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KNOWLEDGE AND PERCEPTION OF CONSUMERS ON MICROBIOLOGICAL MEAT SAFETY, ANTIBIOTIC RESISTANCE AND RESIDUES IN TEMA METROPOLIS, GHANA

Anachinaba, I.A.[1], Adzitey, F[1]. *, Teye, G.A.[1], Brown, C.A. [2] and Boateng, E.F.[3]
[1]Department of Animal Science, Faculty of Agriculture, Food and Consumer Sciences, University for Development Studies, P. O. Box TL 1882, Tamale, Ghana.
[2]Department of Medical Laboratory Sciences College of Health Sciences, School of Biomedical and Allied Health Sciences, University of Ghana, Accra, Ghana.
[3]College of Food Science and Technology, Nanjing Agricultural University, No. 1 Weigang, 210095, Nanjing, China P.R.

* ***Corresponding author's email:*** *adzitey@yahoo.co.uk*

ABSTRACT
This study assessed the knowledge and perception of consumers on microbiological meat safety, antibiotic resistance and residues in Tema Metropolis, Ghana. A semi-structured questionnaire was used to collect information from 384 randomly selected meat consumers on their knowledge and perception of meat safety and antibiotics. Data obtained was analysed using Statistical Package for Social Sciences version 20 and Chi Square was used to determine relationships among some parameters. The results revealed that 56% were males, with the majority (54%) aged between 21-40 years. Most (51%) of the respondents had basic education. For consumption, most of the respondents preferred chicken (53%) to beef (32%) and pork (14%), mostly because of taste (50%), followed by accessibility (39%) and price (11%). Majority (80%) of the respondents agreed (slightly to strongly agree) that meat consumption is associated with hypertension/high cholesterol and diabetics. Also, most of the respondents had heard about microbiological meat safety (64%) mostly from their teachers in school (62%) and the media (25%). They had also heard about antibiotic resistance (55%) and antibiotic residues (53%), mostly from their teachers in school (56% and 58%, respectively). Generally, most of the respondents did not know much about antibiotic resistance and antibiotic residues, although they had heard about them. The findings of the study warrant the need to educate consumers on food safety and antibiotic related issues.

Key words: Antibiotic residues, Antibiotic resistance, Consumers, Microbiological meat safety

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INTRODUCTION
Food safety and antibiotic resistance related issues remain essential in the health of mankind (World Health Organization, 2020). The use of antibiotics in animal farming, lapses occurring during meat processing and the consumption of meats contaminated by antibiotic resistance pathogens are among the main forces propelling the spread of foodborne/meatborne pathogens, antibiotic resistance bacteria and residues (Adesokan *et al*., 2015; Abass *et al*., 2020). Microbiological meat safety is the handling, storing and/or preparation of meat to prevent meatborne illnesses. Antibiotic resistance happens when bacteria develop the ability to defeat drugs originally designed to kill them (World

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Health Organization, 2020). Antibiotic residues are metabolites or compounds present in trace amounts in edible animal tissues or products after administration of antibiotics (Bacanlı and Başaran, 2019). Antibiotics are used in animal farming either to prevent infections, for treatment of sick animals or to promote growth (Laxminarayan *et al.*, 2013; Ventola, 2015). This can cause pathogens associated with animals to become resistant to antibiotics. Furthermore, non-observance of antibiotic treatment withdrawal periods can lead to the deposition of antibiotic residues in animal tissues (Adesokan *et al*., 2015; Abass *et al*., 2020). Slaughtering of animals, cutting carcasses into parts and selling meats under unhygienic conditions contribute to the spread of antibiotic resistant meatborne pathogens and antibiotic residues. This will happen when meats are not cooked properly prior to consumption. In addition, foodborne diseases can occur as a result of consumption of contaminated meat.

Foodborne diseases and antimicrobial resistance issues unabatedly pose threat to public health. World Health Organization (2022) estimated that unsafe foods cause 600 million cases of foodborne diseases, 420,000 deaths, and an underestimated 33 million years of healthy lives are lost each year worldwide. In USA, the Centers for Disease Control and Prevention (2018) also estimated that 31 known pathogens caused 37.2 million illnesses, 22,844 hospitalizations and 2,612 deaths annually. Gregory (2022) pointed out that, antimicrobial resistance poses a significant threat to mankind, killing about 3,500 people each year. Furthermore, estimates showed that more than 1.2 million people died as a result of direct antibiotic resistant bacterial infections (Gregory, 2022).

