DOI: https://doi.org/10.21323/2414-438X-2024-9-1-4-14
Received 15.11.2023
Accepted in revised 02.02.2024
Accepted for publication 06.02.2024

Available online at https://www.meatjournal.ru/jour
Original scientific article
Open Access

ASSESSMENT OF HYGIENE OF SLAUGHTER AND DISTRIBUTION OF BUSHMEAT IN ZOGBODOMEY MUNICIPALITY

Gwladys G. A. Ahouanse[1],* Mamatou Gbankoto[1], Honorat S. Houngbedji[1], Chakirath F. A. Salifou[1], Ignace O. Dotché[1], Souaïbou Farougou[1], Guy A. Mensah[2], Issaka A. K. Youssao[1]
[1] University of Abomey-Calavi, Abomey-Calavi, Benin
[2] National Institute for Agricultural Research of Benin, Abomey-Calavi, Benin

Keywords: *Bushmeat, pathogen, quality, Bénin*

Abstract
Bushmeat production process influences its quality. The objective of the study is to take stock of the hygiene of slaughter and distribution of bushmeat in southern Benin. Therefore, data on the bushmeat production process were collected and analyzed for wild species slaughtered or captured in the village of Tègon. It has been found that except for snakes and ruminants, two types of bushmeat production schemes were used according to the practices identified by category of wild species: small mammals and birds. The first type (Practice 1) was done without application of fresh blood to carcasses and the second one (Practice 2) was characterized by application of fresh blood to carcasses just after evisceration. Tools used by operators in general were poorly maintained from the hygienic point of view. No operator had a specific location suitable for storing tools. Operators did not wear mufflers, clean gloves, clean clothes and appropriate footwear. The state of animal health also remained unknown to all these operators. There was no cleaning and disinfection program for processing areas and work tools. Forward movement was not practiced at any meat processing station. Among the respondents, 3.16% did not wash carcasses, 46.88% did it poorly (with dirty water or water already used) and 50% did it unsufficiently (with very little water). Blood applied to carcasses was not cleaned by 3.13% of respondents, poorly cleaned (with dirty water) by 40.63% and unsufficiently cleaned with a little water by 56.25%. The study shows that in Tègon, the bushmeat production process is not hygienic and measures must be taken to protect the health of consumers.

For citation: Ahouanse, G. G. A., Gbankoto, M., Houngbedji, H. S., Salifou, C. F. A., Dotché, I. O., Farougou, S. et al. (2024). Assessment of hygiene of slaughter and distribution of bushmeat in Zogbodomey municipality. *Theory and Practice of Meat Processing*, 9(1), 4-14. https://doi.org/10.21323/2414-438X-2024-9-1-4-14

Introduction

Animal and plant natural resources are used by humans for their survival and well-being. Regarding protein requirements, wildlife resources are exploited through the consumption of wild animal meat, also known as bushmeat [1]. This meat is preferred for its taste and makes a better nutritional contribution, in terms of proteins, essential amino acids and mineral salts (iron, potassium, magnesium, zinc, etc.) [2]. It is also a profitable source of income for the generally poor rural population [3,4]. Bush animal organs are also used for other purposes such as decoration and traditional medicine [5–9].

In Benin, like in most tropical countries, bushmeat is consumed from north to south not only because of eating habits in rural areas but also because of food insecurity [4,10,11]. This consumption of bushmeat poses two fundamental problems, namely the disappearance of wildlife and the transmission of diseases to consumers. Regarding the threats of disappearance of wild animals, efforts have been made for their conservation. These efforts include inventorying threatened species, creating conservation reserves, and adopting laws to protect heavily hunted species [12–14]. Measures to preserve endangered species are supplemented by the domestication and breeding of certain less aggressive species such as the grasscutter, the Gambian pouched rat (*Cricetomys gambianus*), the guinea pig, etc. [15–17]. Attempts have been taken to protect wild animals and ensure the continued availability of bushmeat. Unfortunately, the latter has never been the subject of a health study. However, cases of disease transmission between wild animals and humans are frequent and are sometimes responsible for endemic diseases as in the case of the Ebola virus disease and coronavirus disease (COVID-19) [18–21]. In Benin, cases of death due to the Lassa virus are often reported [22]. The microorganisms responsible for these diseases can be accidentally or intentionally introduced into meat from sick animals, processors, equipment or the environment during food preparation and other vectors [23,24]. Based on this observation, quality control of bushmeat is necessary to preserve the health of consumers. However, on the outskirts of the Lama forest, bushmeat is produced in the open at the edge of the runway, under sheds called posts without any control and is then exposed at the edge of the same runway to be sold to passengers. This practice does not guarantee the quality of meat and an improvement in the slaughtering, processing and sale pro-

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cesses is essential. The objective of the study is to take stock of the conditions of slaughter and distribution of bushmeat in southern Benin.

Material and methods

Study framework

The study was carried out at the bushmeat market in the Tègon village, on the edge of the Lama classified forest, Zogbodomey municipality. This village defends the largest market for the marketing of these meats in the municipality. The municipality of Zogbodomey is located in the heart of the Lama forest and is the place for hunting and the following marketing of bush animals. Protected by the State by decree No. 05574/SE/F of December 24, 1946, the Lama classified forest is located in the south of Benin and extends between 6°55' and 7°00' north latitude and between 2°4' and 2°12' east longitude. Its total surface is estimated at 16,250 ha, distributed between the departments of Atlantique (9,750 ha in the municipality of Toffo) and Zou (6,500 ha in the municipality of Zogbodomey). The Lama classified forest occupies the phytogeographic zone with Guinea-Congolese affinity in southern Benin [25]. Intensive hunting activities take place in the Lama forest. In fact, the central core of the Lama classified forest is home to relatively various hunting fauna (mammals, birds, reptiles, amphibians, fish, mollusks, insects) and is partially dense. Data were collected at bushmeat sales points in the village of Tègon near the Lama forest from bushmeat processors.

