



# Preservative chemicals as a new health risk related to traditional medicine markets in western Africa

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## ABSTRACT

Health risks associated to the use of tropical wildlife have so far been envisioned through the lens of zoonotic pathogens spread by the bushmeat trade, putting aside the equally vibrant network of traditional medicine markets (TMMs). We collected information on the preservative techniques used for animal body parts from TMMs in Benin through a semi-structured questionnaire addressed to 45 sellers. We show that a recent shift from traditional preservative techniques using harmless treatments towards modern techniques –involving the recurrent use of hazardous chemicals (such as Sniper)– is likely to pose a serious health risk to practitioners and consumers of animal parts from TMMs in Benin. We conclude that the non-regulation of the TMM activities represents a critical risk to both biodiversity conservation and human health in western Africa.

## 1. Introduction

Across the tropics, wildlife has traditionally been used for consumption and cultural practices, providing a crucial source of food and revenue for rural households. However, wildlife has become one of the most threatened resources in the world due to a combination of deleterious factors, including habitat loss, overexploitation, and a growing demand from large urban centers [1]. Because the unsustainable harvesting of wildlife poses a threat to ecosystem services, food security and human health [2], the issue of the wildlife trade is best apprehended under a One Health research framework [3].

In tropical Africa, the bushmeat trade –i.e. the trade of wild game used for food consumption– is a sprawling network at the origin of marking zoonotic spillovers such as HIV-AIDS and Ebola [4]. Across western Africa, wildlife is also frequently used as part of spiritual and medicinal practices [5]. Contrary to bushmeat markets, traditional medicine markets (TMMs) exhibit live animals, skulls and dried body parts (together with vegetal and wood-crafted items) entirely dedicated to traditional practices [6]. In Benin and neighboring countries (from southeastern Ghana to southwestern Nigeria), TMMs represent a vibrant

economy, deeply anchored into the Vodoun religion and its spiritual practices [7]. However, the business around the animal products sold in TMMs is mostly unknown and unregulated. TMMs are considered a severe threat to wildlife conservation, as they trade a large diversity of –notably protected– species potentially across large distances [8,9]. In Benin, Djagoun et al. [7] reported that rare species were sold at higher prices, possibly constituting an economic incentive for the trade of threatened species.

One specificity of TMMs is that animal body parts, which are not aimed at being eaten fresh, generally have a longer market ‘life span’ compared to that of bushmeat products. Therefore, the practitioners have to prepare the animals so the latter can be stored at stalls for weeks or months. Although there is a genuine challenge in preserving animal tissue from decay in a tropical climate, the preservative techniques and the impact that these may have on human health remain largely unknown. Health risks associated with the consumption of tropical wildlife have so far been envisioned through the lens of zoonotic pathogens spread by the bushmeat trade [10,11]. Here we show for the first time that an unmonitored, global shift in preservative practices specific to TMMs may pose a serious health risk to practitioners and consumers of