There are evidences of meats contaminated with pathogens such as *Campylobacter jejeni*, *E. coli* O157:H7, *Listeria monocytogenes*, *Salmonella enterica*, *Staphylococcus aureus* among others (Zhao *et al.,* 2011; Anachinaba *et al*., 2015; Albarri *et al*., 2017; Jaja *et al*., 2019; Tay *et al*., 2019; Adzitey, 2020), which exhibited varying antibiotic resistances to antibiotics such as amoxycilin, ciprofloxacin, erythromycin, gentamicin, norfloxacin, tetracycline, etc (Zhao *et al*., 2011; Albarri *et al*., 2017; Jaja *et al*., 2019; Adzitey *et al*., 2020a; Adzitey *et al*., 2020b). There are also reports of meats contaminated with antibiotic residues such as ampicillin, danofloxacin, doxycycline, penicillin, tetracycline, norfloxacin, tylosin etc contributing to making meats unsafe (Cheong *et al.,* 2010; Ramatla *et al*., 2017; Agmas and Adugna, 2018; Akansale *et al*., 2019; Ekli *et al*., 2020). Besides biological hazards, chemical and physical hazards also make meat unsafe for consumption. Cavalheiro *et al*. (2020) reported that consumers complained of physical hazards such as stones, hair, plastic, metal and wood in meat and meat products. Chemical hazards like halogenated carbon compounds, heavy metals, pesticides and veterinary drugs, and physical hazards like metal, glass, plastic and wood that make food unsafe have also been shown to be present in poultry meats (Banach *et al*., 2017).

Consumers' knowledge and perception about microbiological meat safety, antibiotic usage/resistance and antibiotic residues could make them to demand for safe foods which will propel food producers, processers and/or stakeholders in the food chain adhere to precautions to produce safe food. Albeit, studies on the knowledge and perception of consumers in Ghana on food safety is very limited and such study in Tema metropolis is unavailable. The menace of microbial contamination of meat, antibiotic resistance and residues can lead to higher cost of medical treatment, prolong hospitalization, reduce manpower and increase mortality

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(World Health Organization, 2020). Therefore, this study was conducted among consumers of meat in Tema, Ghana to determine their knowledge and perception towards microbiological meat safety, antibiotic usage and residues.

MATERIALS AND METHODS

Study area

The study was conducted in the Tema Metropolis which is described as the city located on the Bight of Benin and Atlantic Coast of Ghana (Tema Metropolitan Assembly, 2021). Tema is a cosmopolitan city and harbors middle to high income earners actively involved in meat consumption. The city is an industrial hub in Ghana and contributes massively to the economy of Ghana (Tema Metropolitan Assembly, 2021). Tema Metropolis is also nicknamed as the 'Harbor City' because it hosts Ghanas' largest seaport and other industries (Tema Metropolitan Assembly, 2021). Geographically, the Metropolis lies between latitude 5º38'32' North and longitudes 0º0'9''West (Tema Metropolitan Assembly, 2021). Tema is entirely urban and has a population of 29, 2773 (Ghana Statistical Service, 2014).

Study design and questionnaire administration

A survey was conducted using a semi-structured questionnaire to obtain data on meat consumers' knowledge and perception on microbiological meat safety, antibiotic usage/resistance and antibiotic residues. The questionnaire was pre-tested prior to the actual survey. Meat consumers (respondents) as used in this study, refers to all people who consume meat and excluded vegetarians. The sample size was determined using sample size calculator at a confidence level of 95%, error margin of 5% and population portion of 50% (Calculater.net, 2020). The population of Tema according to Ghana Statistical Service (2014) was 29, 2773. Based on this population the sample size for consumers was computed to be 384. Therefore 384 meat consumers were randomly selected and interviewed.

Data analysis

Data collected were subjected to analysis using Statistical Package for Social Sciences version 20, Armonk, NY. Descriptive statistics using frequencies were used to obtain percentages. Chi square ($\chi 2$) was used to determine the relationship among some of the data obtained at 5%. The results were presented in tables and figures.