Equipment

The material used consisted of survey sheets created for bushmeat producers to obtain as much information as possible on operations, conditions and hygiene of slaughter of wild animals, as well as practices of processing of wild animals on different bushmeat processing sites.

Methodology

The study was carried out among bush animal processors. In total, 10 processors working in five stations (two per processing station) were recorded and monitored from reception of game to cutting to make observations during processing. Processors bought slaughtered game from hunters. As the felling was not planned in advance, site visits were carried out every day of the week. The respondents were chosen at random with the support of guides or resource people. Their availability and agreement to be investigated and monitored was negotiated in advance.

Investigation

The survey was carried out using a semi-structured interview coupled with observations made in the field. In total, 10 respondents were interviewed, an average of two respondents per station.

A questionnaire was used for the interview and addressed points such as: the identity of processors, animal species processed, the cause of death of an animal to be processed, processing practices.

Concerning the observations, an evaluation grid was made on the basis of the points considered important to ensure the hygiene of the finished product according to the technical specification standard ISO/TS22002–1:2009 (F)[1]. These include environmental hygiene of premises, hygiene of slaughtering material, water, energy and other supplies, cleaning and disinfection programs, adequacy of equipment and its accessibility for cleaning, maintenance, ancillary services, in particular, services for the elimination of waste and wastewater. Each point was assigned to a category according to the observation: satisfactory (S: hygiene measures were well applied), unsatisfactory (PS: some measures were well applied, and others not), poor (P: all measures were poorly applied) and zero (0: if nothing was done).

A description of hygiene practices was also done according to the 5M (raw material, equipment, method, labor and environment).

Statistical analyzes

After counting and coding, the data were analyzed with SAS software [26]. The observed frequencies were calculated using the Proc FREQ procedure for each modality and the relative frequencies were compared two by two using the two-sided Z test. For each relative frequency, a 95% confidence interval (CI) was calculated according to the equation:

$$IC = 1{,}96\sqrt{\frac{P(1-P)}{N}} \quad (1)$$

Where:

P is the relative frequency;

N is the sample size.

Results and discussion

Description of preparation practices and assessment of bushmeat preparation hygiene

Hygiene of bushmeat preparation areas and general services

Most of the game processed was *Thryonomys swinderianus* (31.25%) followed by *Varanus niloticus* (12.25%), *Cricetomys gambianus* (9.38%), and then by *Xerus erythropus*, *Lepus crawshayi*, *Python sebae*, *Bitis arietans*, *Tragelaphus scriptus* with the same percentages (9.25%) and finally by *Pternitis* sp, *Streptopelia semitorquata*, *Philantomba walteri*, *Naja nigricolis* with a frequency of 3.13% each (Table 1). None of the respondents had a suitable building for processing of these animals. Animals were processed in sheds, 90.63% of which had a sheet metal roof and 9.38% a straw roof. The viscera were thrown away not far from the workstations, which caused unwanted odors at the processing sites (Table 1). Not all operators had trash bins, changing

[1] ISO/TS22002–1:2009. Prerequisite programmes on food safety. Part 1: Food manufacturing. Technical Committee: ISO/TC34/SC17. ICS: 67.020

rooms, toilets or a sufficient number of taps for drinking water. Only 3.13% of respondents had water taps compared to 96.87% who did not. The activities were all carried out without separating the clean circuits from the dirty circuits and this was observed in all positions. Almost all operators threw garbage at or near the workplace. The water used by many respondents was neither clean nor in sufficient quantity. Thus, 59.38% of respondents had insufficient quantity of well water (non-potable water) compared to 40.63% who had water of satisfactory quality (drinkable pump water) but still in insufficient quantity.

Table 1. Types of meat, buildings and general services

Variable		Percentage (N = 32)	CI
TYPES OF MEAT	LOCAL NAME (FON)		
Bushbuck or Antelope *(Tragelaphus scriptus)*	Agbanlin	6.25[b]	8.39
Grasscutter *(Thryonomys swinderianus)*	Hô	31.25[a]	16.06
Blue duiker or doe *(Philantomba walteri)*	Zoungbô/ Tegbô	3.13[b]	6.03
Python *(Python sebae)*	Hon	6.25[b]	8.39
Cobra *(Naja nigricolis)*	Klibo	3.13[b]	6.03
Squirrel *(Xerus erythropus)*	Awassagbé/Don	9.25[b]	10.04
Hare *(Lepus crawshayi)*	Azui	6.25[b]	8.39
Francolin *(Pternitis* sp)	Assôklé	3.13[b]	6.03
Gambian rat *(Cricetomys gambianus)*	Atchou	9.38[b]	10.10
Doves *(Streptopelia semitorquata)*	Houélé	3.13[b]	6.03
Monitor lizard *(Varanus niloticu)*	Vê	12.25[ab]	11.36
Viper *(Bitis arietans)*	Djapkata	6.25[b]	8.39
Evaluation of buildings			
Straw roof shed		9.38[b]	10.10
Tin roof shed		90.63[a]	10.10
ODORS AT TREATMENT SITES			
Yes		18.75[b]	13.52
No		50[a]	17.32
Yes, but weak		31.25[ab]	16.06
ODORS AROUND THE TREATMENT SITE			
Non-existent		6.25[b]	8.39
Existing		93.75[a]	8.39
PRESENCE OF DEAD ANIMALS SLAUGHTERED			
Non-existent		37.5[b]	16.77
Existing		62.5[a]	16.77

N: number; NS: not significant; CI: Confidence interval. Intra-class percentages followed by different letters are significantly different at the 5% level.

