Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.53555/jptcp.v31i4.5321

ASSESSMENT OF SALMONELLA CONTAMINATION IN RAW GOAT MEAT: ISOLATION, IDENTIFICATION, ANTIMICROBIAL RESISTANCE, AND PUBLIC HEALTH AWARENESS IN MIR ALI, NORTH WAZIRISTAN

Samina Saliha[1], Ashar Bin Dawood[2], Hafsa Asghar[3], Hilla Jehan[4]*, Fahim Ullah[5], Qazi Sami Ul Haq[6], Shafiq Ur Rahman[7], Kaleem Ullah[8]

[1]The Islamic University of Bahawalpur, Bahawalpur, Pakistan, Email: samina.saliha@gmail.com
[2,3]akhtar Saeed Medical and Dental College, Lahore, Pakistan, Email: asharbindawood@gmail.com
[4*]Department of Microbiology, Iqra National University, Peshawar, Pakistan.
Email: hillajehan@inu.edu.pk
[5,6,7] Department of Microbiology, Abbottabad University of Science and Technology, Abbottabad, Pakistan, Email: fahimwazir996@gmail.com
[8]Department of Medical Laboratory Technology, Abbottabad University of Science and Technology, Abbottabad, Pakistan, Email: kaleemkhan2296@gmail.com

***Corresponding Author:** Hilla Jehan
*Department of Microbiology, Iqra National University, Peshawar, Pakistan.
Email: hillajehan@inu.edu.pk

ABSTRACT

Salmonella is a major public health hazard, and infected raw meat products, such as goat meat, are a prevalent means of transmission. The rise of antimicrobial-resistant Salmonella strains complicates treatment and increases the risk to world health. The objective of the study is to look at the Salmonella prevalence in raw goat meat in Mir Ali, North Waziristan, as well as to analyze antibiotic resistance patterns and knowledge of meat safety, attitudes, and behaviors among abattoir workers, butchers, and consumers.

A cross-sectional study was undertaken between January and May 2021, and it included microbiological testing of goat carcasses as well as a KAP survey of individuals who handle goat meat. Salmonella isolation and identification were accomplished using ISO techniques, and antibiotic susceptibility was determined using disc diffusion method. SPSS was used to conduct statistical analysis on the data.

In the meat samples, 35.0% of the Salmonella isolates were resistant to Ampicillin, 32.4% to Amoxicillin-clavulanic acid, and 15.2% to Gentamicin. The KAP study results found gaps in sanitary standards, as well as a lack of training and awareness among meat handlers. Notably, the majority of abattoir workers and butchers did not utilize clean equipment or wash their hands properly. Consumers had a limited grasp of the dangers connected with raw and inadequately handled meat.

The study discovers a high concentration of antimicrobial-resistant Salmonella in raw goat meat and shows gaps in public knowledge and hygiene procedures among meat industry workers. It emphasizes the importance of enhanced surveillance, prudent antibiotic use, and public health

education in reducing the dangers associated with raw goat meat consumption and combating the spread of antimicrobial resistance.

Keywords: Salmonella, antimicrobial resistance, goat meat, food safety, knowledge attitudes practices, Mir Ali, North Waziristan.

INTRODUCTION

Infections from bacteria that are spread through food are most frequently caused by salmonella worldwide (1, 2), and its presence in raw meat poses a considerable risk to public health (3, 4). The Salmonella genus contains a diverse group of pathogenic bacteria that can cause gastrointestinal and systemic disorders in humans and animals (5). Consuming contaminated meat is a well-known pathway for Salmonella transmission to humans (6), which can result in symptoms ranging from self-limiting gastroenteritis to more serious and possibly life-threatening illnesses such as typhoid fever (7, 8). Goat meat, a prominent dietary component in many cultures, is no exception to this problem, especially when handling and cooking techniques are inadequate (9).

Furthermore, the rise of antimicrobial-resistant (AMR) strains of Salmonella complicates treatment choices and represents a substantial problem in treating infection outbreaks (10). The misuse and overuse of antibiotics in animal husbandry for therapeutic and preventative purposes have contributed to the increase in AMR, which is now considered a global crisis with far-reaching consequences for human and animal health (11, 12).

Mir Ali, North Waziristan

Mir Ali, North Waziristan, is notable for its animal rearing, particularly goats, which are an important source of meat for local populations. However, there is a scarcity of information about the safety of raw goat meat and the prevalence of microbiological contamination, notably Salmonella, in this region. Given these regions' limited health infrastructure and surveillance systems, there is an increased risk of foodborne illness transmission and uncontrolled antibiotic resistance development.