RESULTS AND DISCUSSION

Demographic characteristics and information about consumers

The demographic characteristics of meat consumers are shown in Table 1. This study revealed that, the meat consumers interviewed were dominated by males (56%), youth (54%), married couples (46%), Christians (59%) and people with basic education (51%). The majority also consumed meat once a day (34%) and preferred chicken (53%) due to it taste (50%). Most of the consumers slightly agreed (29%) that meat consumption is a risk factor to the development of hypertension/high cholesterol and diabetics as shown in Table 2. Age ($\chi 2$=96.536, df=24, P=0.000) had influence on how often consumers consumed meat, but not educational level of the consumers ($\chi 2$=35.187, df=30, P=0.236). Kirk *et al*. (2002) indicated that consumer's response to food safety risks was affected by their demographic characteristics such as gender, age and education, which agrees with this study. A survey conducted by Gulab (2018) reported that majority of meat consumers consumed beef (58.5%), chicken (72.62%) and pork (40.5%) weekly, which contradicts

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the daily intake observed in this study. Also, Gulab (2018) found that, 34.8% of meat consumers attended high school or less, 29.0% of them were males and the respondents had an average age of 52 years, which is comparable to this study. The perception that meat consumption is associated with hypertension/high cholesterol and diabetics is worrying since it can affect meat consumption. Nonetheless, meat contains some essential amino acids which are absent in plants. In addition, meat is needed for normal growth and development.

Knowledge and perception of meat consumers on microbiological meat safety

The study depicted that most of the consumers had heard about microbiological meat safety (64%) and heard about it from their teacher/school (62%) as depicted in Table 3. Majority of the consumers knew that meat can be contaminated with bacteria/germs by poor handling and can cause foodborne diseases (69%), eating, drinking and smoking while selling meat increases the risk of its contamination (52%) and observance of meat hygiene by meat sellers/handlers reduces the risk of meat contamination (73%). Thus, most of them had some knowledge in how meat is contaminated by bacteria, risks associated with certain practices of handling meat and means of reduction of meat contamination. Refrigeration was identified to be the best method of preserving meat mainly due to the fact that it makes meat to last longer. Fewer consumers had ever seen animals being slaughtered and did not like it. The consumers purchased their meats from open markets, supermarkets and cold store mainly because of the price, quality of the meat, neatness of the place, convenience and personal relationship with the meat seller. Age ($\chi 2$ =39.029, df = 12, P=0.000) and educational level ($\chi 2$=136.468, df=15, P=0.000) of meat consumers influenced their knowledge of meat safety. Lower number of consumers knew that bacteria such *Listeria* spp. (34%), *Campylobacter* spp. (32%), *Yersinia* spp. (32%), *Salmonella* spp. (32%), *E. coli* (31%), *Shigella* spp. (28%), and *Bacillus* spp. (28%) can cause foodborne diseases (Figure 1). Bacteria, including *Salmonella*, *E. coli, Campylobacter* spp. and *Listeria* spp. have been implicated in a number of foodborne diseases resulting in hospitalization, recovery or death. In a study to understand consumers' attitudes towards antimicrobial risk reducing practices, 71.4%, 14.0%, 5.3%, 1.1% and 7.9% indicated food safety is very important, important, neutral, unimportant and very unimportant, respectively to them when purchasing meat (Gulab, 2018). Furthermore, animal welfare was considered to be very important (41.5%), important (26.2%), neutral (18.7%), unimportant (5.9%) and very unimportant (7.6%). Consumer's regard and demand for meat safety is important to make farmers, middlemen, processors, meat sellers and all stakeholders to work towards the production of safe food of animal origin.

Knowledge and perception of meat consumers on antibiotic resistance

The knowledge and perception of consumers on antibiotic usage is shown in Table 4. This study brought to light that most meat consumers in Ghana had heard about antibiotic resistance (55%) from teacher/school (56%), and had ever taken or used antibiotics (73%) to treat infections (59%) and injury (41%). The antibiotics ever used by consumers are presented in Figure 2a. They were tetracycline (77%), teicoplanin (75%), amoxicillin/clavunic acid (73%), ciprofloxacin (72%), sulphamethoxazole/trimethoprim (70%), gentamicin (68%), azithromycin (67%), ceftriaxone (64%) and chloramphenicol (64%). Bekoe *et al*. (2020) reported that consumers were exposed to antibiotics