Description of bushmeat preparation practices

Observation of the process of slaughtering hunting animals and their processing for meat at the Tègon market revealed that the bushmeat preparation operations were generally the same for all operators and species with the exception of applying blood to the meat surface (painting), which was done differently by different operators. Some did not do any painting before smoking (Practice 1) and others did it with blood before smoking (Practice 2). The established slaughter patterns for species are shown in Figures 1 to 6. Species with the same meat production pattern were grouped together. Generally, application of oil to carcasses (oil painting of carcasses) took place just after animals were smoked. Some operators brushed meat with blood after eviscerating animals to give it a better presentation and better preservation over time. The smoked meat production diagram for *Guttera pucherani*, *Pternitis* sp and *Streptopelia semitorquata* is shown in Figure 3 for Practice 1 and Figure 4 for Practice 2. The production diagram for snake carcasses (*Python sebae*, *Bitis arietans* and *Naja nigricollis*) is presented in Figure 5. Finally, the production diagram for smoked carcasses of *Tragelaphus scriptus* and *Philantomba walteri* is presented in Figure 6 for Practice 1. There was no Practice 2 for snake and ruminant meats.

Description of the flowchart steps

Transportation and reception of dead animals

Game hunted in the Lama Forest was sold by hunters to merchants and other customers in places dedicated for this purpose. These dead animals were then transported to processing sites by traders in bags or on two-wheeled vehicles. The animals were also transported by hunters themselves for sale to processing sites on two-wheeled vehicles. These animals usually arrived dead for at least 24 hours because they were animals killed by firearms or fatally trapped. In some cases, animals arrived alive and once received at the processing site, an operator hit the transport bag containing an animal against the ground with a sharp blow to knock it over. This was especially the case with monitor lizards or snakes. A part of the hunted animals was resold without processing to travelers and restaurateurs who preferred it this way, the second part was processed.

Skinning/scaling

After the transportation and reception steps, comes skinning/scaling, which consists of removing hairs or feathers in birds or scales in reptiles. This operation was done by flaming for certain animals such as *Thryonomys swinderianus, Xerus erythropus, Varanus niloticus*, *Cricetomys gambianus*, *Lepus crawshayi* and *Genetta* spp, *Pternitis* sp and *Streptopelia semitorquata*. The flaming was done over a wood fire. An animal was brought into contact with flames several times and then stripped of its coat. In the case of animals with fur or with scales, such as reptiles, this was done gradually using a knife to ensure scraping until there was nothing left on the body of an animal.

Skinning of some animals, such as *Tragelaphus scriptus* and *Philantomba walteri* was done by simply tearing off the skin.

Washing

A skinned animal was then washed: the first time with simple water and the second time with simple water or water already used to rinse other carcasses (Figure 3). This second washing was carried out only by operators using Practice 1.

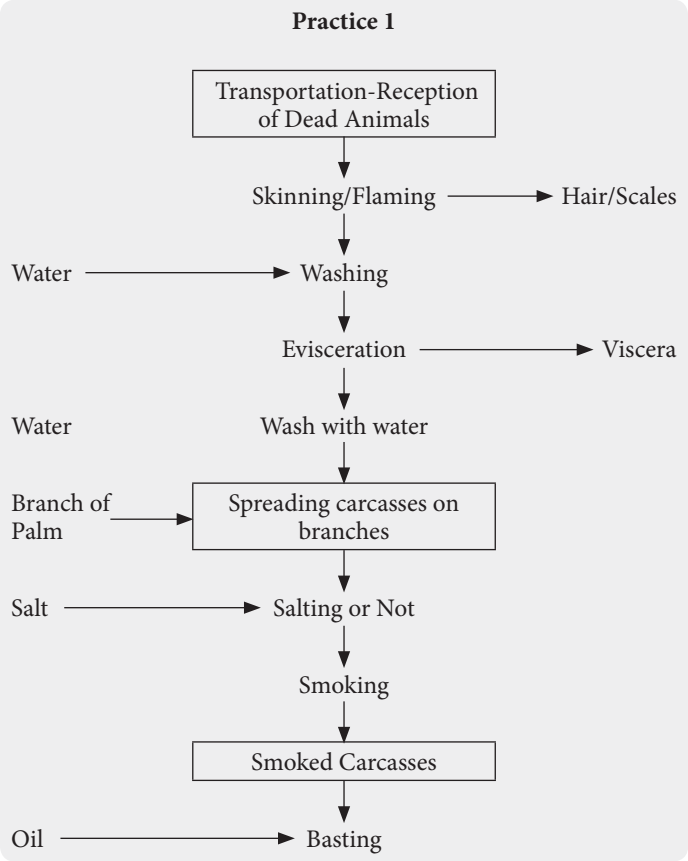

Figure 1. Production diagram for smoked carcasses of *Thryonomys swinderianus, Xerus erythropus*, *Varanus niloticus*, *Cricetomys gambianus*, *Lepus crawshayi* and *Genetta* spp. (Practice 1)

