety practices employed by meat consumers. Lastly, inquiries on the awareness level of respondents regarding food safety challenges relating to meat processing were included in section five.

Before administering the final questionnaire, a pilot study was conducted on ten meat consumers, five from the Ilorin West and Ilorin South LGAs, to evaluate the feasibility, duration, cost, and possible challenges during administration. Responses obtained were used to improve upon the questionnaire design before the performance of a full-scale administration. The Cronbach's alpha scale of the reliability analysis for the questionnaire sections on consumers' knowledge of food safety, the self-reported food safety practices, and awareness of food safety challenges were computed as 0.37, 0.72, and 0.72, respectively. A reliability score above 0.7 demonstrates the internal consistency and reliability of the questionnaire administered [33,34]. The Cronbach's Alpha measure for the knowledge questions was low possibly because the options for the responses were only two (correct or incorrect).

2.6. Data analysis

The responses from the respondents were coded, and the data generated were cleaned using Microsoft® Excel 2019. The IBM SPSS version 25 was used to perform descriptive and inferential statistics. Data on socioeconomic characteristics, which served as the independent variables, were first computed as percentages. Two outcome variables were developed to determine satisfactory knowledge and practices on meat safety of the respondents (Table 1). First, the knowledge and practice scores were determined through a previously established numeric scoring system [14,15,35–37] from the respondents' correct responses to knowledge and practices questions. Each correct response for the questions on knowledge was scored as “1” and the incorrect ones as “0”. The responses for the practice questions were scored as “3”, “2”, “1”, and “0” for the options provided as “always”, “sometimes”, “rarely”, and “never”, respectively, by the respondents. These outcome variables were further categorized into binary variables based on a cut-off point (mean + 1 SD of the scores) of the obtainable scores of the respondents. Knowledge and practices scores greater and lower than the cut-off points were considered satisfactory (acceptable/appropriate) and unsatisfactory, respectively [14,15,35–37]. The Chi-square test (and Fisher's exact test for 2×2 variables) was used to determine the association between the socioeconomic characteristics and the computed outcome variables. Significant socioeconomic variables from the Chi-square test were then subjected to stepwise backward binary logistic regression model. All analyses were carried out at the 95% confidence interval with a value of $p < 0.05$. The model's goodness of fit was assessed using the Hosmer-Lemeshow test.

3. Results

3.1. Socioeconomic information of the respondents

The socio-demographic information shows that the respondents are predominantly female, 54.9% ($n = 477$), and within the age range of 19–25 years, 54.2% ($n = 471$). The majority of the respondents, 71.1% ($n = 618$), were unmarried. About average percentages of 53.5% and 50.5% were students and at the undergraduate level, respectively (Table 2). Other categories of respondents to this survey were below average in number.

3.2. Responses to the knowledge questions on food safety among meat consumers

A total of 46.4% of the respondents to this survey had adequate knowledge of food safety, with a mean score of 6.3 ± 1.9 of a total obtainable score of 12 (Table 1). The correctness of the responses of the surveyed meat consumers is presented in Table 3. Largely, the surveyed meat consumers are oblivious of the correct methods of cleaning dirty hands, pots, pans, silverware, and other kitchen equipment. Additionally, most respondents were unaware of the safe internal temperature to serve meat. Over three-quarters of the meat consumers were oblivious of how well leftover meats should be thoroughly reheated. Also, more than half (43.5%) of the participants were unaware that washing contaminated raw meats could further spread pathogens. However, about 70.7% of the respondents know about the risk of meat contamination from the point of purchase until it is served (Table 3).

Table 1

Description of scores for the outcome variables obtainable by the respondents.

Outcomes	Scores received by respondents.			Maximum obtainable score	Satisfactory n (%)	Unsatisfactory n (%)
	Minimum	Maximum	Mean $\pm$ SD			
Knowledge	0.0	11.0	6.3 ± 1.9	12	403 (46.4)	466 (53.6)
Practices	3.0	30.0	15.3 ± 4.9	36	348 (40.0)	521 (60.0)

Cut-off marks: mean + 1 SD (i.e. Knowledge = $6.34 + 1$, Practice = $15.32 + 1$). Satisfactory scores: scores > cut-off scores obtained by respondents. SD – Standard Deviation.