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including amoxicillin, erythromycin, ceftriaxone, tetracycline, gentamicin, ciprofloxacin, clavunic acid, penicillin G, sulphamethoxazole and trimethoprim available at authorized and unauthorized sale outlets across the country for use by consumers. They also added that most of the consumers (75.93%) often sought self-treatment without a prescription form from unauthorized sale outlets. Gulab (2018) stated that some consumers' belief animals were given antibiotics (57.2%) to treat illness (55.6%), prevent infections (51.4%), and as growth promoters (45.4%). In this study, the minority (32%) who had never used antibiotics before ascribed it to the fact that, no one ever prescribed antibiotics for them (32%) or have never had infection (68%). Majority of the consumers also knew that antibiotic usage produces effects such as nausea and headaches (48%), allergies and skin irritation (37%) as well as body pains (16%). Most of the consumers said that: 1) antibiotic resistance occurs in bacteria/germs (64%), 2) antibiotic resistance occurs when bacteria develop the ability to survive exposure to antibiotics (51%), 3) infections caused by antibiotic resistant bacteria are difficult to treat (49%), and 4) the more antibiotics we use, the higher is the risk that resistance develops and spreads (37%). However, most of them did not know that 1) the result of antibiotic resistance is that certain antibiotics can no longer be used to successfully treat certain infections (41%), 2) antibiotic use for animals can reduce the possibility of effective antibiotic treatment for humans (43%), 3) meat can be contaminated by antibiotic resistant bacteria (41%) and 4) human can consume meat contaminated by antibiotic resistant bacteria (52%). According to majority of the consumers, locally produced (74%, slightly to strongly agree) and imported (64%, slightly to strongly agree) meats in Ghana sometimes contain antibiotic resistant bacteria as presented in Figure 2b and 2c, respectively. Age ($\chi2$=32.190, df = 9, P=0.000) and educational level ($\chi2$=86.782, df=20, P=0.000) of meat consumers influenced their knowledge in antibiotic resistance. Phares *et al.* (2020) found that factors including farmer's years of experience, educational level, type of animal kept, access to antibiotics and extension services significantly influenced the administration of antibiotics by farmers.

Knowledge and perception of meat consumers on antibiotic residues

The knowledge and perception of consumers on antibiotic residues is presented in Table 5. This study revealed that, most of the consumers had heard about antibiotic residues (53%) such as amoxycilin (52%), chlortetracycline (56%), ciprofloxacin (74%), danofloxacin (57%), doxycycline (57%), norfloxacin (61%), oxytetracycline (59%), sulfadiazine (53%), tylosin (47%), chloramphenicol (58%) and metronidazole (57%) (Figure 3a) mostly from their teachers in school (58%). However, most of the consumers did not know that: 1) antibiotic residues are molecules that remain in meat from animals that have been treated with antibiotics (45%), 2) antibiotic residues in meat can be reduced by observing withdrawal periods (43%), and 3) antibiotic residues can be transferred from meat to humans via consumption (42%). A good number of the consumers (38%) knew that farmers play a key role in the deposition of antibiotic residues in meats. Most of the consumers also agreed that locally produced (57%, slightly to strongly agree, Figure 3b) and imported (57%, slightly to strongly agree, Figure 3c) meats sometimes contain antibiotic residues. Age ($\chi2$=18.759, df =12, P=0.095) and educational level ($\chi2$=52.554, df=15 P=0.000) of meat consumers influenced their knowledge in antibiotic residues. Phares *et al*.

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(2020) reported that most farmers had easy access (92.8%) to antibiotics as opposed to those that had difficulties (7.2%). Also, most farmers administered antibiotics by themselves, had no training on the effects of antibiotics and did not observe withdrawal periods (Phares *et al*., 2020). These could influence and result in the wrong administration of antibiotics and consequently the deposition of antibiotic residues in meat.

CONCLUSION/RECOMMENDATION

Majority of the meat consumers were males, young and had basic education. A greater proportion of the consumers ate meat once a day, preferred chicken to beef and pork mainly due to taste and accessibility, and said meat consumption was associated with hypertension/high cholesterol and diabetics. Most of them had heard about microbiological meat safety, antibiotic resistance and antibiotic residues. However, most of them did not know much about microbiological meat safety, antibiotic resistance and antibiotic residues.

Most of the consumers agreed that locally produced and imported meats on the Ghanaian market sometimes contain antibiotic resistant bacteria. Similarly, most of the consumers agreed that locally produced and imported meats on the Ghanaian market sometimes contain antibiotic residues. The findings of this study necessitate the formulation and introduction of policies aimed towards providing education on meat safety, antibiotic resistance and residues for consumers. This will empower consumers to demand for food safety which will translate into producing safe foods in Ghana. Regular informal education and hands on training on microbiological meat safety, antibiotic resistance/usage and antibiotic residues is recommended for consumers. Food safety regulations should be enforced to the latter in order to protect human lives.