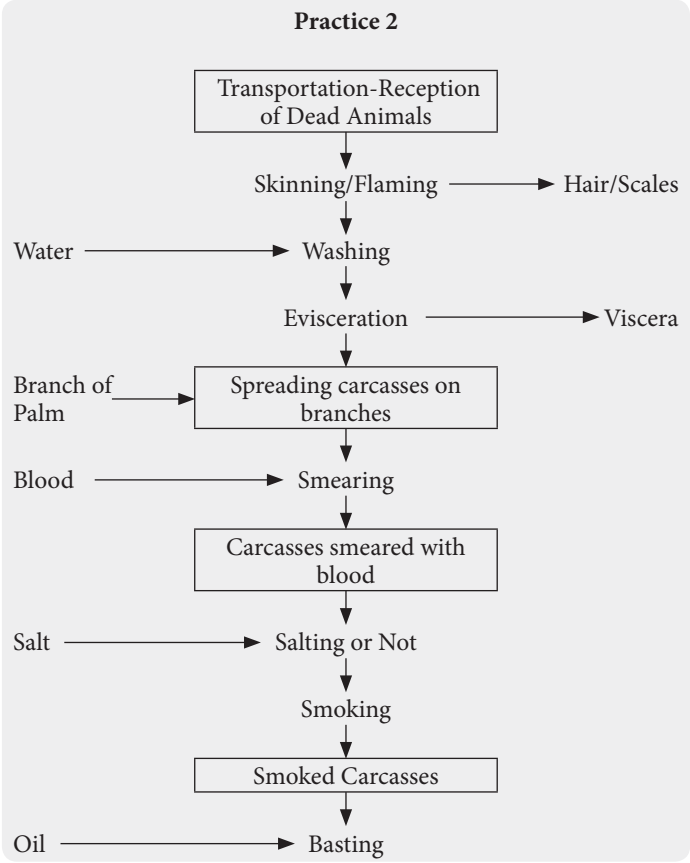

Figure 2. Production diagram for smoked meat carcasses of *Thryonomys swinderianus, Xerus erythropus*, *Varanus niloticus*, *Cricetomys gambianus*, *Lepus crawshayi* and *Genetta* spp. (Practice 2)

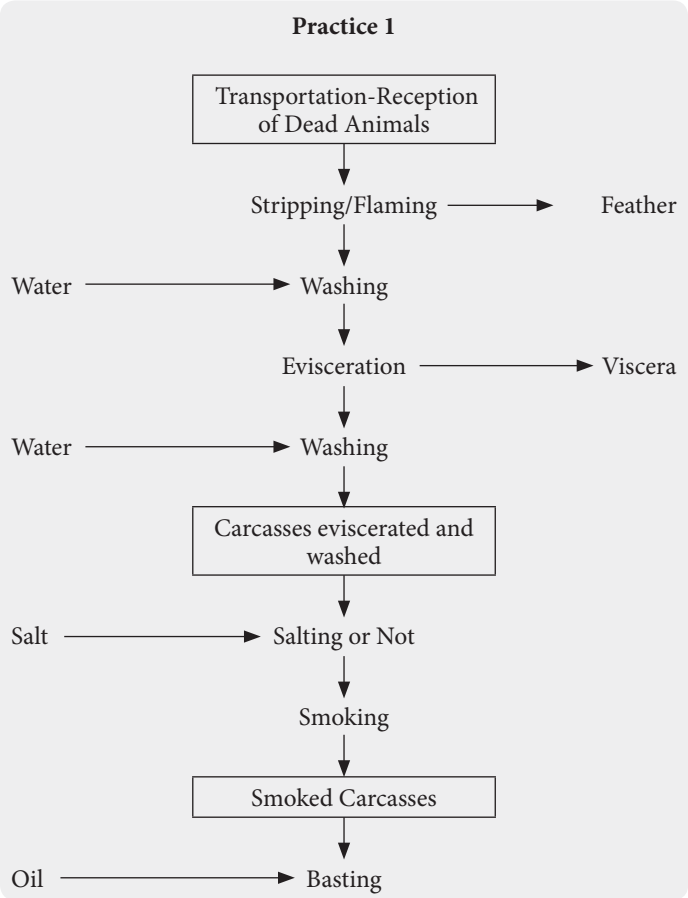

Figure 3. Production diagram for smoked carcasses of *Pternitis* sp, *Guttera pucherani* and *Streptopelia semitorquata* (Practice 1)

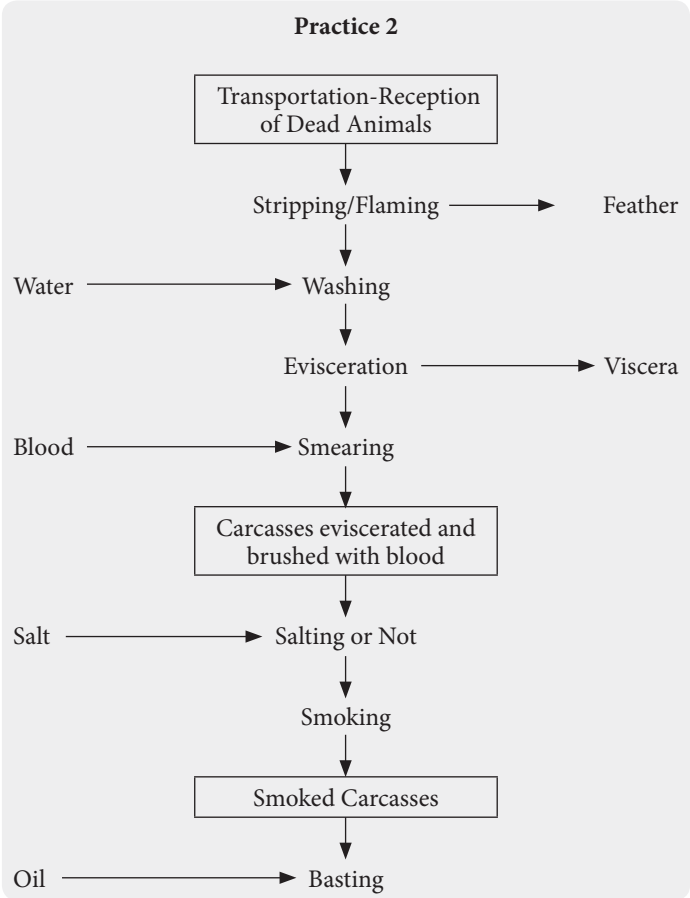

Figure 4. Production diagram for smoked carcasses of *Pternitis* sp, *Guttera pucherani* and *Streptopelia semitorquata* (Practice 2)