Table 2

Respondents' socioeconomic information ($n = 869$).

Variables	Frequency	Percentage	95% Confidence Interval
Gender			
Male	392	45.1	41.82–48.43
Female	477	54.9	51.57–58.18
Age (years)			
15–18	106	12.2	10.15–14.50
19–25	471	54.2	50.88–57.5
26–35	149	17.1	14.75–19.76
>36	143	16.5	14.10–19.03
Marital status			
Single	618	71.1	68.03–74.06
Married	251	28.9	25.94–31.97
Educational status			
Primary	22	2.5	1.63–3.75
Secondary	125	14.4	12.17–16.84
Undergraduate	439	50.5	47.19–53.84
Graduate	193	22.2	19.54–25.07
Postgraduate	90	10.4	8.46–12.52
Occupation			
Civil servant	198	22.8	20.09–25.66
Student	465	53.5	50.18–56.81
Private business owners	206	23.7	20.97–26.62

3.3. Self-reported food safety practices among respondents

Though a total of 40.0% of the respondents to this survey demonstrated acceptable practices on food safety with a mean score of 15.3 ± 4.9 out of a total obtainable score of 36 (Table 1), only 43.5% of the participants have the habit of washing their hands with soap and water before handling fresh meat, 46.7% protect wounds or cuts with gloves or finger cots before handling fresh meat, and 56.4% dry their hands with a clean kitchen towel after washing them (Table 4). Above 60.0% of the respondents reported neither having used a thermometer to check if meat is thoroughly done while cooking nor confirmed the temperature of their refrigerators before storing raw meats. A high number of respondents, 732 (84.2), reported “never” to the question on “I don't rinse raw meat before cooking” (Table 4).

3.4. Identified food safety challenges among meat consumers

Most meat consumers have identified various challenges to food safety and hazards related to unsafe food safety practices. These identified food safety challenges are presented in Table 5. At least 71% of the respondents uphold that handling and ingestion of infected meats can cause harm to human health; that improper storage of meat can facilitate microbial growths; that they can be infected through improperly cooked meats; that buying raw meats from an unreliable source can predispose to health hazards; that consumption of expired canned meat can endanger one's health; consumption of ready-to-eat (roasted meat) can predispose to diseases; that improper disposal of spoiled meat can contaminate the environment. Other food safety issues centered on contracting an infection through animal transportation, hypersensitivity to drug residues in meat, and antimicrobial resistance from ingestion of drugs residues in meat, as reported by 69.9%, 69.3%, and 65.1% of the respondents, respectively.

Table 3

Correctness of food safety knowledge among meat consumers.

S/N	Questions	Correct n (%)	Incorrect n (%)
1	When dirty, hands should be cleaned by: • Washing with soap and warm water [✓], • Rinsing with water only [], • Washing with soap and ordinary water [].	279 (34.2)	572 (65.8)
2	Raw meat that is defrosting should be stored: • On the top shelf in the refrigerator [], • Any shelf in the refrigerator [], • In the freezer [✓].	592 (68.1)	277 (31.9)
3	Risk of meat contamination exists: • At each step in the flow of the meat (flow of meat is what happens to the meat from the point of purchase until it is served) [✓], • Only during the preparation and service of food (meat) [], • Only with potentially hazardous food (potentially hazardous food is food that requires special care to keep it safe as long as possible) [], • Only when leftover foods are used [].	614 (70.7)	255 (29.3)
4	Meat is safe to serve if internal temperature is upto: • 60 °C [], 68 °C [], 74 °C [], 82 °C [].	311 (35.8)	558 (64.2)
5	The basic procedure for cleaning pots, pans, silverware, and other kitchen equipment is to: • Wash with soap and warm water [], • Rinse with water only [], • Wash with soap and ordinary water only [✓], • Wash with hot water only [].	330 (38.0)	539 (62.0)
6	The practices most likely to result in sickness from food are: • Cleaning and sanitizing cutting boards after cutting raw meat [], • Serving cooked meat with fork and knives [], • Cutting raw meat using clean disposable gloves, then refrigerating the meat until it is ready to be cooked [], • Using a cutting board to cut raw meat for grilling, then to shred cabbage for a salad [✓].	432 (49.7)	437 (50.3)
7	Leftover meats should be thoroughly reheated upto: • 60 °C [], 68 °C [], 74 °C [], 82 °C [].	185 (21.3)	684 (78.7)
8	Freezing kills all pathogens that cause foodborne diseases: • Yes [], No [✓].	724 (83.3)	145 (16.7)
9	Fresh meat contains microorganisms on the surface: • Yes [✓], No [].	663 (76.3)	206 (23.7)
10	Cooked meats are free from microorganisms: • Yes [✓], No [].	504 (58.0)	365 (42.0)
11	I know that washing contaminated raw meats lead to the further spreading of pathogens.	378 (43.5)	491 (56.5)
12	I know that 4 °C is the proper temperature for storing raw meats.	466 (53.5)	403 (46.4)