To understand the current situation, it is necessary to examine the prevalence of Salmonella in raw goat meat, the antimicrobial susceptibility profiles of isolated strains, and the local population's knowledge, attitudes, and practices, including abattoir workers, butchers, and consumers. Such insights are critical for establishing focused treatments, informed legislation, and comprehensive educational campaigns that improve meat safety and protect public health.

The purpose of this study is to isolate and identify Salmonella strains from raw goat meat in Mir Ali, North Waziristan, determine their susceptibility to various antimicrobials, and assess public awareness of safe meat handling procedures and the dangers associated with Salmonella ingestion. We believe that our multidimensional inquiry will add to the existing information on foodborne pathogens and AMR in a location with little data, laying the framework for future research and public health activities.

MATERIALS AND METHODS

Study site

The study was carried between January and May 2021 in Mir Ali, a city in North Waziristan Agency. The city is situated at an altitude of 655 meters and is surrounded by Afghanistan, Kurram Agency, Hangu district, Bannu and Karak districts, South Waziristan Agency, and Afghanistan. The climate is cold in winter and warm in summer, with the warmest month being June. October marks the beginning of winter, which lasts until April. The coldest months are December, January, and February (13).

Study population

The goat carcasses that were killed in the abattoir and the people who handled the goat meat—butchers, consumers, and employees of the abattoir—made up the study population.

Sample size determination

The sample size for the observation and questionnaire survey was specifically chosen based on respondent willingness, ease of follow-up, and the supply chain for goat meat from the abattoir to the consumer. As a result, the study included 42 participants: 16 abattoir staff, 14 butchers, and 12 consumers.

The sample size for Salmonella isolation and identification was estimated using Thrusfield's (2005) formula, with 8.7% predicted prevalence, 5% required precision, and a 95% confidence range. As a result, the minimal sample size was estimated as 98. The sample size was raised to 120 carcasses in order to increase the estimate's precision.

Study Design

A cross-sectional investigation was conducted using an observational survey, a questionnaire, and microbiological analysis.

Methodology for sampling and collection of samples

The carcasses were sampled using a systematic random sampling technique. Swabs were taken using procedure outlined in ISO-17604 (2003). The sampling sites included the abdomen (flank), thorax (lateral), crutch, and breast (lateral). A 10 × 10 cm aluminum foil template was used to outline the sampling locations. A sterile cotton-tipped swab (2X3 cm) with a shaft was first soaked in about 10 ml of buffered peptone water (BPW) and then rubbed over the demarcated area horizontally and vertically numerous times. After rubbing, the swab was immersed in the buffered peptone water used to moisten it, and wooden shaft resting against within the universal bottle was broken off and discarded, putting the cotton swab back in the bottle. The remaining specified areas received more swabs of the same type, which were also put in the same container. As previously mentioned, a second dry, sterile cotton swab of the same kind was used to cover the whole sampled region, and deposited in the same container. Finally, the materials were conveyed to Abasyn University in Peshawar using cold boxes and ice packs.

Isolation and identification

Salmonella was isolated and identified using the international standardization organization's recommended technique (ISO-6579, 2002). The bacteriological media were prepared in accordance with manufacturer guidelines.

Pre-enrichment and selective enrichment

Swab samples were pre-enriched with the required amount of buffered peptone water (1:9) and incubated at 37°C for 24 hours. Müller Kauffman Tetrathionate with Novobiocin (MKTTn) broth and Rappaport-Vasiliadis medium (RV) broth were used to selectively enrich the samples. A volume of about 0.1 milliliters of the pre-enriched sample was moved to a tube that held 10 milliliters of Rappaport-Vasiliadis medium (RV broth), and it was incubated for a full day at 42 degrees Celsius. A tube holding 10ml of MKTTn soup was filled with an additional 1ml of the pre-enriched broth, and it was incubated for 24 hours at 37°C.

Plating out and identification

Plating and identification were carried out on Xylose Lysine Desoxycholate (XLD) agar and brilliant green agar (BGA) plates. On XLD and BGA plates, a loop containing inoculums from each RV and MKTTn broth culture was incubated for 24 hours at 37 0C. Following incubation, the plates were examined to see if any regular and dubious colonies were present. Because of the media's color shift, typical Salmonella colonies grown on XLD-agar have a black center and a faintly transparent reddish zone (ISO 6579, 2002). In contrast, H2S negative variants developed on XLD agar are pink with a darker pink center. On XLD agar, lactose-positive Salmonella cultures appear yellow, sometimes with blackening. Salmonella colonies on BGA typically turn the medium red, are pink,

and have a diameter of 1 to 2 mm. From the selective plating media, five common or suspected colonies were chosen, streaked over the nutrient agar plate surface, and then cultured for twenty-four hours at 37°C. Following ISO-6579 (2002), a variety of biochemical tests, including TSI agar, L-lysine decarboxylation medium, urease, and Indole synthesis assays, were used in the biochemical testing.