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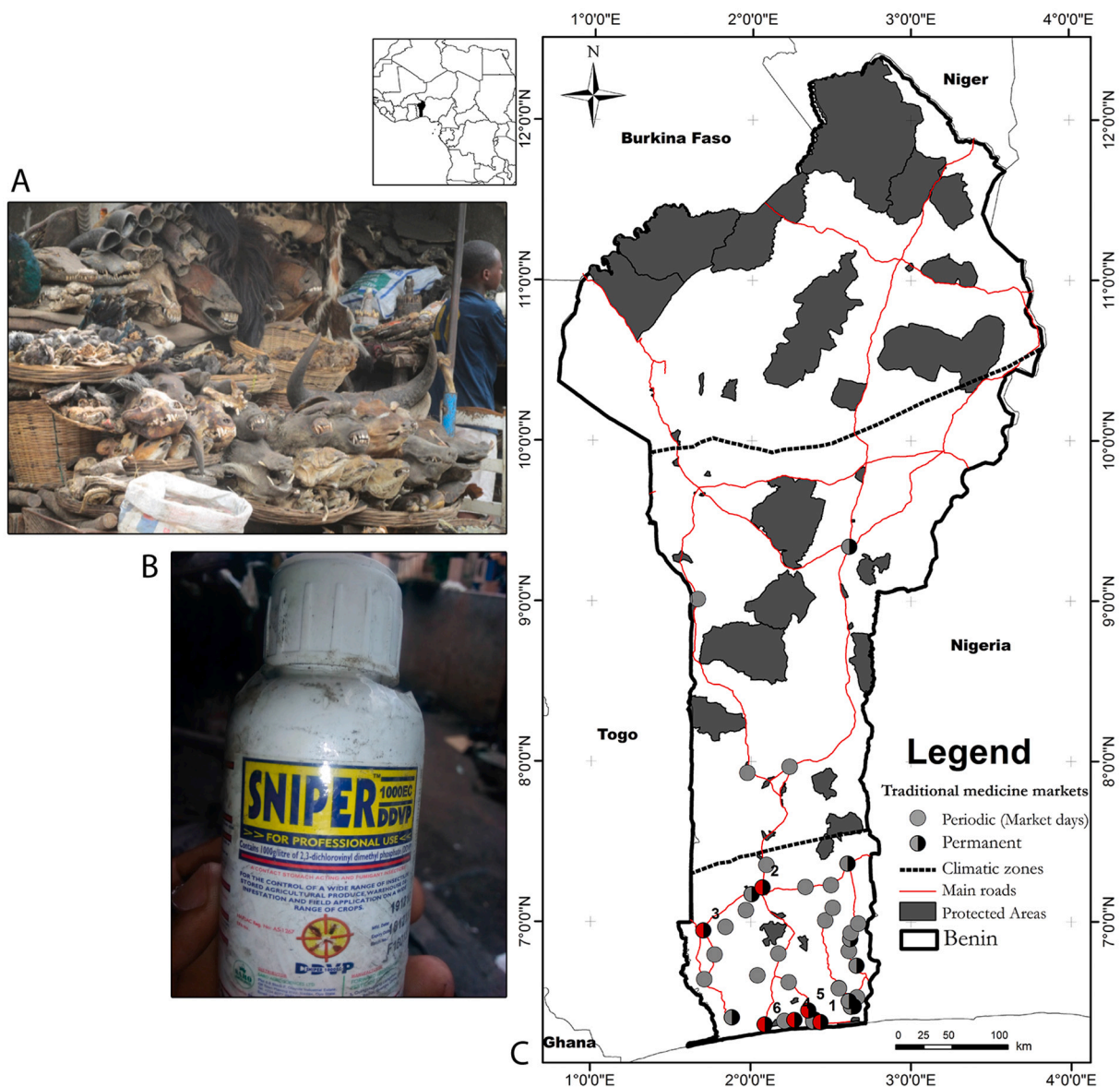
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**Fig. 1.** Context of the survey conducted on the traditional medicine markets in Benin.

A- Stall of a stakeholder in the traditional medicine market of Dantokpa (Cotonou). B- Bottle of Sniper used to preserve the animal body parts from decay. C- Distribution of the traditional medicine markets surveyed in southern and central Benin. Information on preservative techniques were collected from the following markets (in red): 1-Dantokpa (Cotonou; 56 stalls); 2-Avogbannan (Bohicon; 36 stalls); 3- Azovè (25 stalls); 4- Godomey (16 stalls); 5- Calavi (13 stalls); 6- Zobè (Ouidah; 3 stalls). The upper left insert figures Benin (in black) within western Africa. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

animal parts in western Africa.

## 2. Material and methods

The study was conducted during April–June 2018 and March–May 2019 in southern and central Benin ( $6^{\circ}25'–9^{\circ}45' N$ ), where the TMM network is most prominent in the country. An exhaustive census of TMMs was conducted following a snowball approach [12], using the main six cities of the study area (Cotonou, Bohicon, Abomey, Calavi, Porto-Novo and Azovè) as a starting point. We surveyed a total of 40 TMMs, for which the number of sellers and stalls, and weekly activity were recorded (Fig. 1). We collected information on the preservative techniques of animals through a semi-structured questionnaire addressed to 45 sellers from six TMMs (Avogbannan, Azovè, Dantokpa, Godomey, Calavi and Zobè), as constrained by the willingness of the sellers to participate in the survey. Each interviewed seller was given a

consent sheet to sign where the aims of the project were summarized. Our questionnaire addressed the different preservative techniques used by the sellers, together with their timing and frequency of use. The characteristics of chemicals and related hazard statements were obtained from the Hazardous Substances Data Bank in PubChem (<https://pubchem.ncbi.nlm.nih.gov/>). We assessed the interrelationships of use between traditional and modern techniques through a circular layout designed from the *chordDiagram* function in the package *circlize* [13] under R version 4.0.3.