The correct options have been marked as ✓.

3.5. Socioeconomic characteristics of the respondents associated with and affecting food safety knowledge and practice levels

Table 6 shows the association (and influencing factors) between the respondents' socioeconomic characteristics and food safety knowledge and practice levels. All the independent variables (gender, age category, marital status, educational status, and occupation) of the meat consumers were significantly ($p < 0.05$) associated with food safety knowledge. However, only gender ($p = 0.034$) and educational status ($p = 0.005$) were significantly associated with food safety practices among the respondents. At binary logistic regression analysis, meat consumers with higher age categories and educational levels were more likely to have good food safety knowledge than those of the 15–18 years age category and primary educational level, respectively. Also, respondents who were students (Odds

ratio (OR) = 1.80; 95% Confidence Interval (CI): 1.28, 2.55; $p = 0.001$) were significantly more likely to possess adequate knowledge of food safety than civil servants. Additionally, respondents with higher levels of education were more likely to demonstrate satisfactory food safety practices than those of primary education status, while males (OR = 1.34; 95% CI: 1.02, 1.76; $p = 0.043$) were more likely to report satisfactory food safety practices.

4. Discussion

We found that meat consumers in Ilorin, Nigeria demonstrated less than average knowledge and food safety practices. These respondents were mostly unaware of basic procedures for cleaning meat, hands, and meat processing equipment, though they tend to be aware of the risk of meat contamination. Furthermore, this study revealed that more than half of the

Table 4

Participants' responses to food safety practices.

S/N	Questions on food safety practices	Responses n (%)			
		Always	Sometimes	Rarely	Never
1	I wash my hands with soap and water before handling fresh meat	378 (43.5)	344 (39.6)	113 (13.0)	34 (3.9)
2	I protect wounds or cuts on my hand with gloves or finger cots before handling fresh meat	406 (46.7)	246 (28.3)	165 (19.0)	52 (6.0)
3	I dry my hands using a clean kitchen towel after washing them.	490 (56.4)	289 (33.3)	77 (8.9)	13 (1.5)
4	I wash my hands after handling raw meats before cooking properly	612 (70.4)	161 (18.5)	73 (8.4)	23 (2.6)
5	I do not use the same cutting board when preparing raw meats, fish, chicken, and vegetables	236 (27.2)	271 (31.2)	273 (27.3)	125 (14.4)
6	I use a thermometer to check the temperature of my refrigerator before storing raw meats.	66 (7.6)	76 (8.7)	188 (21.6)	539 (62.0)
7	I use a thermometer to check if my meat is thoroughly done	66 (7.6)	66 (7.6)	95 (10.9)	642 (73.9)
8	I wash my hands before eating roasted meat (suya) after buying	206 (23.7)	378 (43.5)	143 (16.5)	142 (16.3)
9	I don't rinse raw meat before cooking	52 (6.0)	52 (6.0)	33 (3.8)	732 (84.2)
10	I throw away leftover meats refrigerated after 3–4 days	110 (12.7)	189 (21.7)	180 (20.7)	390 (44.9)

Table 5

Identified food safety challenges among meat consumers.