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APPENDICES

Table 1: Demographic characteristics of consumers

Variable	Frequency	Percentage (%)
Gender		
Male	216	56
Female	168	44
Age (years)		
Below 21	58	15
21- 40	209	54
41 – 60	87	23
Above 60	30	8
Marital status		
Married	174	46
Single	168	44
Divorced	23	6
In a relationship	16	4
Religion		
Christianity	226	59
Islamic	112	29
Traditional	32	8
Non-religious	10	3
Educational background		
None	3	1
Basic	195	51
Secondary	183	48
Tertiary	1	0

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Table 2. Information about consumers on meat consumption

Variable	Frequency	Percentage (%)
How often do you consume meat?		
Once a day	132	34
2-6 times a week	128	33
Once a week	99	26
Once a mouth	25	7
Which of these meats do you prefer most?		
Beef	116	32
Chicken	193	53
Pork	52	14
State your reason (s) for your preference		
Taste	187	50
Price	41	11
Accessibility	143	39
Meat consumption is associated with hypertension/high cholesterol and diabetics		
Strongly agree	87	26
Slightly agree	97	29
Moderately agree	83	25
Slightly disagree	54	16
Strongly disagree	15	4

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Table 3. Knowledge and perception of meat consumers on microbiological meat safety

Variable	Frequency	Percentage (%)
Heard of microbiological meat safety		
Yes	245	64
No	137	36
If, yes from who/where?		
Health officer	18	8
Teacher/school	148	62
Media	59	25
Friends	12	5
Meat can be contaminated with bacteria/germs by poor handling and can cause foodborne diseases		
Yes	184	69
No	84	31
Eating, drinking and smoking while selling meat increases the risk of its contamination		
Yes	182	52
No	165	48
Observance of meat hygiene by meat sellers/handlers reduces the risk of meat contamination		
Yes	241	73
No	89	27
Best method to preserve meat to reduce/prevent contamination		
Refrigeration	221	61
Salting	72	20
Smoking	69	19
Frying	3	1
Why did you choose this method?		
Appropriate method	52	14
Meat last longer	118	32
Economical	75	21
Availability	63	17
Kills bacteria	14	4
Safe	43	12
Seen how animals are slaughtered and dressed before being sold on the market		
Yes	137	45
No	167	55
If yes, did you like it?		
Yes	42	31
No	95	69

Where do you buy your meat?		
Open market	121	32
Butcher shop	118	31
Super market	97	26
Cold store	39	10
Why do you buy meat from such place?		
Price of the meat	148	39
Neatness of the place and meat	104	27
Convenience (Closeness to my house)	14	4
Quality of product	112	29
Sellers relationship	6	2