Antimicrobial susceptibility tests

The disc diffusion method was utilized to assess the isolates' antibiotic susceptibility in compliance with the guidelines provided by CLSI (2012) and the National Committee for Clinical Laboratory Standards (NCCLS, 2002). From nutrient agar plates, four to five well-isolated colonies were put into tubes with five milliliters of tryptone soy broth (Oxoid). After four hours of incubation at 37ºC, the broth culture reached the 0.5 McFarland turbidity threshold. The suspension was dipped into a sterile cotton swab, which was then spun many times before being evenly swabbed across the Muller Hinton agar plate (Oxiod, England). To allow for drying, plates were left at room temperature for thirty minutes.

The antibiotic discs containing 10 µg of ampicillin (AMP), 30 µg of amoxicillin-clavulanic acid (AMC), and 10 µg of gentamicin (CN) were used to test the isolates' susceptibilities. For twenty-four hours, the plates were incubated at 37ºC. Using the interpretive criteria developed by the Clinical Laboratory criteria Institute (2012), the widths of the inhibitory zones were compared to those of the control organism, E. coli ATCC 25922, and the organisms were categorized as resistant, intermediate, or susceptible.

Analysis and management of data

Information obtained from the survey and observational database, as well as laboratory study results, were imported into Microsoft Excel and prepared for analysis. The Descriptive statistics were obtained with SPSS version 20 statistical.

RESULTS

Triple sugar iron agar (TSI agar)

The results obtained from the Triple Sugar Iron agar (TSI agar) tests revealed distinctive patterns indicating the metabolic activity of Salmonella within the samples. Samples showing positive reactions for glucose fermentation and hydrogen sulfide (H2S) production, along with negative results for lactose and/or sucrose fermentation, suggest the presence of Salmonella strains capable of utilizing glucose while not fermenting lactose or sucrose. Additionally, the detection of H2S production in some samples further confirms the presence of Salmonella, as H2S production is a characteristic feature of certain Salmonella strains.

Figure 1: (a= Positive for glucose fermentation and H2S production, negative for Lactose and/or Sucrose fermentation), (b= Positive for H2S production, negative for Lactose and/or Sucrose fermentation), (c= Positive for gas production, H2S production, and negative for Lactose and/or Sucrose fermentation), and (d= Uninoculated)

L-Lysine decarboxylation medium

Furthermore, the findings from the L-Lysine decarboxylation medium tests provided additional insights into the biochemical characteristics of the isolated Salmonella strains. Positive results for lysine decarboxylation and H2S production in some samples indicate the presence of specific Salmonella strains exhibiting these metabolic activities, whereas negative results in other samples suggest the absence of such characteristics.

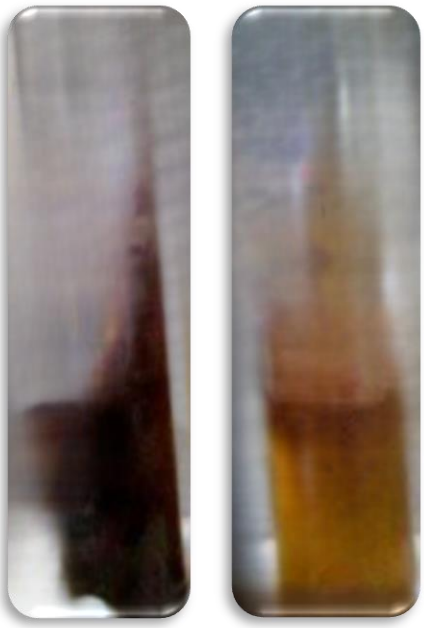

Figure 2: a= Lysine decarboxylation and H2S production positive and b=Lysine decarboxylation and H2S production negative

Urea Broth and Indole Tests

The Urea broth and Indole tests were conducted to further confirm the presence of Salmonella and assess specific biochemical activities associated with this pathogen. Positive results for urease activity in some samples indicate the presence of Salmonella strains capable of hydrolyzing urea, while positive results for indole production in other samples suggest the presence of Salmonella strains capable of metabolizing tryptophan to produce indole.

