

Full Length Research Paper

## Microbiological quality of food sold by street vendors in Kisangani, Democratic Republic of Congo

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Food sold by roadside vendors was compared with French Standards (AFNOR, 1996) in order to determine the microbiological quality of cooked meals. Forty-two samples of fresh and smoked fish and bushmeat were collected between March and May 2013 in Kisangani (The Democratic Republic of Congo), and analysed. Analysis of variance (ANOVA) and post-hoc Tukey tests were used to analyse the level of contamination according to the category of cooked food. Results were significant at the 0.05 threshold. For all three categories of dishes, the average bacterial counts (total aerobic plate count) were above the critical threshold: bushmeat ( $6.70 \pm 0.15 \log \text{cfu g}^{-1}$ ), smoked fish ( $6.44 \pm 0.09 \log \text{cfu g}^{-1}$ ) and fresh fish ( $5.97 \pm 0.33 \log \text{cfu g}^{-1}$ ). The difference in levels of contamination between groups was statistically significant ( $p < 0.05$ , ANOVA test). Bushmeat was the most contaminated category ( $p < 0.05$ , Tukey test). Most of the 42 samples were of unsatisfactory microbiological quality: 38 (90.5%) due to total aerobic plate count; 24 (57.1%) to *Salmonella* sp. and 21 (50%) to *Staphylococcus aureus*. The application of hygienic practices during the preparation and sale of street food could reduce the microbial risk. Such training is highly recommended for roadside food vendors.

**Key words:** Microbiological quality, street food, food contamination, bacteriological count, Kisangani, Democratic Republic of Congo.

### INTRODUCTION

Consumption of food prepared and sold by street vendors is growing rapidly in developing countries. Street food, particularly beverages and cooked snacks or meals, are sold in public places such as roadsides, markets and similar locations (Muyanja et al., 2011). They represent an important part of the daily diet for millions of low- and

middle-income consumers in urban areas (FAO, 2003).

Street food plays an important socio-economic role: it provides a regular source of income for millions of low- or unskilled men and women in developing countries (FAO, 2010). In Indonesia, street food also contributes to local economic growth. This informal activity generates an

annual estimated income of US\$ 1 million in taxes (FAO, 2010; Cohen, 1986).

In the Democratic Republic of Congo (DRC), meals sold by the street vendors (called *Malewa* in Lingala, a local dialect) are very popular and are primarily consumed in Kisangani. The menu usually consists of a meal cooked in sauce, either based on beans (*madesu* in Lingala), meat (smoked or fresh) or fish (fresh or smoked). These stews are often accompanied by cassava-based starches (*fufu*), mashed plantains (*lituma* in Swahili) or rice (*loso* in Lingala). These street meals are sold in small restaurants next to public places (markets, schools, hospitals), along main roads or on the ground in the street.

*Salmonella* sp. and *Staphylococcus aureus* are the most common foodborne pathogens and are responsible for food poisoning and food-related infections (Akbar and Anal, 2013). Manguiat and Fang (2013) showed that contamination of street food in the Philippines was mainly due to *S. aureus*, *Salmonella* sp. and *Vibrio cholerae*, while *Salmonella* sp. was isolated in 15% of samples from grilled pork and chicken.

According to a study carried out in Egypt by Moustafa El-Shenawy et al. (2011), 24% of street food was infected with *Listeria* sp. This bacterium is responsible for listeriosis and is manifested by septicaemia, meningitis and intrauterine infections, leading to spontaneous abortion in pregnant women. In Nigeria (Omemu and Aderoju, 2008), Kenya (Muinde and Kuria, 2005) and South Africa (Holy et al., 2006) researchers have shown that the overall hygiene of pre-prepared street food is poor.

One strategy to reduce microbial risk in the consumption of street food is the World Health Organisation resolution AFR/RC53/R5/2003 (WHO, 2003) that recommends capacity strengthening of health authorities in signatory countries to control the hygienic quality of street food, which must comply with international standards.

However, relation to hygiene at the locations where food is sold (rubbish in the streets, blocked drains, the hygiene of cooked street food in Kisangani (D. R. Congo) remains questionable and addition to problems asked and quality checked by Health Inspectors (and other health services) are often irregular.