S/N	Questions on food safety challenges	Responses n (%)		
		Agree	Disagree	I don't know
1	I am aware that handling and ingestion of infected meats can cause harm to human health.	781 (89.9)	64 (7.4)	24 (2.8)
2	I am aware that I can be infected through the transportation of live animals meant for slaughtering and consumption	607 (69.9)	155 (17.8)	107 (12.3)
3	I am aware that I can be resistant to certain antimicrobials by ingesting drug residues in meat.	566 (65.1)	54 (6.2)	249 (28.7)
4	I know that I can be allergic or hypersensitive to drug residues in meat.	602 (69.3)	72 (8.3)	195 (22.4)
5	I am aware that improper storage of meat can facilitate microbial growth.	675 (77.7)	37 (4.3)	157 (18.0)
6	I know that I can be infected if my meat is not properly cooked.	747 (86.0)	45 (5.2)	77 (8.8)
7	I know that buying raw meats from an unreliable source can predispose me to health hazards.	719 (82.7)	64 (7.4)	86 (9.9)
8	I am aware that the consumption of expired canned meat can endanger my health.	792 (91.1)	37 (4.3)	40 (4.6)
9	I am aware that the consumption of ready-to-eat (roasted meat) can predispose me to diseases.	619 (71.2)	128 (14.7)	122 (14.1)
10	I am aware that improper disposal of spoilt meat can contaminate the environment.	781 (89.1)	25 (2.9)	63 (7.2)

respondents engage in poor food safety practices during meat processing. Education appears to be a major factor for enhanced satisfactory knowledge and practices of food safety of the surveyed meat consumers. Though a few studies available in Nigeria have attempted to present reports on the level of food safety awareness, to the best of our knowledge, this study presents the foremost report of the knowledge and practice levels of food safety among meat consumers in the country. The need to introduce food safety policies engaging meat consumers has been highlighted. It is expedient that meat consumers adhere to the five keys recommended by the WHO

for safer foods which include keeping clean, separating raw and cooked, cooking thoroughly, keeping food at safe temperatures, and using safe water and raw materials [38]. Our finding of more female meat consumers being more than males indicates that women are more involved in meat processing and preparation than males. This is similar to the findings of some previous studies acknowledging the roles of females in meat preparation [12,31]. The preponderance of the lower age category and female respondents to this survey shows that culturally, the young and women (mostly housewives) are usually involved in purchasing and processing

Table 6

Factors of socioeconomic information of the respondents associated with and affecting food safety knowledge and practice levels.