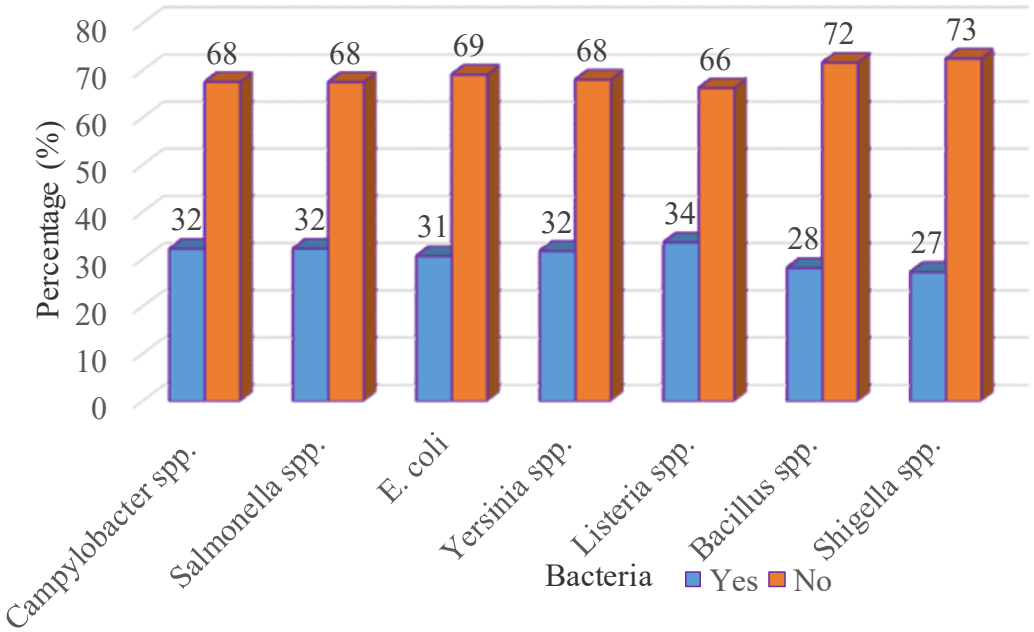

FIGURE 1. Bacteria that cause foodborne diseases - Consumers response

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Table 4. Knowledge and perception of consumers on antibiotic resistance

Variable	Frequency	Percentage (%)
Heard of antibiotic resistance		
Yes	213	55
No	171	45
If, yes from who/where?		
Health officer	24	11
Teacher/school	119	56
Media	58	27
Friends	12	6
Have you ever used or taken antibiotics?		
Yes	281	73
No	103	27
Why did you use this/these antibiotic/s?		
Treat infection	207	59
Others (injury, wound, diarrhea)	144	41
If you have never used antibiotics, why?		
Have never had infection	68	68
No one has ever prescribed antibiotics to me	32	32
Antibiotics have effects on humans		
Yes	263	76
No	83	24
If yes, what do you think are the effects of antibiotic usage?		
Nausea and headaches	121	48
Body pains	40	16
Allergies and skin irritation	93	37
People can become resistant to antibiotics		
Yes	207	64
No	84	26
I do not know	34	10
Antibiotic resistance occurs in bacteria/germs		
Yes	205	64
No	94	29
I do not know	20	6
Antibiotic resistance occurs when bacteria develop the ability to survive exposure to antibiotics		
Yes	187	51
No	93	25
I do not know	87	24

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Antibiotic resistance bacteria can infect humans		
Yes	114	31
No	82	23
I do not know	168	46
Infections caused by antibiotic resistant bacteria are difficult to treat		
Yes	167	49
No	35	10
I do not know	142	41
The result of antibiotic resistance is that certain antibiotics can no longer be used to successfully treat certain infections		
Yes	109	29
No	112	30
I do not know	156	41
Antibiotic use for animals can reduce the possibility of effective antibiotic treatment for humans		
Yes	98	29
No	94	28
I do not know	146	43
Meat can be contaminated by antibiotic resistant bacteria		
Yes	96	28
No	110	32
I do not know	143	41
Human can consume meat contaminated by antibiotic resistant bacteria		
Yes	78	21
No	97	27
I do not know	189	52
The more antibiotics we use, the higher is the risk that resistance develops and spreads		
Yes	128	37
No	103	29
I do not know	119	34

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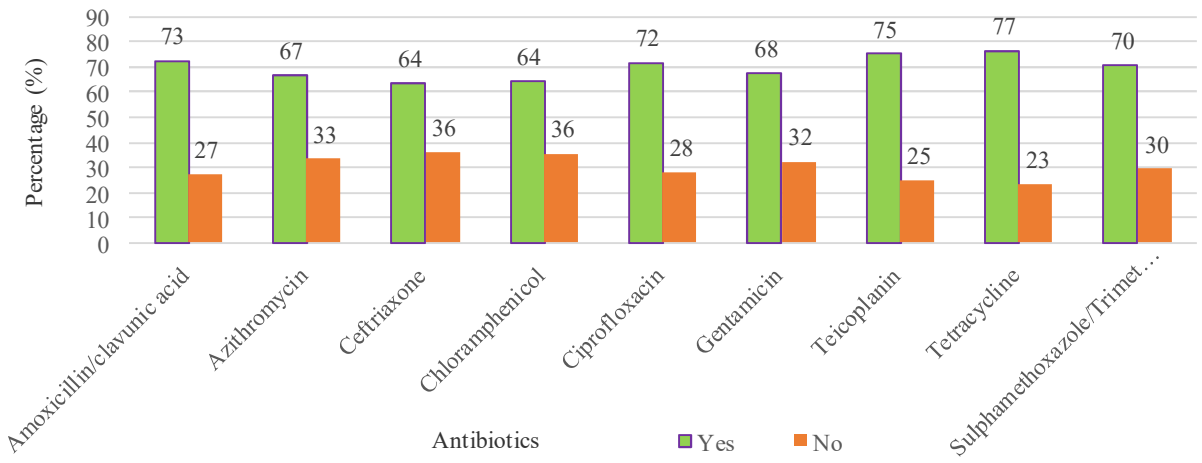