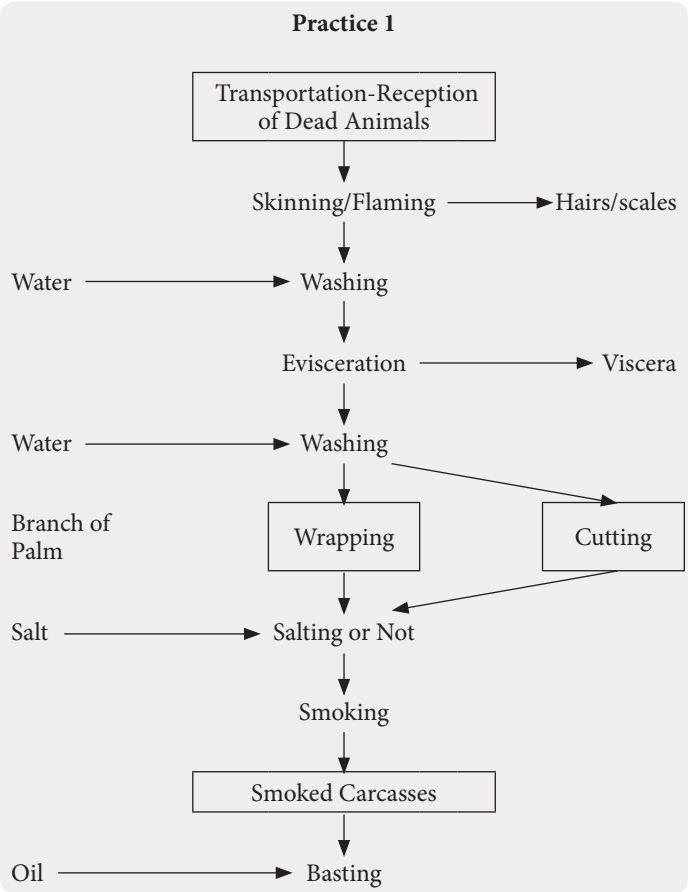

Figure 5. Production diagram for smoked snake carcasses (Practice 1)

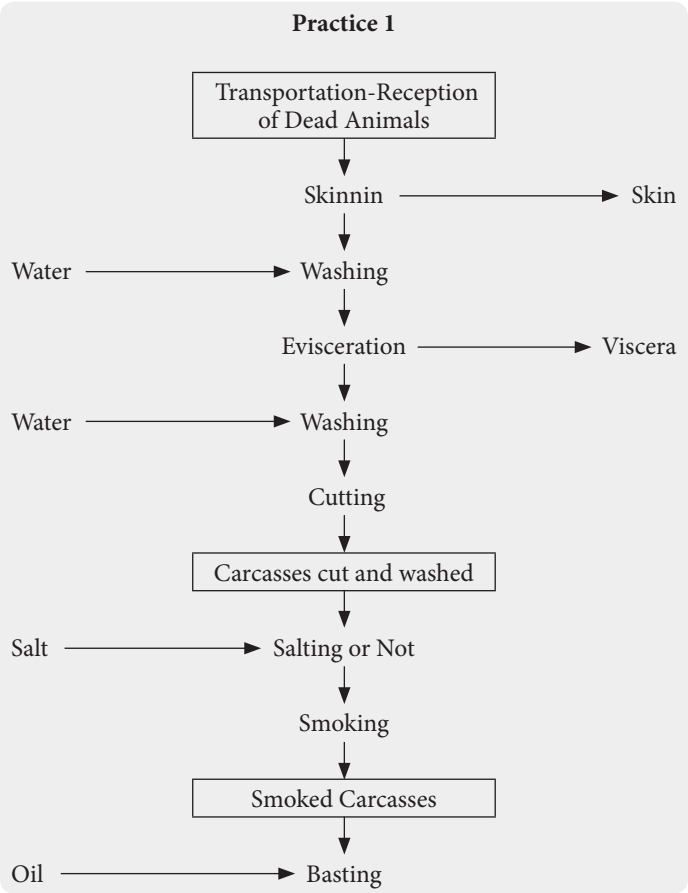

Figure 6. Production diagram for smoked carcasses of *Tragelaphus scriptus* and *Philantomba walteri* (Practice 1)

Evisceration

Evisceration was generally done on cereal bags or on teak leaves on the ground, or occasionally on a wooden board on the ground. An operator removed the viscera through a longitudinal opening in the thorax and abdomen using a knife. All viscera were removed in most cases, but depending on an operator, the kidneys were sometimes left hanging from mammal carcasses (Figure 6).

Spreading carcasses on branches, rolling and cutting

After washing, carcasses of small mammals and monitor lizards were spread with sticks with two pointed ends made of cut and trimmed palm branches which were inserted from one end to the other at the level of carcasses, so that the inside of carcasses was clearly visible. The purpose of this practice is to facilitate smoking and allow good presentation of meat during marketing. However, some carcasses, such as those of snakes, deer and antelope, were not presented in the same way. Carcasses of these species were often cut into easy-to-handle pieces for smoking. Snake carcasses were sometimes coiled on themselves and held by sticks with two pointed ends pushed from one end to the other. These sticks were also made from palm branches. Wild bird carcasses were not spread out on branches. Just curled up and bent in half by the pressure exerted by processors, they were smoked after gutting without further processing. Sometimes the same method was also used for monitor lizards. It was at this step that processors using Practice 2 painted the inside of certain carcasses with blood.