Outcomes	Variables	Unsatisfactory n (%)	Satisfactory n (%)	P-value (χ^2)	Odds Ratio	95% Confidence Interval	P-value
<i>Knowledge</i>	Gender						
	Female	270 (56.6)	207 (43.4)	0.030*	1.00		
	Male	196 (50.0)	196 (50.0)		1.30	0.99, 1.71	0.061
	Age category (years)						
	15–18	75 (70.8)	31 (29.2)	0.000*	1.00		
	19–25	209 (44.4)	262 (55.6)		3.03	1.92, 4.79	<0.001*
	26–35	84 (56.4)	65 (43.6)		1.87	1.10, 3.18	0.027*
	>36	98 (68.5)	45 (31.5)		1.11	0.64, 1.92	0.814
	Marital status						
	Single	306 (49.5)	312 (50.5)	0.001*	1.00		
	Married	160 (63.7)	91 (36.3)		0.55	0.41, 0.75	<0.001*
	Educational status						
	Primary	13 (59.1)	9 (40.9)	0.000*	1.00		
	Secondary	90 (72.0)	35 (28.0)		0.56	0.22, 1.43	0.333
	Undergraduate	227 (51.7)	212 (48.3)		1.35	0.57, 3.22	0.649
	Graduate	86 (44.6)	107 (55.4)		1.79	0.73, 4.40	0.285
	Postgraduate	50 (55.6)	40 (44.4)		1.16	0.45, 2.98	0.957
	Occupation						
	Civil servants	131 (66.2)	67 (33.8)	0.003*	1.00		
	Students	242 (52.0)	223 (48.0)		1.80	1.28, 2.55	0.001*
	Private business owners	113 (54.9)	93 (55.1)		1.61	1.08, 2.41	0.026*
<i>Practices</i>	Gender						
	Female	301 (63.1)	176 (36.9)	0.037*	1.00		
	Male	220 (56.1)	172 (43.9)		1.34	1.02, 1.76	0.043*
	Age (years)						
	15–18	72 (67.9)	34 (32.1)	0.345	–	–	–
	19–25	276 (58.6)	195 (41.4)		–	–	–
	26–35	87 (58.4)	62 (41.6)		–	–	–
	>36	86 (60.1)	57 (39.9)		–	–	–
	Marital status						
	Single	375 (60.7)	243 (39.3)	0.549	–	–	–
	Married	146 (58.2)	105 (41.8)		–	–	–
	Educational status						
	Primary	15 (68.2)	7 (31.8)	0.005*	1.00		
	Secondary	74 (59.2)	51 (40.8)		1.48	0.56, 3.88	0.583
	Undergraduate	284 (64.7)	155 (35.3)		1.19	0.47, 2.93	0.933
	Graduate	94 (48.7)	99 (51.3)		2.26	0.88, 5.78	0.130
	Postgraduate	54 (60.0)	36 (40.0)		1.43	0.53, 3.85	0.651
	Occupation						
	Civil servants	126 (63.6)	72 (36.4)	0.495	–	–	–
	Students	298 (64.1)	167 (35.9)		–	–	–
	Private business owners	141 (68.4)	65 (31.6)		–	–	–

χ^2 : Chi-square test, *: significant a $p < 0.05$.

foodstuffs, including meat from the markets in the study area. This observation is similar to a previous finding [39]. A total of 46.4% of the respondents had adequate knowledge of food safety. A high proportion of poor knowledge of food handling, equipment cleaning, and personal hand hygiene calls are of concern as this could portend a serious food safety and public health challenge.

In an earlier study, consumers had good knowledge regarding actions capable of compromising food safety [40]. The unsatisfactory knowledge level reported in this study could be because consumers usually believe that food safety is more of the responsibility of meat processors, food safety inspectors, and regulating agencies than themselves [15,41,42]. Elsewhere, several interventions to enlighten consumers and the general public on raising their knowledge levels on food safety have been emphasized [43,44]. Stakeholder holders in the Nigerian food safety sector should focus on this strategy targeting consumer education. It is imperative that food, including meat, is adequately heated during cooking to destroy harmful pathogens at 75 °C [42]. The findings of this study indicated that a high percentage (64.2%) of respondents were unaware of the safe internal temperature to serve meat. This is also evident from the results. A high percentage of respondents (>70.0%) to this survey reported never having used a thermometer to check if meat is thoroughly done or were oblivious to how well leftover meats should be thoroughly reheated. There exists the report of the widespread practice of subjecting meat to high temperatures during preparation locally in Nigeria [15]. While use of a thermometer is the most reliable method of confirming that meat is well cooked at expected temperatures, efforts should be made by concerned stakeholders to educate meat consumers on how to also acclimatize their sensory cues to detect well cooked meat since thermometers are hardly found in most home kitchens. In other studies, a few respondents (4.0%) were reported to use a thermometer to check the doneness of meat [45]. Also, the utilization of thermometers was considered low among consumers around the world when preparing food products, including meat [22,46,47]. In Canada, about 29–45% of consumers reportedly used thermometers while cooking and checking meat doneness [40,48]. Murray et al. [40] and Soon et al. [49] reported that Canadian and Malaysian consumers use visual appearance to determine the doneness of meat. This is the typical situation among consumers in Nigeria, as thermometers are hardly used while cooking. We found that more than half (56.5%) of the participants were unaware that washing contaminated raw meats could further spread pathogens. This is also observed as the usual practice of the consumers, as 84.2% of the respondents rinse meat before cooking. Elsewhere, consumers have the habit of washing meat [49], while 64% of surveyed Canadians reported often or always washing their poultry before cooking [48]. Logically, consumers believe that washing before cooking meat makes it cleaner and safer. However, several reports have de-emphasized meat washing as this process is not preventive against contamination but facilitates the spread of pathogenic organisms to other foods, kitchen facilities, and food contact surfaces [50,51]. Consumers should be encouraged to take sanitation and hygiene seriously while preparing meat [52].