Overall, the findings of this research paper underscore the importance of monitoring and addressing Salmonella contamination in raw meat products, particularly goat meat, to mitigate potential health risks associated with consumption. By identifying and characterizing Salmonella strains, as well as raising public awareness about food safety practices, stakeholders can work towards ensuring the safety and quality of meat products to safeguard public health.

Figure 3: (a= uninoculated (control), b= Urease positive and c= urease negative)

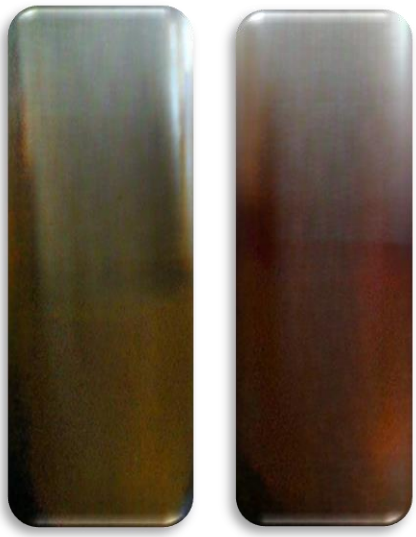

Figure 4: (a= Indole negative a= Indole positive)

Salmonella prevalence and susceptibility to antibiotics

Among the isolates subjected to Ampicillin (8 µg), a notable 35.0% exhibited resistance, with 2.5% showing intermediate susceptibility and 32.5% being susceptible to the antimicrobial. For Amoxicillin-clavulanic acid (25 µg), 32.4% of the Salmonella isolates displayed resistance, 23.5% showed intermediate susceptibility, and 16.2% were found to be susceptible. Notably, Gentamicin (9 µg) demonstrated a lower resistance percentage at 15.2%, with 32.6% of the isolates showing intermediate susceptibility and a substantial 52.2% exhibiting susceptibility. These findings suggest varying degrees of resistance and susceptibility among the Salmonella isolates, emphasizing the importance of understanding antimicrobial susceptibility patterns to inform effective treatment strategies and mitigate the risk of foodborne illnesses associated with raw goat meat consumption. Additionally, the observed differences underscore the need for targeted interventions and surveillance to address specific antimicrobial resistance challenges associated with Salmonella contamination in raw goat meat.

Antimicrobial	Number of Isolates	Resistant (%)	Intermediate (%)	Susceptible (%)
Ampicillin (AMP) 8 µg	40	35.0	2.5	32.5
Amoxicillin-clavulanic acid (AMC) 25 µg	34	32.4	23.5	16.2
Gentamicin (GEN) 9 µg	46	15.2	32.6	52.2

Table 1: Antimicrobial susceptibility and resistance numbers of isolates

Number	Antimicrobial Resistance Pattern	Number of Isolates Resistant
0	None	0 (0%)
1	AMC (Amoxicillin-clavulanic acid)	16 (13.3%)
2	Gentamicin (GEN)	6 (5%)
	Ampicillin (AMP)	19 (15.8%)
	AMC (1)	
3	AMC (1)	14 (11.7%)
	Gentamicin (2)	
	Ampicillin (2)	
4	Gentamicin (1)	14 (11.7%)
	Ampicillin (2)	
	AMC (1)	
5	Gentamicin (2)	26 (21.7%)
	Ampicillin (6)	
	AMC (1)	

Table 2: Multiple antimicrobial resistances of isolated Salmonella

Surveys using questionnaires and observational data

Abattoir workers

Knowledge, Attitudes, and Practices of Abattoir Workers

This table presents findings regarding the knowledge, attitudes, and practices of abattoir workers (n=16) employed at 16 slaughterhouses. The results reveal mixed levels of awareness and adherence to hygiene practices, highlighting areas for potential improvement.

The majority of workers (50%) had received education up to Grade 8, while 25% completed grades 9-12. A smaller portion (18.8%) had no formal education, and another 18.8% held education beyond Grade 12.

Over half of the workers (56.3%) were directly involved in slaughtering activities (cutting, flaying, eviscerating, etc.), while the remaining workers were involved in loading (18.8%), stomach washing (12.5%), and intestine washing (6.3%).

Only 31.3% of the workers reported receiving job-related training, and 37.5% had undergone recent medical testing. These findings suggest a potential lack of comprehensive training and health surveillance programs for abattoir workers. While 81.3% of the workers acknowledged that contamination poses a risk, their practices did not always reflect this knowledge. Only 12.5% reported wearing clean clothing consistently, and hand washing practices varied considerably, with only 25% washing before work and 56.3% washing after work.