## 3. Results

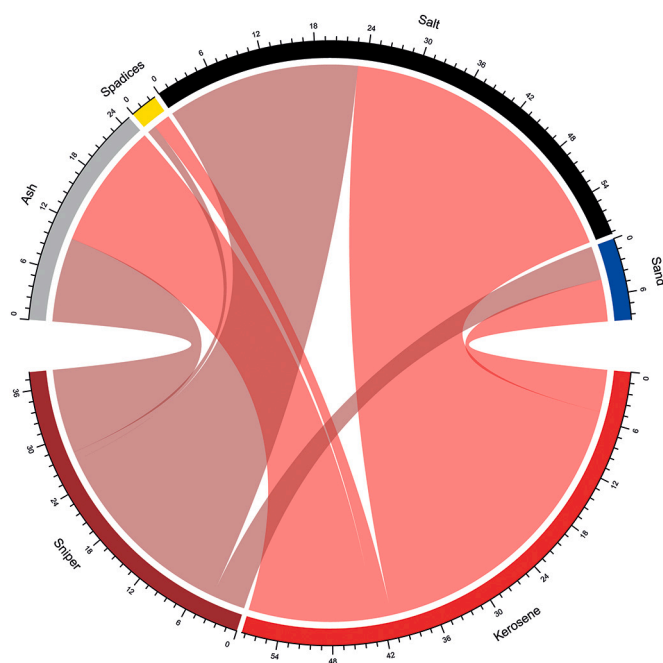
All the TMM sellers were adult men (>18 yrs. old), mostly from the dominant *Fon* ethnic group. Each seller had one or two, generally young, assistants (average age = 13 yr old). Of the 40 TMMs surveyed, 48% were permanent (Fig. 1). The largest markets were Dantokpa (56 stalls),

**Table 1**

Detailed information on the preservative techniques used for preparing animal body parts in the traditional medicine markets of Benin.

Technique	Percentage of users	Category <sup>a</sup>	Frequency of use		Application
			Dry season	Rainy season	
Sun drying	100%	Traditional	Every day (first two weeks), thrice a week	Every day	Dessiccation, short-term preservation
Ash	24.4%	Traditional	Once	Once	Dessiccation, short-term preservation
Flour from palm spadices	4.4%	Traditional	Once	Once	Dessiccation, short-term preservation
Salt	75.6%	Traditional	Once	Once	Against microorganisms, long-term preservation
Beach sand	4.4%	Traditional	Once	Once	Against microorganisms, long-term preservation
Kerosene	97.8%	Modern (c. 50 yrs. ago)	Thrice a day (first week), thrice a week	At least five times a day (first week), once a day	Against microorganisms and insects, long-term preservation
Sniper (insecticide)	71.1%	Modern (c. 10 yrs. ago)	Twice a day (first week), once a week	Three to four times a day (first week), once a day	Against microorganisms and insects, long-term preservation
Formalin	2.2%	Modern (c. 4 yrs. ago)	Once	Once	Against microorganisms and insects, long-term preservation

<sup>a</sup> Between parentheses, starting period of use as given by the sellers.



**Fig. 2.** Combination of modern (kerosene, Sniper) and traditional (ash, palm spadices, salt, sand) techniques used to prepare animal body parts in the traditional medicine markets of Benin.

Scale figures the number of mentions of use between pairs of modern and traditional techniques. Because sun drying was reported to be used by all the sellers (in conjunction with other techniques), it was removed from the analysis. For purpose of readability, formalin was also removed as mentioned only once.

Avogbannan (36 stalls), Gbèdagba (34 stalls) and Azovè (25 stalls), all located in southern Benin. The TMMs were generally included within ordinary markets, with the notable exception of Avogbannan and Gbèdagba in Bohicon.

