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Bushmeat Consumption in Africa: A Microbiological Safety Challenge?

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Authors' contributions

This work was carried out in collaboration among all authors. Author GGAA designed the study, wrote the protocol and first draft of the manuscript. Authors AIZ and NM did the read and approved final manuscript.

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ABSTRACT

Objective: This review analyzed the microbiological safety of bushmeat consumed in Africa over the past decades.
Methodology: Previous Studies mainly focused on large animals like antelopes and smaller ones like grasscutter. Most microbes studied were similar to those in domestic animal meat, except for rare pathogens such as *Salmonella spp*, *E.coli*. Sampling, experiments, and microbe prevalence varied among studies.
Results: All studies confirmed the presence of zoonotic pathogens dangerous to human beings. Therefore, more investigations are needed, especially for the chronic and severe cases of pathogens, since only few studies have addressed the bushmeat's microbiological safety in Africa.
Conclusion: Efforts should be made to improve bushmeat safety and public health in Africa. New policies and public regulations must be developed and implemented to ensure hygienic and legal bushmeat production in Africa.

Keywords: Meat safety; foodborne; pathogens; public health; Bushmeat.

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1. INTRODUCTION

Bushmeat is the name given to raw, smoked or cooked meat from wild animals [1,2]. These bushmeats are being highly esteemed for a long time all over the world and mainly in Africa where they constitute a real source of protein, but also of income for several populations, in particular for those living near forests [3,4]. Although the consumption of bushmeat contributes a lot to food security, with the various activities around it, it is also subject to two major problems which are: the degradation of biodiversity and the degradation of public health [3-6]. Bushmeat is often held responsible for foodborne diseases cases and other zoonoses [7,8]. It is well established that foodborne zoonoses can be a threat to the human health, as pathogens can be present in products intended for human consumption, either through product from an infected animal or through cross-contamination with urine or feces.

Several bush animals can serve as container of some diseases that can be transmitted from animals to human (zoonosis). Although, the consumption itself may transmit zoonosis, the handling and cutting of bush meat could act as the causal factor [9]. In Africa, very few studies have provided information on microbiological analyzes in order to know the health status of consumed bushmeat [10]. The recent epidemiological crises linked to the Lassa, Ebola and Covid 19 viruses showed that particular attention must be paid to what concerns pathogenic bacteria, particularly in Africa. This article is part of an analysis of scientific publications on the microbiological safety of bushmeat in Africa.

2. BUSHMEAT CONSUMPTION TODAY IN AFRICA

Bushmeat consumption in Africa has increased due to factors such as food insecurity, demographic changes, cultural practices, taste preferences, and perceived medicinal value [11, 5,12]. Even during the Ebola crisis, countries like Nigeria and Liberia showed a continued preference for bushmeat [13-15]. Surveys indicate that consumption patterns vary by gender, age, and location, with some individuals consuming bushmeat on a regular basis while others abstain from it [16]. Understanding these consumption patterns is crucial for an effective monitoring of the bushmeat production chain.

3. RISKS AND DANGERS ASSOCIATED WITH THE CONSUMPTION OF BUSHMEAT

The food we consume may contain substances or pathogens that involve health risks leading to foodborne illnesses and infectious diseases [17,18]. These substances can unintentionally enter our food during production, processing, or preparation, and microorganisms can be introduced from sick animals, processors, other foods, or the environment [19,18].

Bushmeat carries a risk of harmful substances since animals are often hunted directly from the wild with an unknown health status and preparation methods that may not adhere to proper slaughtering measures [20]. In Africa, the consumption and handling of bushmeat have contributed to the emergence and spread of viral diseases, including Lassa virus hemorrhagic fever and Ebola viral infection [14,21-30]. The consumption and the various manipulations of the carcasses of wild animals therefore, expose the population to many health risks including infectious diseases, zoonoses that are very dangerous and difficult to control just like the Corona virus infection: COVID 19 [21,31].

Apart from pathogenic microbes, meat preservation methods like smoking can also involve risks, such as the presence of Polycyclic Aromatic Hydrocarbons (PAHs) [32]. Foodborne illnesses remain a serious public health concern in Sub-Saharan Africa, but the incidence is often underestimated, and the origins are rarely identified due to the limited diagnostic capabilities and the weak health management systems

4. MICROBIOLOGICAL QUALITY OF BUSHMEAT CONSUMED IN AFRICA

4.1 Micro-orgamism Found in Bushmeat in Africa

In Africa, recent health crises prompted studies on the microbiological status of bushmeat to assess risks to the human health. Cooked bushmeat in Kisangani, Congo, showed a high prevalence of Salmonella spp (56.25%) [10]. This exceeds the rates in fresh bushmeat muscle (0.8%) in Gabon [33] but is lower than smoked bushmeat in Lumbubashi, DRC (3.8%) [34]. The high prevalence of *Salmonella spp* in Kisangani might not be solely from bushmeat because

unsanitary cooking and serving conditions could as well contribute to contamination. In Nigeria, a study found Salmonella contamination (5.7%) in smoked meat samples of large cane rats or grasscutters (*Thryonomys swinderianus*), wild rabbits (*Oryctolagus cuniculus*), monitor lizards (*Varanidae*), and antelope species sold in urban markets [35]. Cross-contamination is considered as a possible cause. Salmonella spp is a pathogen found in warm-blooded animals, with *S. Typhi, Paratyphi*, and *Sendai* as the most pathogenic serotypes for human [36]. Serotypes were not identified in these studies although *Salmonella* is a zoonotic pathogen.