None of the workers reported using clean knives, and 87.5% admitted to placing equipment unhygienically. These findings raise significant concerns about the potential for cross-contamination and the spread of foodborne pathogens within the slaughterhouse environment.

Overall, these results highlight the need for comprehensive training programs to educate abattoir workers on proper hygiene practices, the importance of using clean equipment, and the potential consequences of non-compliance. Additionally, implementing mandatory job-related training and regular medical testing could contribute to improving overall hygiene standards and safeguarding public health.

Factor	Value	Frequency	Percentage (%)
Educational Status	Illiterate	1	6.3
	Grade 1-8	8	50.0
	Grade 9-12	4	25.0
	Beyond Grade 12	3	18.8
Placement in Abattoir	Slaughtering (a)	9	56.3
	Loading	3	18.8
	Washing stomach	2	12.5
	Washing intestine	1	6.3
Job-Related Training	Yes	5	31.3
	No	11	68.8
Job-Related Medical Test	Yes	6	37.5
	No	10	62.5
Knowledge of Contamination as Risk	Yes	13	81.3
	No	3	18.8
Clean Clothing	Yes	2	12.5
	No	14	87.5
Hand Washing	Before work	4	25.0
	After end of work	9	56.3
	Before and after work	3	18.8
Knives are Clean	Yes	0	0
	No	16	100
Unhygienic Equipment Placement	Yes	14	87.5
	No	2	12.5

Table 3: Attitudes, Knowledge, and Practices of Abattoir Workers (n=16)

a = Cutting the throat, flaying, eviscerating, splitting, and washing the carcass.

Butchers

Knowledge, Attitudes, and Practices of Butchers

This table (Table 4) presents the findings regarding the attitudes, knowledge, and practices of 14 butchers. The results reveal concerning hygiene practices and highlight the need for improvements in various areas. Half of the butchers (50%) had received education up to Grade 8, while nearly a third (28.6%) completed grades 9-12. A smaller portion (7.1%) had no formal education, and another 7.1% held education beyond Grade 12.

Only 14.3% of butchers reported receiving job-related training, and a mere 7.1% used aprons (protective clothing) consistently. These findings suggest a potential lack of comprehensive training and inadequate utilization of essential PPE.

While 78.6% of butchers reported washing their hands after work, none reported washing them before work or during work. Additionally, 21.4% admitted to not washing their hands at all. Concerningly, 42.9% of workers wore jewelry while handling meat, potentially increasing the risk of contamination.

Nearly all butchers (92.9%) handled money with bare hands, potentially introducing cross-contamination between financial transactions and meat handling. While all butchers reported cleaning equipment and the shop daily at the end of the workday, only 7.1% used disinfectants during this process. This indicates a potential gap in proper disinfection practices.

The majority of butchers (92.9%) used a single cutting table for all types of meat and organs, raising concerns about cross-contamination between different cuts. Overall, these findings highlight several critical areas for improvement in abattoir hygiene practices. Implementing mandatory job-related training, emphasizing the proper use of PPE, and promoting proper hand washing procedures throughout the workday are crucial steps. Additionally, discouraging the use of jewelry while handling meat, enforcing separate cutting surfaces for different meat types, and incorporating disinfection into cleaning routines are essential to ensure safer food handling practices and minimize the risk of foodborne illnesses.

Factor	Value	Frequency	Percentage (%)
Educational Status	Illiterate	2	14.3
	Grade 1-8	7	50.0
	Grade 9-12	4	28.6
	Beyond Grade 12	1	7.1
Job-Related Training	Yes	2	14.3
	No	12	85.7
Apron (Protective Clothing)	Used	1	7.1
	Not Used	13	92.9
Jewelry Materials	Worn	6	42.9
	Not Worn	8	57.1
Hand Washing	Before Work	-	-
	After Work	11	78.6
	During Work	-	-
	Not Washed	3	21.4
Manner of Hand Washing	Rinsing with Water Only	11	78.6
	Using Detergents and Water	-	-
	Not Washed	3	21.4
Handling Money	Butcher with Bare Hand	13	92.9
	Cashier	1	7.1
Cleaning Equipment & Shop	Every Day (End of Work)	14	100
Use Disinfectants	Yes	1	7.1
	No	13	92.9
Cutting Table	Single	13	92.9
	Separate for Different Organs/Meat Types	1	7.1

Table 4: Knowledge, Attitudes, and Practices of Butchers (n=14)

Consumers

Demographic characteristics of the goat meat customers

The figure 1 presents the demographic characteristics of the 12 participants involved in the study on goat meat consumption. All participants were male. The age distribution showed a majority falling within the 9-28 age range (66.6%), followed by 29-50 year olds (25%), and lastly, individuals aged 51-90 (8.3%). Regarding educational background, the highest frequency was among those with an "illiterate" status (58.3%), followed by primary school (25%), and equal representation of secondary school and university graduates (8.3% each).