FIGURE 2a. Antibiotics ever used - Consumers response

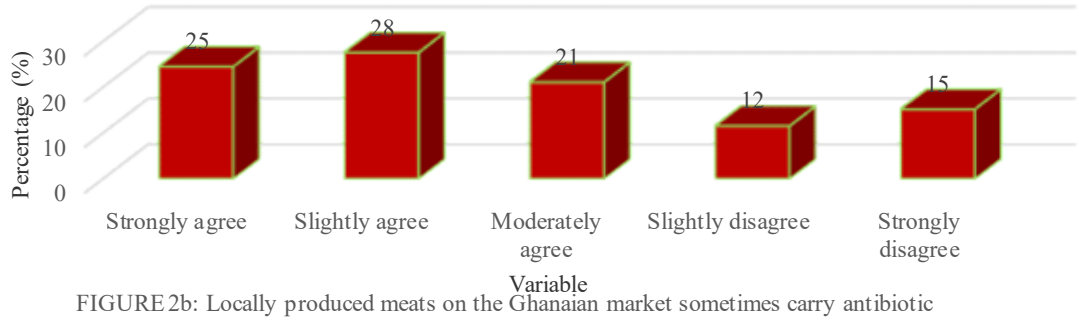

FIGURE 2b: Locally produced meats on the Ghanaian market sometimes carry antibiotic resistant bacteria - Consumers response

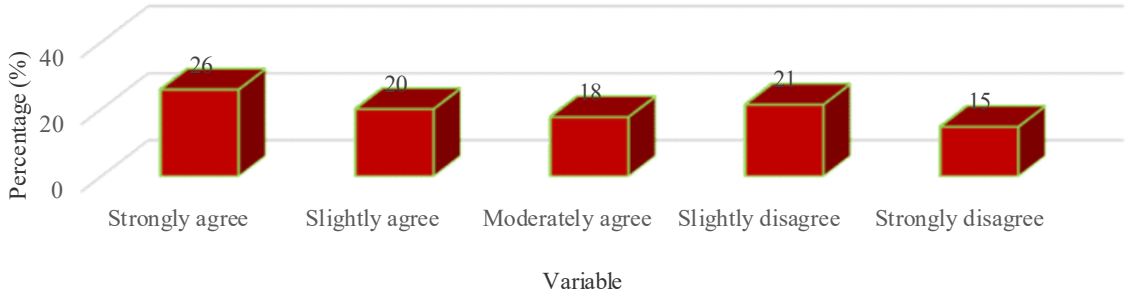

FIGURE 2c: Imported meats on the Ghanaian market sometimes carry antibiotic resistant bacteria - Consumers response

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Table 5. Knowledge and perception of meat consumers on antibiotic residues

Variable	Frequency	Percentage (%)
Heard of antibiotic residues		
Yes	193	53
No	168	47
If, yes by what means?		
Health officer	34	18
Teacher/school	110	58
Media	12	6
Friends	34	18
Antibiotic residue can occur in humans		
Yes	134	35
No	97	25
I do not know	150	39
Antibiotic residue occurs in bacteria/germs		
Yes	86	23
No	109	29
I do not know	183	48
Antibiotic residues are molecules that remain in meat from animals that have been treated with antibiotics		
Yes	132	35
No	79	21
I do not know	171	45
Antibiotic residues in meat can be reduce by observing withdrawal periods		
Yes	97	26
No	121	32
I do not know	162	43
Antibiotic residues can be transferred from meat to humans via consumption		
Yes	83	22
No	137	36
I do not know	157	42
Animal farmers play significant role in antibiotic resistant residues in meat		
Yes	146	38
No	89	23
I do not know	146	38