Smoking

Smoking was carried out using charcoal, often from the fire used for flaming.

Carcasses of small mammals and wild birds spread out on a rack sometimes were sprinkled with salt and sometimes were not. The grid containing carcasses was then placed on a hearth held by four blocks of stones. The glowing coals inside the stone blocks produced heat needed to cook meats.

Brushing

After having been smoked, meat was brushed with vegetable oil, and placed in trays to be displayed at the side of the road for sale to passers-by and travelers. Since bushmeat was not weighed, its price was estimated based on its quantity and quality.

Description of bushmeat processing

Certain operator practices that could lead to meat contamination have thus been identified.

Raw materials

Wild animals brought to different processing sites were often dead for more than 12 hours. The skin of these animals was mainly covered with blood or gastric or in-

testinal contents through openings created by rifle bullets or snares.

Tools used and state of cleanliness

Tools used by different operators consisted of a knife, a machete, a basin, a wooden cutting board, a bag of cereals, a container of water, trays iron and a smoking grill. Knives and axes were often not cleaned before processing meat or were only cleaned with water immediately after operations. Bowls, cutting boards and cereal bags were almost never washed. Cans and basins as well as bags of cereals, trays and cutting boards were also left on processing sites, either on the ground or on the roofs. In the absence of a water source at the workplace, operators used drums for water storage. Well or tap water was generally used and collected from the nearest village.

Labor Force

Processors had no qualifications. The work was often done in dirty house clothes or sometimes shirtless. None of the operators interviewed wore gloves, mufflers or appropriate footwear. They lay down, ate and received visitors in the place of processing.

Method of working

None of the animals processed during the investigation period underwent bleeding, so all other steps of the production schemes were carried out without evacuation of the animal's blood. Evisceration and butchering were carried out by one person. The knives used for these operations were left on the ground and the same knives could be used for two or more different animals without washing or disinfection between carcasses. When butchering game by flaming, in the absence of support, processors carried out the operation on the ground. This was followed by washing with dirty water to remove dirt caused by smoke and fire. Washing carried out after evisceration remained incomplete in most cases observed. Water used was the same for all animals treated in the same period. Blood cleaning was absent among some operators who left blood on meat for reasons of protection against flies and aesthetics of meat.

Work places

All five different meat processing stations recorded in this study had a shed with a tin roof except one station which had a shed with a straw roof, with a bare floor and a traditional brick-based hearth. The game was treated in the open air, on wooden cutting boards or very often, in most cases, on wool bags placed on the ground. Although regular sweeping was carried out every morning to remove remains of raw meat, remains of intestines, intestine contents and dead leaves were found around the sheds. Water used for washing carcasses was thrown away near the workplace. Sometimes, there were smells of putrefaction. We also noted the presence of domestic animals (dogs, chickens, roosters) and flies on the processing sites.

Cleaning and disinfection of bushmeat transformation sites

All participants surveyed did not have a drainage system for washing carcasses, hands or work tools. Sharp tools (knives and cutters) used by operators in general were easy to clean, but not very resistant to corrosion and often poorly maintained. In total, 68.75% of respondents used unclean cutters and 31.25% used dirty cutters (Table 2). Similarly, 31.25% used unclean wood to display carcasses, 9.38% used dirty wood and 59.38% of the respondents did not even use wood. Concerning basins, 25% of respondents used basins that were not very clean, compared to 43.75% who used dirty basins and 31.25% who did not use them (Table 2). No specific storage locations or closets existed to store materials for all respondents. There was also a complete absence of scales and water boats.

Table 2. Hygiene of processing sites and tools

Variable	Percentage (N = 32)	CI
STATE OF HYGIENE OF THE SITES		
Not clean	68.75[a]	8.68
Dirty	31.25[b]	12.87
BASIN HYGIENE CONDITION		
Non-existent	31.25[a]	16.23
Not clean (blood residue)	25[a]	16.94
Dirty	43.75[a]	14.69
STATE OF HYGIENE OF SUSPENSION WOOD		
Non-existent	59.38[a]	12.50
Not clean (blood residue)	31.25[b]	16.23
Dirty	9.38[c]	18.57

N: number; CI: Confidence interval, Intra-class percentages followed by different letters are significantly different at the 5% level

Personnel hygiene and bushmeat production operations

No qualified personnel was observed in all the stations surveyed, those responsible for meat production were for the majority of villagers without any notion of hygiene or good practices. All processors did not wear mufflers, clean gloves, clean clothes and suitable shoes. Some processors worked shirtless or in generally dirty house or street clothes, while others carried out meat processing operations barefoot or in street shoes. None of the respondents practiced disinfection. Bleeding at slaughter was completely absent and strict compliance with the slaughter process remained unsatisfactory in all positions encountered. The work was done out of order. Concerning washing carcasses, 3.16% of respondents did not do it, 46.88% did it poorly (with already contaminated water) and 50% did it with a small quantity of water. As for cleaning blood from carcasses, 3.13% of respondents did not do it, 40.63% did it poorly with dirty water and 56.25% did it unsufficiently with a little water (Table 3).