It's important to acknowledge that due to the small sample size (n=12), these findings may not be generalizable to a larger population of goat meat consumers. Further research with a larger and more diverse sample could provide more comprehensive insights into the demographic characteristics of this population.

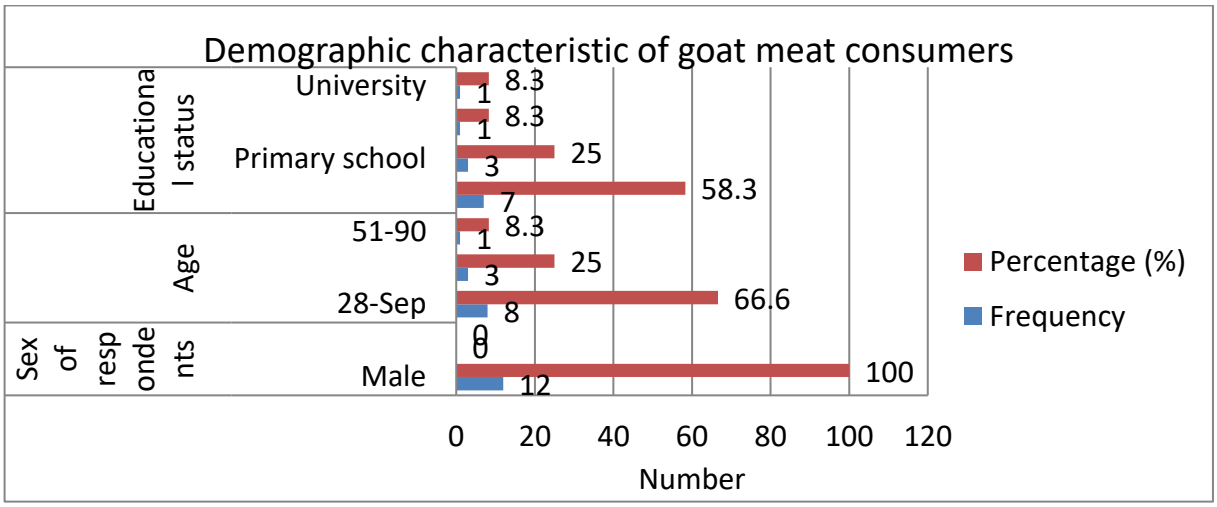

Figure 1: Demographic characteristics of the goat meat customers.

Variable	Values	Frequency
Priority Criterion to Purchase Goat Meat	Freshness	4
	Low Cost	1
	Low Fat Content	4
	Healthiness	1
	Mixed	2
How to Use Goat Meat	Fried	3
	Cooked	7
	Raw	1
	All types	1
Consume Raw Goat Meat	Yes	3
	No	9
Do Think Cooked Meat is Always Safe to Eat	Yes	11
	No	1
History of Food Poisoning	Yes	7
	No	5
Meat Slaughtered in Abattoir is Always Safe to Eat	Yes	11
	No	1
Have Refrigerator	Yes	7
	No	5
Heard About Salmonella	Yes	3
	No	9
Do you Know Meat Can Act as Source of Salmonella	Yes	2
	No	10

Table 5: Knowledge, Attitude, and Practice of Goat Meat Consumers (n=12)

Discussion

This study investigated the occurrence of Salmonella in raw goat meat, antimicrobial susceptibility of the isolates, and the knowledge, attitudes, and practices (KAP) of abattoir workers, butchers, and consumers toward meat safety and hygiene. Isolation of the Salmonella from the raw goat meat underscores the public health implications of consuming such products, especially in light of the significant antimicrobial resistance (AMR) observed among the strains.