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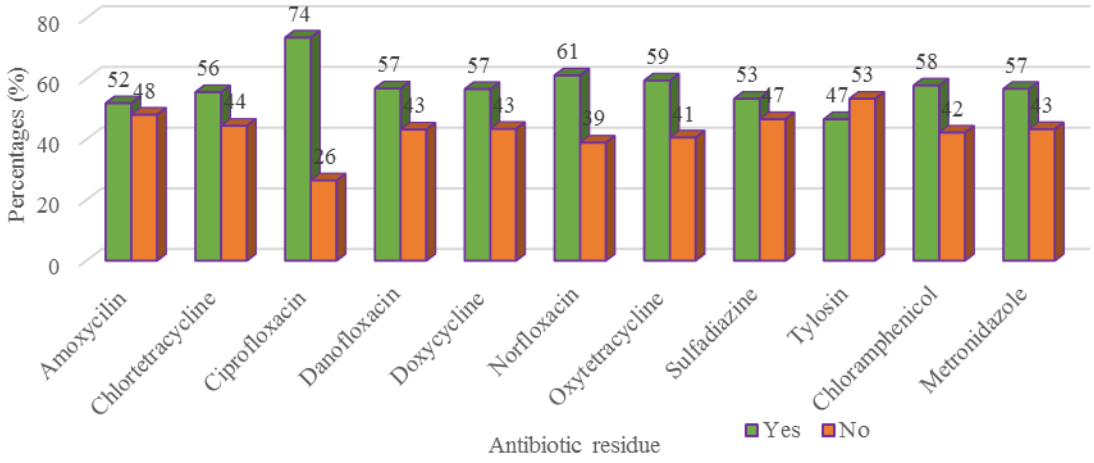

FIGURE 3a: Antibiotic residues heard of - Consumers response

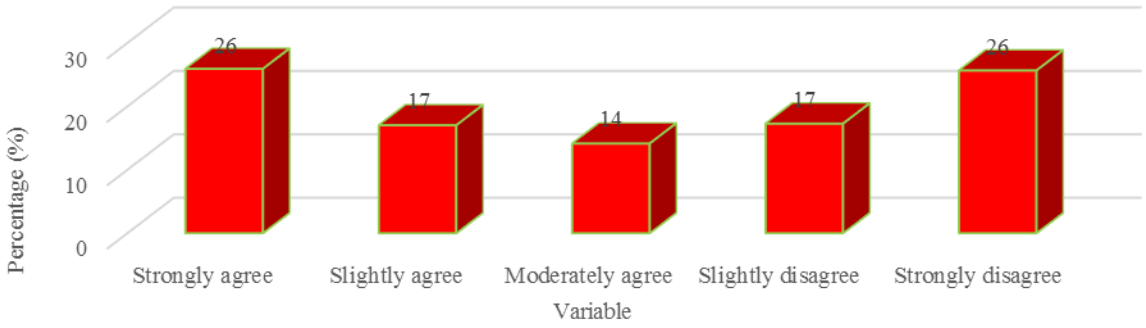

FIGURE 3b. Locally produced meats on the Ghanaian market sometimes contain antibiotic residues - Consumers response

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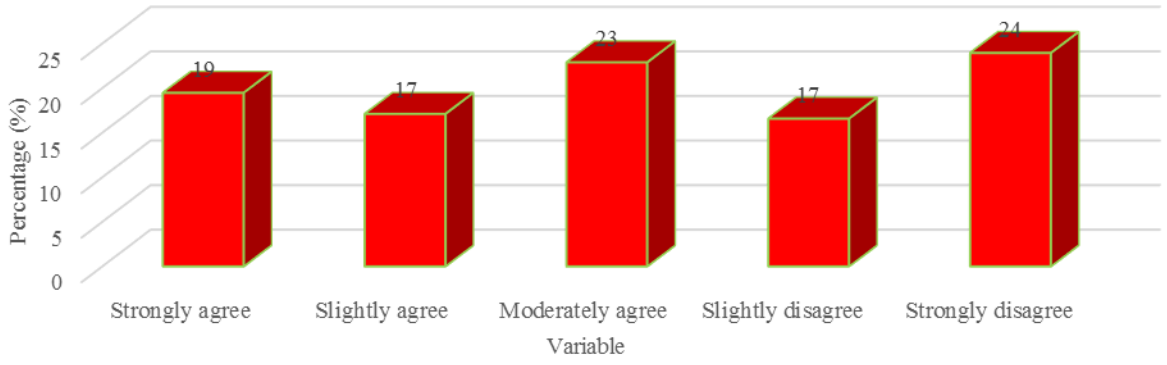

FIGURE 3c: Imported meats on the Ghanaian market sometimes contain antibiotic residues - Consumers response