Eight preservative techniques were reported to be used by TMM sellers, including five traditional and three modern (the earliest starting five decades ago) techniques (Table 1). Traditional techniques were mainly used for the desiccation of specimens (sun drying, ash, flour from palm spadices) along with protection against pathogenic microorganisms (salt and beach sand), whereas modern techniques (kerosene, insecticide [Sniper] and formalin) were used for their action against both microorganisms and insects. Traditional techniques were mostly

used once through the preservative process (except sun drying), whereas modern techniques had to be used recurrently, several times per week (Table 1). Kerosene was the most frequently used modern, chemical technique (97.8% of the sellers), before Sniper (insecticide; 71.1%) and formalin (mentioned by a single seller; 2.2%).

Interrelationship analysis showed that sellers from the TMMs were using one or two traditional techniques (always including sun drying) in combination with a modern technique to prepare the specimens (Fig. 2). The most frequently used combination was salt + kerosene (80%) and salt + Sniper (51%).

#### 4. Discussion

Traditional preservative techniques used in TMMs are likely to be harmless to humans and ecosystems as they rely on soft, natural treatments of the animal body parts (sun drying, ash, flour from palm spadices). Health risks associated to the use of sodium chloride (as pure salt or in beach sand) are minimal, especially since salt is removed after a single use.

Our investigations revealed that traditional techniques have been used in combination with modern, chemical techniques that act against microorganisms and insects. This shift in the preservative process seems to have started with the addition of kerosene c. 50 years ago. Chronic exposure to kerosene without protective equipment may notably induce dermatitis [14]. However, health risks related to the use of kerosene by TMM sellers are likely minor, as minimal safety practices are easy to implement. The impact of kerosene particles on consumers after ingestion remains uncertain [15].

Strikingly, a large proportion (c. 71%) of TMM sellers reported the use of Sniper in their preservative practices during the past c. 10 years. Sniper is an organophosphate insecticide that has been banned in the European Union, and is classified as “highly hazardous” (class IB) by the World Health Organisation. It is the most commonly used pesticide in developing countries, including Benin [16]. Sniper contains Dichlorvos (DDVP), a molecule of acute toxicity if swallowed, inhaled, or in contact with skin, and possibly carcinogenic for humans [17]. With a probable lethal oral dose of 50–500 mg/kg, and an estimated half-life of 20–23 days as measured from treated wheat shipments [18], Sniper represents a serious threat to humans regularly in contact with the molecule. Although reported only once by TMM sellers, the use of formalin to fix animal tissues is similarly of great concern for human health [19], and should be further investigated.

To our knowledge, our study is the first to report the use of Sniper in the preservation of animal body parts sold in TMMs from western Africa. Given its high frequency of use and the continuous arrival of new specimens to prepare, sellers and their generally young assistants from

TMMs in Benin are using Sniper on a daily basis (often diluted in kerosene; SZ, pers. obs). Given the general lack of safety practices and risk awareness among practitioners, health risks are likely high. Because of the daily frequency of use of the insecticide, consumers may also be highly exposed to Dichlorvos, especially in markets with a great number of stalls. This risk could be broadened to a larger audience as TMMs are mostly located within a larger market, like that of Cotonou (Dantokpa) where c. 1,5 M clients visit daily.

Several questions remain open to fully comprehend the sanitary impact of the use of Sniper in TMMs: how much Dichlorvos is poured on animal tissues; and what is the half-life of the molecule on this specific substrate? What is the quantity of animal tissues actually consumed by clients once animal body parts are bought? How many people are consuming animal body parts from TMMs, and how frequently?

Our study shows that health risks related to wildlife markets are not restricted to zoonotic spillovers. TMMs in southern and central Benin are deeply anchored to the Vodoun religion, which is celebrated every 10th of January as a national holiday. Medical surveys in the TMMs of Benin are urgently required to assess the health risks for practitioners and clients. Given the wide distribution and interconnected aspect of TMMs in western Africa [7,9], the unregulated use of Sniper is likely a “time bomb” [20] of public health concern for the sub-region. There is a global need to rethink the use of animals in traditional medicine, for the sake of both biodiversity conservation and human health.

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### Declaration of Competing Interest

The authors declare no competing interests.

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