The antimicrobial susceptibility testing revealed that a considerable percentage of Salmonella isolates were resistant to commonly used antibiotics such as Ampicillin and Amoxicillin-clavulanic acid. Notably, our findings of 35.0% resistance to Ampicillin and 32.4% resistance to Amoxicillin-clavulanic acid align with global concerns regarding the overuse of these β-lactam antibiotics and the resulting selection pressure leading to AMR (10). This resistance compromises the efficacy of these antibiotics, limiting treatment options for foodborne illnesses caused by these pathogens. In contrast, the lower resistance to Gentamicin may suggest its continued efficacy against these isolates; however, the emerging resistance cannot be overlooked.

Comparisons with other studies demonstrate similar AMR trends among Salmonella isolates from various food sources (14), substantiating the notion that AMR is a widespread and growing problem requiring urgent attention. Moreover, the presence of multiple drug-resistant isolates implies a more complex problem, potentially linked to horizontal gene transfer among bacteria, further aggregating the challenge of controlling such infections (15).

The high prevalence of carcass contamination with Salmonella is of specific public health relevance in a country like Pakistan, where raw and undercooked meat is the most popular food in most places (4). In addition to consuming raw and undercooked meat, most customers are unaware of the risk of contaminated meat because they believe it is safe to eat when slaughtered at an abattoir. As a result, consumers may cross-contaminate with other foods during processing. Furthermore, vegetable eating is frequent in this research location, which increases the likelihood of cross contamination with this virus during unsanitary preparation. This study's findings show that the majority of slaughterhouse staff are aware of the source of meat contamination and but lack knowledge about their role in the appropriate sanitary management of goat meat. As a result, they may unintentionally infect meat with this form of contamination. Workers may not know how to reduce the danger of meat contamination if they do not understand their role in the appropriate sanitary management of goat meat and their involvement in slaughterhouse cleanliness.

The KAP survey of abattoir workers revealed a disconnect between knowledge and practice. Although the majority recognized contamination risks, adherence to good hygiene practices was suboptimal. Similar gaps have been reported by Havelaar et al. (7), suggesting that workers' behaviors might not always reflect their understanding of contamination risks. Furthermore, the lack of proper training and low rates of medical testing could contribute to poor hygiene standards, risking cross-contamination and the spread of pathogens.

The majority of the abattoir workers proposed unclean hand and equipment as the major causes of carcass contamination but none responded that the faces, skin and dirty water can cause carcass contamination. Besides, most consider that keeping hygiene is the role of the management while some of them think the role of management is setting standards for hygiene in abattoir and workers role is maintaining standards for hygiene in the slaughterhouse. It is well documented that, the fecal wastes from animal and humans are important source of bacterial contamination of the environment and foods chain (16).

Workers in the meat sector need to be in good health. People are more likely to carry more germs (pathogenic microorganisms) than normal. These germs may then be passed to meat or food, posing a risk of sickness to consumers. Illness must always be reported to the management and/or meat inspector of the slaughterhouse, who will decide whether the worker may stay or must depart (17). In contrast, this study's findings show that among butcher house workers, 62.5% said they had never had a job-related medical test, while 37.5% said they had only had one throughout their time at work. Furthermore, respondents stated that even when they became unwell, their bosses do not

allow them to leave and relax, and that the managers were unprofessional. This issue might be a major source of meat contamination owing to improper carcass processing and illness among slaughterhouse workers, posing a risk to consumers.

The KAP of butchers also revealed areas of concern, particularly the low use of personal protective equipment and poor hand washing practices, consistent with global trends and previously documented behavior patterns (14). The handling of money with bare hands and the use of a single cutting table for different types of meat are particularly troubling issues, raising the risk of cross-contamination.

From the consumer perspective, there is a marked belief in the safety of cooked meat and abattoir-slaughtered meat, despite the fact that improper handling and inadequate cooking can still present risks. The low awareness about Salmonella and its potential sources among consumers highlights an urgent need for public education on food safety practices.

The study's limitations include its sample size and the potential lack of generalizability. Future research should incorporate a larger, more diverse participant pool to validate these findings and include microbial subtyping to understand the genetic relationships between the resistant strains.

In conclusion, this study suggests that coordinated efforts in surveillance, education, and regulation are imperative to combat the spread of AMR and protect public health. Policies that promote the judicial use of antimicrobials in veterinary practice, alongside comprehensive KAP training for abattoir workers and butchers, could help mitigate AMR risks. Moreover, public health campaigns should be aimed at raising consumer awareness on the safe handling, cooking, and consumption of meat products, ultimately reducing the burden of foodborne illnesses.