Although, the phenomenon of the sale of street food is a major public health problem (Rane, 2011), unlike other African countries (Muyanja et al., 2011; Barro et al., 2006; Diouf, 1992) there are very few international studies of the situation in the DRC. A rare example is a study by the Food and Agriculture Association (FAO, 1996) in Kinshasa, which identified the following variables: consumer typology, the role of female sellers,

daily revenue earned through the sale of street food and the support of United Nations in this sector. However, there was no evaluation of the hygiene of cooked street food.

The objective of this study was therefore to evaluate the microbiological quality of meals cooked in sauce (bushmeat, smoked and fresh fish) sold in the surroundings of the central market in Kisangani, DRC. Total aerobic plate count at 30°C (as indicator of hygienic quality of cooked meals), *S. aureus* and *Salmonella* sp. (as pathogens) were investigated. The contamination level of the different categories of meals was also assessed in order to identify the dishes with high microbial risk.

## MATERIALS AND METHODS

### Sample collection

Cooked meals sold by street vendors were collected by a simple random sampling method from around the central market in Kisangani (DRC). The sampling period (three months) spanned from March to May 2013. A total of 42 sites (restaurants) were investigated. The number of consumers per day ( $n \geq 30$ ) was a determining factor in the choice of sampling sites. Thus, the samples ( $n=42$ ) were randomly collected at noon for microbiological analysis. Samples of meals cooked in sauce consisted of bushmeat ( $n=16$ ); smoked fish ( $n=18$ ) and fresh fish ( $n=8$ ). The samples (weighing approximately 100 g) were collected in sterile borosilicate glass bottles which were then placed in a cooler. Each sample was given an alpha-numeric code that represented the sample number and the meal category. Samples were immediately brought to the laboratory for microbiological analyses.

### Microbiological analysis

Microbiological analyses were performed according to the protocol described by Manguiat and Fang (2013). A 25 g sample was diluted in 225 ml of peptone water (Merck KGaA, Germany). The mixture was macerated in a sterile Stomacher bag for two minutes. The supernatant representing the stock solution was then diluted up to  $10^{-6}$  using sterile physiological water and the corresponding plate agar media were seeded. Counts (colony-forming units per gram) were expressed as a logarithm ( $\log \text{cfu g}^{-1}$ ).

### Total aerobic plate count at 30°C

Total aerobic plate count (TAPC) was determined by the pour plate method using Nutrient Agar (Liofilchem, Italy). Then, one millilitre of the  $10^{-3}$  dilution was introduced aseptically into the Petri dish and was incubated at 30°C for 72 h. After incubation, the colonies were counted. The number of colony-forming units (cfu) obtained was multiplied by the reciprocal of the dilution.

### *Staphylococcus aureus*

*S. aureus* plate count was determined by the pour plate method using Mannitol Salt Agar (Biomérieux, France). After thoroughly

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**Table 1.** Hygienic quality of street food cooked in sauce (Central Market, Kisangani, the DRC).

Hygienic quality	Critical threshold AFNOR (1996) $\log_{10}\text{cfu g}^{-1}$	Fish		Meat		Total (n = 42)			
		Fresh (n = 8)		Smoked (n = 18)		Bushmeat (n = 16)			
		n	%	n	%	n	%		
<b>TAPC at 30°C</b>									
Satisfactory	<5.5	1	12.5	0	0	0	0	1	2.4
Acceptable	5.5–6.0	3	37.5	0	0	0	0	3	7.1
Unacceptable	> 6.0	4	50	18	100	16	100	38	90.5
<b>Salmonella sp.</b>									
Satisfactory	0	2	25	9	50	7	43.75	18	42.9
Unacceptable	> 0	6	75	9	50	9	56.25	24	57.1
<b>S.aureus (coagulase+)</b>									
Satisfactory	< 2	1	12.5	8	44.4	0	0	9	21.4
Acceptable	2–3	7	87.5	4	22.2	1	6.25	12	28.6
Unacceptable	> 3	0	0	6	33.3	15	93.75	21	50

TAPC = Total aerobic plate count at 30°C; *S. aureus* coagulase + = *S. aureus* coagulase-positive;  $\log_{10}\text{cfu g}^{-1}$  = colony-forming units per gram of food (logarithm).

mixing the food sample (25 g) in peptone water (225 mL) in 1:10 dilution, the inoculum (1 ml) was introduced aseptically into the Petri dish. Incubation lasted for 24 h at 37°C. Mannitol positive colonies, surrounded by a yellow halo were counted. Coagulase tests on *S. aureus* strains were carried out using conventional techniques (AFNOR, 2004).