Though only 40.0% of the respondents to this survey demonstrated acceptable practices on food safety, only 43.5% of the respondents have the habit of washing their hands with soap and water before handling fresh meat, 46.7% protect wounds or cuts with gloves or finger cuts before handling fresh meat, and 56.4% dry their hands with a clean kitchen towel after washing them. In contrast, a higher percentage of consumers washing their hands has been reported by other studies. Ruby et al. [12] and Murray et al. [40] reported 56.6% and 93% of consumers always wash their hands with soap and water before cooking. Hand washing is capable of preventing bacterial spread and contamination during processing [47,53]. Hand washing is especially important as persons who process food can be carriers of infectious agents causing food poisoning or foodborne illnesses by transferring pathogens from unclean hands to food directly [54]. For instance, food contamination during processing activities from improper hand hygiene after visiting the bathroom has been reported [55]. Also, a study conducted by Aycicek [56] found a greater bacterial load from samples taken from bare hands than gloved hands ($p < 0.05$) during food preparation procedures.

Strict hand hygiene is, therefore, an important priority in food safety. In addition to poor hand hygiene, injuries before or during meat processing and handling procedures can significantly contaminate meat and become a source of infectious pathogens with health consequences. There is a danger to food safety when workers have gaping wounds, cuts, sores, or illnesses that may be transmitted to food (hepatitis A for instance), hence adequate precautions to prevent injuries or proper wound covering and care in the event of an injury before or during meat handling is of public health importance in this domain.

Our result reports that 46.7% of respondents protect their wounds or cuts with gloves or finger cuts before handling fresh meat, and drying of hands with a clean kitchen towel after washing is common in 56.4% of consumers. This is of increasing concern as meat handlers' frequent injuries are cuts on the hands and more often continue to work after such an injury. For example, a study conducted by Odetokun et al. [14] reported that the majority (87.7%) of work-related injuries affect workers' hands predominantly, and some are obliged to work despite sustaining wounds during meat processing, thereby providing opportunities for FBD pathogens from wounds handlers to be transferred to meat during processing. Therefore, recipes containing hand washing and thermometer/temperature instructions to improve food safety should be developed and circulated among meat consumers [47]. The essence of using videos to pass messages on food safety to consumers has been highlighted. Participants in a study who viewed a 3-min U.S. Department of Agriculture (USDA) food safety video "The Importance of Cooking to a Safe Internal Temperature and How to Use a Food Thermometer" were more likely to use a thermometer to check the doneness of meat compared to those unexposed to the video [44]. The fact that the majority of the meat consumers were able to identify several challenges in food safety that could lead to health implications, including ingestion of infected meats, infection through the transportation of live animals meant for slaughtering and consumption, antibiotic resistance from residues in meat, consumption of improperly stored meat, hypersensitivity to drug residue in meat, consumption of improperly cooked/expired canned meat and roasted beef, improperly stored meat, and purchasing raw meat from untrusted sources present important targets for possible interventions. Consumer exposure to residual antibiotics that remain in the final product is an increasing concern. On a societal scale, antimicrobial resistance could lead to an inability to manage outbreaks and treat diseases with antibiotics [57]. In terms of individual risk to human health, unintended consumption of residual antibiotics may lead to drug resistance or hypersensitivity or other direct effects such as allergic reaction, harm to gastrointestinal flora, or carcinogenic, mutagenic, and teratogenic effects [57]. At their best, interventions resulting from identified challenges should be holistic and all-encompassing in their approach. These interventions should cut across multiple targets, including meat consumers, producers, marketers, and policymakers, emphasizing among consumers the public health impacts of handling and ingestion of infected meats from practices that fall short of food safety standards.