Conclusion

The study reveals Salmonella prevalence in raw goat meat and antimicrobial resistance in isolates from the Mir Ali region of North Waziristan. The findings highlight the need for effective strategies to monitor and control the spread of foodborne pathogens in the food supply chain. Antimicrobial resistance complicates the issue, necessitating prudent use of antibiotics, stringent surveillance systems, and strict guidelines for antimicrobial usage. The research also emphasizes the need for improved education and awareness among workers in the meat industry and consumers. The findings call for a collaborative effort between public health officials, veterinary services, meat industry professionals, and consumers to ensure food safety and combat antimicrobial resistance. Continuous monitoring, capacity building and policy enforcement are required to mitigate risks associated with raw goat meat consumption and protect the population. Future research should expand on these findings to validate the dynamic relationship between food safety, antimicrobial resistance, and public health.

Recommendations

1. Encourage the implementation of strict hygiene protocols across all levels of meat production and distribution.
2. Advocate for policy reforms that ensure responsible use of antimicrobials in livestock.
3. Develop and deploy educational initiatives aimed at improving the KAP of meat industry workers and consumers.
4. Invest in research to assess the impact of interventions and to guide public health policies regarding foodborne pathogens and antimicrobial resistance.

References

1. Pal M, Merera O, Abera F, Rahman M, Hazarika R. Salmonellosis: A major foodborne disease of global significance. Beverage Food World. 2015;42(12):21-4.
2. Ferrari RG, Rosario DK, Cunha-Neto A, Mano SB, Figueiredo EE, Conte-Junior CA. Worldwide epidemiology of Salmonella serovars in animal-based foods: a meta-analysis. Applied and environmental microbiology. 2019;85(14):e00591-19.

3. Yang X, Huang J, Zhang Y, Liu S, Chen L, Xiao C, et al. Prevalence, abundance, serovars and antimicrobial resistance of Salmonella isolated from retail raw poultry meat in China. Science of the total environment. 2020;713:136385.
4. Hussain MA, Wang W, Sun C, Gu L, Liu Z, Yu T, et al. Molecular Characterization of pathogenic Salmonella spp from raw beef in Karachi, Pakistan. Antibiotics. 2020;9(2).
5. Rahman HS, Mahmoud BM, Othman HH, Amin K. A review of history, definition, classification, source, transmission, and pathogenesis of salmonella: a model for human infection. Journal of Zankoy Sulaimani. 2018;20(3-4):11-9.
6. Humphrey T, Jørgensen F. Pathogens on meat and infection in animals–Establishing a relationship using Campylobacter and Salmonella as examples. Meat science. 2006;74(1):89-97.
7. Havelaar AH, Kirk MD, Torgerson PR, Gibb HJ, Hald T, Lake RJ, et al. World Health Organization global estimates and regional comparisons of the burden of foodborne disease in 2010. PLoS medicine. 2015;12(12):e1001923.
8. Scallan E, Hoekstra RM, Angulo FJ, Tauxe RV, Widdowson M-A, Roy SL, et al. Foodborne illness acquired in the United States—major pathogens. Emerging infectious diseases. 2011;17(1):7.
9. Casey NH, Webb EC. Managing goat production for meat quality. Small Ruminant Research. 2010;89(2-3):218-24.
10. Vidovic N, Vidovic S. Antimicrobial resistance and food animals: Influence of livestock environment on the emergence and dissemination of antimicrobial resistance. Antibiotics. 2020;9(2):52.
11. Organization WH. Global action plan on antimicrobial resistance. 2015.
12. Sharma C, Rokana N, Chandra M, Singh BP, Gulhane RD, Gill JPS, et al. Antimicrobial resistance: its surveillance, impact, and alternative management strategies in dairy animals. Frontiers in veterinary science. 2018;4:237.
13. New M, Lister D, Hulme M, Makin I. A high-resolution data set of surface climate over global land areas. Climate research. 2002;21(1):1-25.
14. Stopforth JD, Sofos JN, Taylor SL, Baumert JL. 10 Food Safety Issues in Animal Source Foods Related to Animal Health and Welfare. Animal Welfare in Animal Agriculture. 2011:205.
15. Alimi BA, Lawal R, Odetunde ON. Food safety and microbiological hazards associated with retail meat at butchery outlets in north-central Nigeria. Food Control. 2022;139:109061.
16. Gutema FD, Agga GE, Abdi RD, Jufare A, Duchateau L, De Zutter L, Gabriël S. Assessment of hygienic practices in beef cattle slaughterhouses and retail shops in bishoftu, ethiopia: Implications for public health. International journal of environmental research and public health. 2021;18(5):2729.
17. Skaarup T. Slaughterhouse cleaning and sanitation. 1985.