#### Salmonella sp.

The sample was enriched by incubating the parent suspension for 18–24 h at 37°C. Then, one millilitre of the (enriched) parent sample was added to 9 ml of Selenite broth (Merck KGaA, Germany). This was incubated at 37°C for 24 h. Positive samples (cloudy broth) were cultivated in Salmonella Shigella Agar (Biomérieux, France). The sample taken from the positive Selenite broth was cultured by the streaking method on the Salmonella Shigella agar medium, after which it was incubated at 37°C for 24 h. Translucent *Salmonella* sp. colonies with a black centre appeared and were counted.

#### Interpretation and statistical analysis

Logarithmic bacterial counts ( $\log_{10}\text{cfu g}^{-1}$ ) were compared against French standards in order to determine the hygienic quality of the cooked dishes (Table 1). An analysis of variance (Anova) compared the level of contamination between categories of dishes. In cases where a significant difference was found between cooked food categories, the Tukey test (post-Anova test) was used to determine the most contaminated food categories (Walpole et al., 2002). Microsoft Excel (2007 edition) and R (version 2.15) software was used for statistical analyses. The  $p$ -value was considered to be significant at the 0.05 threshold.

## RESULTS

The hygiene of dishes cooked in sauce was evaluated

(satisfactory, acceptable and unacceptable) according to French standards (AFNOR, 1996) by an assessment of the TAPC, *S. aureus* and *Salmonella* sp. (Table 1).

#### Food quality: TAP count at 30°C

Out of the total of 42 meals analysed, 38 (90.5%) were considered to be of unsatisfactory quality following the TAPC bacterial analysis (Table 1). The difference in level of contamination was statistically significant according to the meal category ( $p < 0.05$ , ANOVA test) (Table 2). Bushmeat was the most contaminated ( $p < 0.05$ , Tukey's post-ANOVA test) (Table 2).

#### Food quality: Salmonella sp.

Out of a total of 42 samples, 24 (57.1%) were non-compliant with French standards (Table 1) following the bacterial analysis. Fresh fish samples (n=8) were the most contaminated category of food with *Salmonella* sp. ( $2.4 \pm 1.5 \log \text{cfu g}^{-1}$ , Table 3). A comparison of bacterial counts of *Salmonella* sp. in the three categories of dishes showed no statistically significant difference ( $p > 0.05$ , ANOVA test, Table 3).

#### Food quality: S. aureus

Out of the 42 dishes street analysed, 21 (50%) were declared unsatisfactory with respect to French standards for cooked foods (Table 1) and unfit for consumption

**Table 2.** TAPC bacterial count (log cfu g<sup>-1</sup>) according to meal category.

Meal category	TAPC at 30°C(log cfu g <sup>-1</sup> )		Anova		Tukey	
	$\bar{X}$	SD	df	f	p <sup>1</sup>	p <sup>2</sup>
Fresh fish (n = 8)	5.96	0.33	2	45.03	<0.05*	<0.05*
Smoked fish (n = 18)	6.44	0.09				
Bushmeat (n = 16)	6.71	0.15				
Average	6.37	0.19				

$\bar{X}$  = mean bacterial count; SD = standard deviation; n = number of dishes analysed; \* = significant at  $p = 0.05$  (difference in contamination levels between categories); p<sup>1</sup> = p calculated using the ANOVA Test; p<sup>2</sup> = p calculated using Tukey's post-ANOVA test; f = F-test of the equality of two variances.

**Table 3.** *Salmonella* sp. count (log cfu g<sup>-1</sup>) according to meal category.

Meal category	<i>Salmonella</i> sp. (log cfu g <sup>-1</sup> )		Anova test		
	$\bar{X}$	SD	df	f	p
Fresh fish (n = 8)	2.4	1.5	2	0.915	> 0.05
Smoked fish (n = 18)	1.5	1.5			
Bushmeat (n = 16)	1.6	1.5			
Average	1.8	1.5			

$\bar{X}$  = mean bacterial count; SD = standard deviation; df = degrees of freedom; f = F-test of the equality of two variances; p = non-significant.

