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Consumption patterns, bacteriological quality and risk factors for *Salmonella* contamination in meat-based meals consumed outside the home in Kigali, Rwanda

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ABSTRACT

Meat-based meals are consumed as a source of animal proteins and constitute one of the leading vehicles for food borne infections in humans. The main objective of this study was to determine the consumption pattern and the bacteriological quality of meat-based meals consumed outside households in Kigali. A survey on meat consumption patterns was carried out in 400 households by using a questionnaire, whereas different meat-based meals were sampled from 150 snack bars and restaurants. Enumeration of hygiene indicator bacteria (total mesophilic bacteria and *Escherichia coli*) and the qualitative detection of *Salmonella* were carried out by using conventional culture methods. The results indicated that goat was the type of meat that was consumed the most outside the home in Kigali and the meat intake varied significantly ($p \leq 0.05$) with the social category of the household. The average levels of total aerobic bacteria and *E. coli* in meat-based meals were found to be 4.7 and 1.4 log cfu/g, respectively, whereas *Salmonella* was detected in 11.7% of all meat-based meals. Eight factors mostly linked to the cooking treatments and hygienic handling practices for cooked meals were found to be significantly ($p \leq 0.05$) associated with the risk of *Salmonella* occurrence in meat-based meals consumed outside the home in Kigali. The findings from this study strongly suggest the need for proper cooking and/or improvements in hygiene in the establishments selling ready-to-eat meat-based meals in Kigali, particularly those located in rural localities.

1. Introduction

Meat is an important source of valuable proteins for different populations in the world. However, it constitutes an important vehicle for microbial pathogens responsible for food borne infections in humans as its composition and physical characteristics are favourable to the growth of a wide range of microorganisms including pathogens (Doulgeraki, Ercolini, Villani, & Nychas, 2012; Scallan et al., 2011). Furthermore, animals often carry germs on the hide or in their digestive tract, and cross-contamination during slaughtering operations is hardly avoidable (Niyonzima, Ongol, Kimonyo, & Sindic, 2015).

Salmonellosis is known as one of the leading food borne infections in humans Centers for Disease Control and Prevention (CDC) (CDC, 2013; EFSA & ECDC, 2015). Though it is recognised that meat is one of the vehicles of *Salmonella* infection in humans, the proportion of human salmonellosis attributable to the consumption of contaminated meat is difficult to estimate accurately. This is mainly due to the fact that only a limited number of illness cases are officially reported. Furthermore, even within the reported cases, a

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very small proportion allows the identification of the food vehicle (Greig & Ravel, 2009; Scallan et al., 2011). The lack of operational disease surveillance systems, particularly in developing countries, has been identified as the main factor hampering the reporting and determination of causative agents for food borne diseases (Newell et al., 2010; Stevens et al., 2006).

Meat-based meals have traditionally been consumed within households. However, the consumption of foods including meat-based meals away from home as ready-to-eat food has significantly increased during the last decades in both developed and developing countries. In the United States for example, the share of the household budget allocated to food consumption outside the home has increased from 20 to 37% in the period between 1960 and 1990 (Lachat et al., 2012). The rising consumption of foods outside the household is attributable to a number of factors including the affordable prices of ready-to-eat foods as well as their readily availability to the consumers (Cardinale et al., 2015). Moreover, the urbanisation of rural areas and the increase of the financial capacity of city dwellers contribute significantly to the growing consumption of foods outside the household as wealth was reported to be an important determinant of food consumption away from home (Ma, Huang, Fuller, & Rozelle, 2006).

Ready-to-eat foods are generally consumed without any other treatment such as cooking intended to eliminate or reduce their microbial load. Therefore, the occurrence of microbial pathogens such as *Salmonella* in those food products constitutes a great public health problem. Several authors have reportedly associated food borne disease outbreaks to the consumption of contaminated ready-to-eat foods (Campos, Gil, Mourão, Peixe, & Antunes, 2015; Gurler, Pamuk, Yildirim, & Ertas, 2015; Osaili et al., 2014; Yang et al., 2016).

The consumption of meat-based meals within Rwandan households has been thoughtfully reviewed by Niyonzima et al. (2016). However, to our knowledge, no published study has yet assessed either the consumption patterns nor the bacteriological quality and safety of meat-based meals consumed outside the home, though a wide variety of meat-based meals are commonly consumed in the majority of Rwandan snack bars and restaurants.

The objective of the present study was to assess the modes of consumption, and the bacteriological quality and safety of meat-based meals consumed outside the households of Kigali. Data collected through this study can have significant applications in conducting an exposure assessment of Kigali city inhabitants to meat borne bacterial pathogens such as *Salmonella*.

2. Material and method

2.1. Meat consumption survey

The present study was conducted in the households of Kigali, which constitutes the most populated city of Rwanda with more that 10% of the national population (National Institute of Statistics of Rwanda, 2012). The number of sampled households was determined by using the formula proposed by Yamane (1967):

$$n = \frac{N}{1 + N(e)^2}$$

where n is the sample size, N is the population size, and e is the level of precision. According to the most recent statistics, the population of Kigali is estimated to be 1,135,428 inhabitants (National Institute of Statistics of Rwanda, 2012). With a precision level e of 0.05, the sample size was estimated to be 400 households.

Selected households were grouped into three (3) socio-economic categories, namely households with low, medium and high income according to the Rwandan mutual health insurance scheme (Goverment of Rwanda, 2008). The main characteristics of these categories are described in Table 1.

From the database of household socio-economic status (data for the year 2012) provided to us by the Local Development Agency of the Rwandan Ministry of Local Government, 21% of the sampled households were selected from low income households, whereas 75 and 4% were chosen from households with medium and high income, respectively. These proportions are in accordance with the percentages of different social categories of households in Kigali. The random selection of households for the survey was carried out by using Microsoft Office Excel 2007 (Microsoft Corporation, Redmond, Washington, USA).

In each household, one member aged 18 years or over was randomly selected and his/her meat consumption outside the household was monitored through a food frequency questionnaire for a period of 60 days from February to June 2015. The questionnaire was composed of two parts. The first section provided socio-demographic information including the physical address of the household, the household's social category, as well as the age and gender of the selected household member. The second section supplied meat consumption information, namely, the type of meat-based dish consumed by the selected household member and the consumption frequency.

The weight of meat components of different meat-based meals consumed by the selected household member was estimated by using two-dimensional pictures of cooked meat portions. The use of two-dimensional pictures to estimate food intake has been validated in several studies as an alternative to conventional weighting methods, which, in some circumstances, are not suitable because of cultural considerations (Dhingra, Sazawal, Menon, Dhingra, & Black, 2007; Williamson et al., 2004).

2.2. Microbiological analyses

2.2.1. Collection of meat samples

Meat samples were collected from the establishments selling meat-based meals in the urban and peri-urban areas of Kigali. From

Table 1
Numbers and main characteristics of different categories of households.

Category of the households	Number	Main characteristics of the household
Low-income household	70	Has no farmland or livestock. Does not have or has a poor shelter. The household food needs are not regularly fulfilled. The household cannot afford the payment of school fees for children or the basic medical care for any member of the household.
Middle-income household	270	Has farmland, livestock and/or practices a revenue generating activity. Does have a shelter and can fulfill regular food needs. Can afford the payment of school fees for children up to the secondary school level and the basic medical care for any member of the household.
High-income household	17	Has farmland, livestock and/or practices a revenue generating activity. The household food needs are regularly fulfilled. The household owns one or many houses and/or vehicles. It can afford the payment of school fees for children up to the university level and any medical care for all household members.

(*) Source: Rwanda Ministry of Local Governement (2012).