There is a significant association between food safety knowledge and the respondents' socioeconomic statuses. Meat consumers of higher age categories and educational levels were more likely to have adequate food safety knowledge than those of the 15–18 years age category and primary educational level, respectively. Also, only gender and educational status were significantly associated with food safety practices among the surveyed meat consumers. These results are similar to the findings of Sanlier [29] and Murray et al. [40], who found that young consumers possess lesser knowledge and practice scores on food safety than other groups. Students were significantly more likely to have adequate food safety knowledge than civil servants. Also, respondents with higher levels of education were more likely to demonstrate satisfactory food safety practices than those of primary education status. At the same time, males were significantly more likely to report acceptable food safety practices. Comparably, consumers' educational backgrounds, among other factors, are associated with good knowledge and practices of food safety [58,59].

Developing nations like Nigeria have struggled to achieve the WHO's five core criteria for safe food because basic utilities like clean water and

adequate sanitary facilities are absent [60]. Deficiencies at every step of the food chain—from farm to table—have exacerbated Nigeria's food safety concerns. The growing population, income inequality, long food supply chains, shifting demographics, low level of education, food consumer behavior, and other factors common to places with low economic growth all add to Nigeria's subpar food safety standards [60,61]. It is a problem that many low-income families are exposed to repetitive meals that exacerbate food safety concerns because of their lack of access to fresh food. Obligatory and profit-driven practices, such as food fraud and food adulteration, have also exacerbated food safety issues in Nigeria [9,60,62]. In addition, several other factors compound food safety issues in Nigeria, including a concerning deficiency in basic amenities and education on the significance of food safety culture [63–66]. Cooking procedures, Food safety education, and facilities are severely lacking in many Nigerian suburbs and villages [63–66]. Poor food practice handling techniques such as poor refrigeration, lengthy handling, improper reheating of prepared meals, improper handling of raw foods, and contamination by commercial or domestic household food handlers have all been recognized as contributing factors contributing to foodborne outbreaks in Nigeria [67,68]. There has been a shift in Nigeria's food safety management due to an increase in the number of ready-to-eat street dishes that are popular among the country's citizens.

Some limitations were encountered in this study. First, the study population is limited to meat consumers in Ilorin, and care should be taken not to generalize the results across the country overall food handlers or consumer types. Secondly, this study entails using a questionnaire reporting the answers provided solely by the meat consumers, who could easily introduce some response bias. However, the questionnaire was pre-tested and had a high-reliability coefficient. Also, the outcome variables developed were aggregated scores during the analysis where each knowledge and self-reported practice item effect was not examined. Future studies should include longitudinal/observational surveys of meat consumers to validate results from food safety knowledge and self-reported practices while ensuring that responses obtained from consumers are accurate.

5. Conclusion

This study showed that food safety knowledge and self-reported practices among meat consumers in Ilorin are unsatisfactory. It is concluded based on these results that respondents are not familiar with their role in the food safety chain or the importance of adhering to strict food safety practices to help to reduce the risk of foodborne pathogens. Hence, foodborne diseases will continue to be a major problem in the nation and the world as a whole regardless of recorded successes and other measures put in place to reduce foodborne illnesses. This study contributes to the critical premise of food safety from the end user's viewpoint with a special focus on meat consumers in a typical city in Nigeria. Important challenges identified in meat safety practices provide readily accessible action points for interventions by appropriate authorities and precautions by consumers at a personal level. Food safety is critical at the consumer level. Therefore, it has been concluded that consumers are still the ultimate link to preventing foodborne pathogens. There is a need for an improvement in consumers' food safety practices.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

The authors thank the respondents to the survey for their participation.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.dialog.2022.100039>.

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