**Table 4.** *S. aureus* count (log cfu g<sup>-1</sup>) according to meal category.

Meal category	<i>S. aureus</i> (log cfu g <sup>-1</sup> )		Anova		Tukey	
	$\bar{X}$	SD	df	f	p <sup>1</sup>	p <sup>2</sup>
Fresh fish (n = 8)	0.4	1.0	2	13.92	<0.05*	<0.05*
Smoked fish (n = 18)	1.7	1.5				
Bushmeat (n = 16)	3.3	0.8				
Average	1.8	1.1				

$\bar{X}$  = mean bacterial count; SD = standard deviation; df = degree of freedom; \* = value is significant (difference in contamination between cooked food categories); p<sup>1</sup> = p-value calculated from the ANOVA test; p<sup>2</sup> = p-value calculated from Tukey's post-ANOVA test.

following the analysis of *S. aureus*. A comparison of *S. aureus* bacterial counts in the three categories of meals was statistically significant ( $p < 0.05$ , ANOVA test, Table 4). Bushmeat was the category most affected by *S. aureus*, demonstrated by the assessment of the bacterial count ( $3.3 \pm 0.8$  log cfu g<sup>-1</sup>, Table 4) using the post-Anova Tukey Test ( $p < 0.05$ ).

## DISCUSSION

The study demonstrated that the popularly sold street foods (cooked meals) were been contaminated by TAPC at 30°C, a microbiological indicator of hygien, demonstrated

that the popularly sold street food (cooked meals) were contaminated. Food pathogens (*S.aureus* and *Salmonella* sp.) were also found. This situation puts the health of the population at risk. According to Rane (2011) and Ghosh et al. (2007), street foods are perceived to be a major public health risk due to lack of basic infrastructure and services, difficulty in controlling the large numbers of street food vending operations because of their diversity, mobility and temporary nature.

## Food quality: TAPC at 30°C

AFNOR Standards (AFNOR, 1996) are used in the DRC

for microbiological food evaluation and provide the criteria for the microbiological evaluation of samples. Studies carried out in the Philippines on grilled pork (Manguiat and Fang, 2013), in South Korea on grilled meat (Cho et al., 2011) and in Nigeria on roasted chicken (Ologhobo et al., 2010) showed an average TAPC of  $\leq 6.0 \log \text{cfug}^{-1}$ . This count is similar to that observed in our study ( $6.37 \pm 0.19 \log \text{cfu g}^{-1}$ , Table 2) and suggests non-compliance with good hygiene practices during the handling, cooking and storage of street food in Kisangani, DRC.

### Food quality: *Salmonella* sp.

The prevalence of *Salmonella* sp. (57.1%, Table 1) in Kisangani was very high as compared to that of, for example, in Mexico (5%) (Estrada-Garcia et al., 2004). According to Rane (2011), the contamination of street food due to *Salmonella* sp. can be explained by the use of dirty dishwater (from dirty dishes) or lack of good hygiene practices of vendors when handling street food.

### Food quality: *S. aureus*

In Mexico, Diaz-Lopez et al. (2011) detected *S. aureus* in 4 out of 43 (9.3%) street dishes. According to Guven et al. (2010) and Harakeh et al. (2005) meals prepared in the street provide a suitable culture medium for the emergence of *S. aureus* strains that are resistant to multiple antibiotics. These antibiotic-resistant strains are thus transmitted to humans through eating contaminated street food.

### Conclusions

This study on the hygienic quality of cooked meals sold in the main public places in Kisangani (DRC) showed that these foods are mostly unfit for consumption and present a significant risk of food poisoning to consumers.

With the proliferation of street restaurants in Kisangani, this situation puts the health of the population at risk. This should be a wake-up call for those responsible for health services to carry out regular quality checks and ensure compliance with best hygiene practices for the safety of cooked food sold in the streets of Kisangani.

The application of these measures could reduce morbidity from diarrheal diseases related to contaminated cooked meals sold by street vendors. A training programme in good hygiene practices (food handling and sale) is highly recommended for these vendors.

### Conflict of interests

The authors did not declare any conflict of interest.

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