Table 3. Operators' working method

Variable	Percentage (N = 32)	CI
BLOOD CLEANSING		
Non-existent (not done)	3.13[b]	6.03
Badly done (with dirty water)	40.63[a]	17.02
Yes (with a little wather)	56.25[a]	17.19
WASHING		
Non-existent (not done)	3.16[b]	6.06
Badly done (with dirty water)	46.88[a]	17.29
Yes, but poor (barely rinsed)	50[a]	17.32

N: number; CI: Confidence interval, Intra-class percentages followed by different letters are significantly different at the 5% level

Discussion

Analysis of the stages of bushmeat production

The survey carried out showed that grasscutter was the most hunted species and grasscutter meat was the most consumed bushmeat. The same observation was done by Djagoun et al. [27] in South Benin. Hunters' preference for this species was linked to consumer demand. The enthusiasm of the Beninese population for grasscutter meat is not new and to meet the needs of consumers, the Beninese government initiated its breeding and the promotion of this breeding in 1943 [28]. Other hunted species such as snakes *(Python sebae, Bitis arietans*, *Naja nigricolis)*, birds (*Pternitis* sp, and *Streptopelia semitorquata,* etc.) and mammals (*Xerus erythropus*, *Cricetomys gambianus*, *Lepus crawshayi,* etc.) have already been reported by hunters in Benin [14,29]. These hunted species are sold to processors, passers-by and restaurateurs [27,30,43]. These meats were processed using two practices which were similar with the exception of the application of blood to carcasses which was absent in one practice. The transportation and reception steps were carried out under the same conditions by all respondents, regardless of the animal species hunted. Most of the time, dead animals were transported in dirty bags causing contamination of carcasses. This observation has already been done by Nganga et al. [31] in Congo where bushmeat is transported in inappropriate packaging, which affects its quality. In addition, the conditions of bushmeat transportation can lead to meat contamination [32]. The second step, skinning or flaming, was also the same in both practices for various species captured and different from the procedures used for farm animals in slaughterhouses where, after the steps of transportation and reception of living animals, there are several steps (*ante-mortem* inspection, water diet, bleeding) before skinning or flaming [33,34]. The absence of these steps in bushmeat processing is due to the method of slaughter. Indeed, game is often killed with guns, dogs or traps [3,35,36] and it would be very difficult to carry out ante-mortem inspection [37–39] and bleeding. Failure to follow these steps can not only expose consumers to zoonoses, but pose a threat to biodiversity because pregnant females are sometimes slaughtered [40]. The skinning technique reported in small animals in this study was burning because of the small size of these species which would not allow their skin to be easily removed. Unlike small mammals, large mammals like *Tragelaphus scriptus* and *Philantomba walteri* are skinned because their skin is easy to remove and is used for various purposes such as traditional medicine, making drums, quivers, bags, etc. [41–43]. After burning, carcasses were washed so as not to contaminate meat with waste from the hair burned after evisceration. Evisceration common to both practices was carried out late with a lack of water, which could lead to deterioration in the quality of meat on two levels. Firstly, late evisceration leads to deterioration in the quality of a carcass because germs present in the viscera, particularly the abdominal ones, can easily pass on to a carcass. Secondly, washing with insufficient water does not allow processors to rid meat of exogenous contaminants and stomach contents, which exposes meat to high contamination [44]. Indeed, the evisceration process plays an important role in contamination, because feces contain high quantities of coliforms [45]. The absence of cleaning-disinfection of the equipment used leads to heavy contamination of a carcass by microorganisms [45]. After evisceration, a *post-mortem* inspection would normally remove meat unfit for human consumption. Unfortunately, this inspection was not carried out, which could expose consumers to zoonoses. Zoonoses that consumers can contract by consuming uncontrolled meat are Ebola virus disease, Lassa fever, coronavirus disease, monkeypox, etc. [46–49]. However, the presence of some of these diseases has not been reported in Benin and the most recorded zoonoses are Lassa fever and coronavirus disease [21,50–52]. Unlike processors using Practice 1, processors using Practice 2 brushed carcasses with blood before smoking instead of washing after evisceration and this attitude exposed such carcasses to additional contamination because blood is a rich medium for microorganisms [44]. The penultimate step was smoking common to operators of both practices. Smoking considerably reduces the microbial load of carcasses, which results in meat that is more or less suitable for consumption. However, exposure of smoked carcasses to dust during marketing could constitute a new source of contamination. Indeed, the exposure of food products to dust and flies promotes their contamination by pathogenic microorganisms [53].

Hygiene of bushmeat preparation and general services

Most of processed and sold animals were killed by firearms. Consumption of meat from these animals exposes consumers to lead poisoning, as consumption of animal meat killed by lead ammunition has been reported as a high risk factor for lead in blood [4]. Game, once hunted, was processed by merchants who did not have buildings meeting the standards required for slaughtering and processing of meat. Processing carried out in the open air with

an unsanitary environment due to the presence of garbage around the premises and in the premises of almost all operators, promotes contamination of meat. Compliance with hygienic rules in the design and construction of premises, appropriate location and adequate facilities are necessary to enable effective risk control [54]. The viscera thrown away not far from the workstations by almost all operators justifies the high rate of the presence of undesirable odors around the premises, and therefore, the presence of flies, insects and rodents. All these nuisances as well as air pollution are sources of external contamination of bushmeat. Bushmeat can be contaminated with *Escherichia coli, Salmonella enterica, Staphylococcus aureus, Clostridium botulinum, Clostridium perfringens, Bacillus cereus* [34]. The lack of changing rooms, toilets and taps for most operators indicates that meat may be contaminated by workers' dirty hands. As all activities were carried out without separation of clean and dirty circuits, meat intended for consumption was subject to cross-contamination. More than half of processors used insufficient well water. In addition to the dirtiness of this water, it was not enough to carry out washing correctly and this led to further contamination of meat. For operators who used tap water, this contamination was reduced because tap water was clean but nevertheless it remained insufficient. Various tools used (knives, cutters, cutting boards and wooden hangers) were generally dirty or poorly cleaned and constituted sources of carcass contamination. This observation was also made for the evisceration step, which was poorly done, thus leading to contamination of a carcass not only by fecal contaminants from the same carcass during processing, but also by contaminants from previously treated carcasses because the same tools were used without any cleaning [55]. This absence of general hygiene and the non-compliance with hygienic requirements at different steps of meat processing demonstrate the lack of qualification and total ignorance of processors regarding hygiene measures linked to meat processing [56]. Showering before bleeding was absent because there was no bleeding, leading to contamination of meat with germs from the skin. The often long period between the death of an animal and its sale remains a favorable factor for the multiplication of germs, which leads to meat spoilage.