E.coli has been found in smoked bushmeat in Nigeria with 18.6% prevalence [35]. This prevalence is lower than that of antelope (19.2%) and cane rat (25%) in ready-to-eat dried meats in Rivers State, Nigeria [37]. In Lumbashi, Congo, bushmeat showed a 100% prevalence of *E.coli* with an average of 4.87 ± 0.6 log10 CFU·g-1, indicating a significant fecal contamination [34]. The presence of *E. coli* in bushmeat can be attributed to poor evisceration practices and inadequate washing [38]. Some *E.coli* strains, including *Shiga* toxin-producing *E.coli* (STEC) cause substantial risks to human health [39]. Smoked bushmeat in Lumbashi, Congo, had a 2.2% prevalence of STEC based on PCR results [34].

The incidence of *E. coli O157:H7* and non-O157:H7 Shiga toxin-producing *E.coli* (STEC) was assessed in fresh big game meat in Namibia, with 74.6% of samples (94 out of 126) testing positive for *Shiga* toxin virulence genes (stx) and intimin (eae) using real-time PCR [40]. STEC strains are significant foodborne pathogens and can cause severe illnesses such as diarrhea, hemorrhagic colitis, hemolytic uremic syndrome, thrombocytopenic purpura, and even death. The serotype *E. coli* O157:H7 is particularly associated with hemorrhagic colitis and hemolytic uremic syndrome [41,39]. The presence of E.coli in bushmeat highlights the need of enhanced hygiene measures, and further studies in order to explore this finding in more detail, since only one study has examined it so far. This study focuses on the smoked bushmeat analysis and the plausible factors to consider are the poor handling and the cross-contamination.

Staphylococcus spp. were detected in ready-to-eat bushmeat, with an overall prevalence of 28.9%, including antelope (26.9%) and aulacode (25%) [37]. Studies in Nigeria have identified *Staphylococcus aureus* and *Staphylococcus* epidermidis in smoked bushmeat, with *S. aureus* being more commonly found [42,35,43]. In cooked bushmeat from Kisangani, Congo, S. aureus was found with a prevalence of 93.75% [10]. The presence of *Staphylococcus aureus* in bushmeat is likely attributed to the inadequate hygiene measures, because these bacteria are commensal in animal and human [44]. *Staphylococcus aureus* is a significant pathogen responsible for severe nosocomial and community infections, including emerging zoonotic cases [45].

Campylobacter, a zoonotic pathogen, was found in Central Africa with a prevalence of 6% [33]. The most common Campylobacter species associated with diarrhea are *Campylobacter jejuni* and *Campylobacter coli*, with *Campylobacter coli* being more prevalent in slaughterhouses [46]. In Lubumbashi, PCR detected *Campylobacter jejuni* (3.8%) and *Campylobacter coli* (15.9%) in bush meat [34]. *Shigella* (1%) was also found in Central African bushmeat [33], however further studies on these microbes are to be considered.

Zoonotic pathogens including *Bacillus, Brucella*, and *Coxiella* have been detected in bushmeat in Tanzania, with DNA traces found [47]. B. anthracis (0.48%), Brucella (0.9%), and Coxiella (0.66%) DNA signatures were identified in 77 samples, with wildebeest (56%), dik-dik (50%), and impala (24%) showing the highest prevalence rates.

Other microorganisms such as *Klebsiella pneumoniae* (6.8%), *Proteus spp*. (8.5%), *Streptococcus faecalis* (13.5%), and *Lactobacillus casei* (9%) have been found in bushmeat [35]. *Pseudomonas spp.* showed a prevalence of 21.1% (antelope 23.1% and aulacode 12.5%) in Nigeria, with *Pseudomonas aeruginosa* identified [37]. Total aerobic and fungal flora were determined in ready-to-eat bushmeat in Nigeria, with antelope (8.09 ± 0.15 log10 CFU/g) and grasscutter (7.62 ± 0.9 log10 CFU/g) showing aerobic flora levels, and antelope (4.03 ± 0.54 log10 CFU/g) and grasscutter (3.85 ± 0.47 log10 CFU/g) exhibiting fungal flora [37]. These findings indicate hygiene issues and poor handling of the meats.

4.2 Species Analyzed

Microbiological analyses of bushmeat mainly focused on ruminants like bovids, suids, and

Table1. The various microbes found in the specifies analyzed*

Species	Salmonella	Campilobacter	*E. coli* (STEC/CC)	Staphilococcus	Shiguella	Pseudomonas	Klebsiella	Streptococai	Proteus	Lactobacillus	Provenda	Bacillus	Brucella	Coxiella
Cane rat	35	35	35;37	35;37;43	-	35;37	35	35:43	35;43	35	38	37:43		
Hare (hare)	35	35	35	35	-	35	35	35	35	35		12	12	12
Antelope (Impala, Gazelle, Dik-Dik, Springbok, Greater Kudu, Duiker)	35;34	35:34	35;37;34;40	35;37;42;43	-	35;37	35	35;42	35	35		37:12	12	12
Monitor lizard	35	35	35	35	-	35	35	35	35	35	-	-	-	-
Canerat	-	-	42	42	-	-	-	-	42	-	-	-	-	-
Bush Pig	34	34	-	-	-	-	-	-	-	-	42	-	-	-
B uffalo	34	34	34	-	-	-	-	-	-	-	-	-	-	-
W ild Rabbit	35	-	35	35	-	35	35	35	35	35	-	-	-	-
Monk ey	33	-	-	43	33	-	-	-	33	-	-	-	-	-
Zebra	-	-	-	-	-	-	-	-	-	-	-	12	-	12
Wildebaes *t*	-	-	40	-	-	-	-	-	-	-	-	12	12	12
Cattle	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hippo	-	-	-	-	-	-	-	-	-	-	-	12	-	12

** Numbers in the table show the reference of the article*

some small animals. Reptiles, birds, and other small animals received less attention, despite their consumption in Africa [11, 48]. Limited studies identified higher prevalence rates of certain microorganisms in specific species. For instance, in Tanzania, among 32 meat species analyzed (3,784 samples), wildebeest (56%), dik-dik (50%), and impala (24%) exhibited higher prevalence rates [47]. Ruminants, known for a higher incidence of *E. coli*, also showed a significant presence of Shiga toxin-producing *E. coli* (STEC) in large bush ruminants in Namibia. The presence of microbes varied across species, emphasizing the need for future studies to consider species-specific pathogens. However, the scarcity of microbiological studies on bushmeat limits our understanding of the prevalent microorganisms in different species. Future research should prioritize common pathogens for humans and domestic animals while accounting for species difference.

5. BUSHMEAT HYGIENE IN AFRICA

Microbiological loads were reported in 5 of the journals studied and these results were often presented according to European regulations [49]. The bushmeat samples analyzed were in fresh form [33,12,47] and processed [42,37, 47,10]. Samples of bushmeat in processed form were the most dominant, and the type of processing noted was smoking, however some were in cooked forms in sauce, others dried and ready to eat. The vast majority of the carcasses analyzed were not classified for compliance with food standards; Only one study among those analyzed was subject to classification and the bushmeat samples in this case were classified as unsatisfactory on the basis of AFNOR standards [10]. This remark would surely be linked to the virtual non-existence of African standards with regards to the hygiene of bushmeat production as well as microbiological criteria. Future studies should take this in consideration. The average bacterial count on the samples varied from one study to another. The diversity of results reflects the parameters of bushmeat production such as: the methods of capturing and killing animals; the weight and age of animals; the species, the evisceration and the washing procedures; the time or place of sampling, the handling during and after processing; the state of carcass exposure, the temperature, the conservation, etc. [50].

All these elements underline the need to improve the hygiene of primary and secondary production of bushmeat and to respect the requirements and constraints relating to the treatment of the meat after evisceration, as with domestic meats. Good hygiene practices must also be adopted and adapted to the wild game meat production chain. It would also be relevant to set process hygiene criteria for bushmeat carcasses so that food sector actors can respect them. Small bush animals such as lagomorphs, birds and reptiles were poorly represented in the various studies analyzed. In addition, they are included in the post-mortem check because they are often more easily found and consumed [11,6]. This would also limit the risks associated with their consumption. Similarly, other studies should also focus on these small game animals to understand the importance and relevance of hunting and production hygiene at their level.

6. CONCLUSION

A review of research on the microbiological safety of bushmeat in Africa over the past decade revealed that most studies focused on large animals such as antelope and other bovids, with limited researches on small game except for grasscutter. The role of bushmeat in transmitting STEC and Antimicrobial Resistance in the food chain requires further investigation. The pathogens found in wild bushmeat from the literature were similar to those relevant to livestock and humans, including *Salmonella spp, Staphilococcus spp*, and *E. coli*. However, there were relatively few studies on *Shigella spp*, despite its significance as a foodborne pathogen. It is crucial to implement monitoring and control measures for foodborne zoonotic agents in bushmeat, similar to those of domestic animals. Meat hygiene measures need to be implemented, and specific microbiological criteria for bushmeat should be established to enhance safety during official inspections in game handling establishments. Given the unique aspects of the game food chain, such as hunting and field gutting, it is important to prioritize training for hunters.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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