Failure to wear face coverings and clean gloves exposes operators to fluids and blood from hunted animals, leading to cases of zoonoses [34]. In fact, an operator injured in the hand can contract a disease from an animal and, in turn, he can contaminate a carcass [57]. This is confirmed by [58], which states that disease transmission was noted at a higher risk when slaughtering an animal, although disease transmission can occur during manual transportation of animals. Dirty clothes are also a source of meat contamination. Poor washing by most operators exposed meat to a multiplication of germs transmitted by blood. Similar problems are shown in [31], which revealed the total absence of hygiene and non-compliance with good production practices by operators processing bushmeat from the beginning to the end of the chain in Congo.

Conclusion

The assessment of good hygiene practices and slaughtering processes for bushmeat production in southern Benin made it possible to identify two types of bushmeat production practices among operators. The operators using Practice 1 washed game carcasses twice, before and after evisceration. On the other hand, the operators using Practice 2 only washed carcasses once before evisceration, then brushed carcasses with blood after evisceration. Transportation and reception were carried out in poor conditions by all operators and meat processing was done in the open air because there were no real buildings. Sheds were open to dust and nuisances of all kinds, which made the environment unsatisfactory for obtaining meat of acceptable quality. Operations such as bleeding, ante-mortem and post-mortem inspection were not carried out at processing sites. Other operations, such as washing and evisceration, were mostly poorly done, and smoked bushmeat was exposed to poor conditions during marketing. In general, bushmeat processing conditions in southern Benin are not satisfactory and operators need to be made more aware of slaughter hygiene.

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AUTHOR INFORMATION

Gwladys Gloria A. Ahouanse, PhD Student, Researcher, Laboratory of Animal Biotechnology and Meat Technology, Department of Animal Production and Health, Polytechnic School of Abomey-Calavi, University of Abomey-Calavi, BP 526, Cotonou, Littoral, Benin.Tel: +229–96–42–92–36, E-mail: glwady2014@gmail.com
ORCID: http://orcid.org/0000-0001-9632-2773
* corresponding author

Mamatou Gbankoto, Doctor, Lecturer, Non-Communicable Diseases and Cancer Research Unit, Laboratory of Applied Biology Research, Polytechnic School of Abomey-Calavi, University of Abomey-Calavi, BP 526, Cotonou, Littoral, Benin.
Tel.: +229–96–10–38–59, E-mail: mgbankoto@yahoo.fr
ORCID: https://orcid.org/0000-0002-1477-0984

Honorat S. Houngbedji, MSc of Science, Researcher, Laboratory of Animal Biotechnology and Meat Technology, Department of Animal Production and Health, Polytechnic School of Abomey-Calavi, University of Abomey-Calavi, BP 526, Cotonou, Littoral, Benin. Tel.: +229–96–64–81–67, E-mail: vidok.houngbedji@gmail.com
ORCID: https://orcid.org/0009-0002-9133-5457

Chakirath F. L. Salifou, Doctor, Associate Professor, Laboratory of Animal Biotechnology and Meat Technology, Department of Animal Production and Health, Polytechnic School of Abomey-Calavi, University of Abomey-Calavi. BP 526, Cotonou, Littoral, Benin. Tel.: +229–97–08–77–20, E-mail: chakiraths@yahoo.com
ORCID: https://orcid.org/0000-0002-0955-3918

Ignace O. Dotché, Doctor, Researcher, Laboratory of Animal Biotechnology and Meat Technology, Department of Animal Production and Health, Polytechnic School of Abomey-Calavi, University of Abomey-Calavi. BP 526, Cotonou, Littoral, Benin.
Tel.: +229–67–56–52–20, E-mail: dotcheign@gmail.com
ORCID: https://orcid.org/0000-0002-0245-3420

Souaïbou Farougou, Full Professor, Communicable Diseases Research Unit, Department of Animal Production and Health, Polytechnic School of Abomey-Calavi, University of Abomey-Calavi. BP 526, Cotonou, Littoral, Benin. Tel.: +229–97–97–69–59, E-mail: souaibou.farougou@gmail.com
ORCID: https://orcid.org/0000-0002-7563-8792

Guy A. Mensah, Full Professor, National Institute for Agricultural Research of Benin. 01 BP 884, Cotonou 01, Benin.
Tel.: +229–95–22–95–50, E-mail: mensahga@gmail.com
ORCID: https://orcid.org/0000-0001-5590-0071

Issaka A. K. Youssao, Full Professor, Laboratory of Animal Biotechnology and Meat Technology, Department of Animal Production and Health, Polytechnic School of Abomey-Calavi, University of Abomey-Calavi. BP 526, Cotonou, Littoral, Benin.
Tel.: +229–97–91–20–74, E-mail: iyoussao@gmail.com
ORCID: https://orcid.org/0000-0001-9591-1664

All authors bear responsibility for the work and presented data.

All authors made an equal contribution to the work.

The authors were equally involved in writing the manuscript and bear equal responsibility for plagiarism.

The authors declare no conflict of interest.