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Procedia Food Science 6 (2016) 323 – 325

Procedia
Food Science

International Conference of Sabaragamuwa University of Sri Lanka 2015 (ICSUSL 2015)

Exposure assessment to *Salmonella* by consumption of informally marketed milk and Gouda cheese in Musanze town, Rwanda

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Abstract

This study assesses the exposure to *Salmonella* by consumption of boiled milk and Gouda cheese in Musanze town, Rwanda. A consumer survey (n = 90) revealed that among milk buyers in milk shops, 40.0% were also buying boiled milk for their families resulting in consumption by 136 consumers, mainly adults aging between 19-29 years (32.3%). Among those interviewed consumers in households, 66.7% were re-boiling the milk and 33.3% were storing it refrigerated before consumption. Gouda cheese is usually sold in supermarkets belonging to the formal market. A cheese portion with a weight of 62.5 g is mainly consumed (80.0% , n=370), and the weekly consumption frequency is most in practice (38.1%). A probabilistic exposure model was built up by taking into account prevalence data of *Salmonella* contamination in boiled milk and Gouda cheese in Rwanda, assumed concentration data of *Salmonella*, information of the milk chain gathered by observation, and collected consumption data and consumer behavior information. Finally, the risk of infection per day and per year were calculated for different categories of consumers. It appears that even though *Salmonella* is eliminated by milk boiling, the risk of infection still persists due to post-contamination in the milk shops (8.4% of consumers infected per year), but is decreased by additional boiling in households to 4.9% (children) and 4.6% (adults) per year . For cheese consumption, the risk of infection was lowered by multiple food safety interventions for cheese producers such as trainings on food hygiene and provision of modern equipments improving thus the situation from before to after 2012 by 30.0%% per year in case of adults. Those calculations demonstrate clearly that the additional efforts to reduce the occurrence of *Salmonella* in the Rwandan dairy chain will benefit the Rwandan population and decrease the burden of food borne disease.

Keywords: *Salmonella*; exposure assessment; milk; dairy.

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Peer-review under responsibility of International Conference of Sabaragamuwa University of Sri Lanka 2015 (ICSUSL 2015).

1. Introduction

Milk-borne salmonellosis accounts for approximately 48.0 % of all milk-borne outbreaks reported in different industrialized countries¹. Although in Rwanda limited information is available on food-borne disease, the prevalence of *Salmonella* in milk and dairy products indicates a high probability of salmonellosis occurrence. In Rwanda, where the co-existence of the formal and informal markets as well as in other developing countries was noticed, a recent study conducted by Kamana² revealed that 8.3% (n=96) of Gouda cheese and 11.4% (n=96) of boiled milk were contaminated by *Salmonella* at consumption level.

The present study aims to develop a probabilistic shop-to-consumer exposure model, including prevalence data of *Salmonella*, milk chain information, collected consumption and consumer behavior information in order to gain insight in the risk on illness per day and per year of the Rwandan population in Musanze town, consuming informally marketed milk and formally marketed Gouda cheese. The formal market involves farms, collection centers, processing companies and supermarkets monitored and controlled by the competent authorities, whereas the informal one concerns farms, mobile traders and milk shops without official control. The outcomes of the model provide useful information and serves as a case study for future mitigation strategies to decrease the burden of salmonellosis in the Rwandan dairy chain.

2. Methodology

2.1. Microbiological analyses

Microbiological analyses were performed to isolate *Salmonella* from boiled milk, purchased in the milk shops (n=96) and Gouda cheese (n=96) purchased in milk shops and (before 2012) supermarkets (after 2012) in Musanze town. The presence of *Salmonella* was detected in 25 ml (or g) samples according to ISO 6579:2002+A1:2007 i.e. by nonselective enrichment in buffered peptone water (Oxoid), cultivation on modified semisolid Rappaport Vassiliadis (Oxoid), selective isolation on xylose lysine desoxycholate agar (Oxoid), and purification of presumptive isolates on nutrient agar (Oxoid), and finally, confirmation of typical colonies by the triple sugar iron test. Those analyses were performed in 2012, 2013 and 2014.

2.2. Consumption survey and consumer handling practices

Two questionnaires were developed for this purpose, i.e. for milk consumption and for cheese consumption. Data were collected in 3 different milk shops, and 3 supermarkets. In milk shops, 90 respondents were interviewed, and 60% of them were consuming boiled milk in milk shops, whereas 40% were buying boiled milk for home consumption. The survey was conducted from January to March 2014.

2.3. Exposure and risk model

A mathematical model was designed in a Microsoft Excel spreadsheet for further simulations using @Risk (Version 6, Palisade, USA) software. Monte Carlo simulations were run three times using 50,000 iterations. For milk consumption in milk shops, input data were initial prevalence and concentration of *Salmonella* in served milk, consumption frequency, volumes consumed and data on dose-response on salmonellosis. For cheese consumption, two scenarios were considered. The first scenario was based on available microbiological prevalence data in the context of informally marketed cheese in 2012. The second scenario was considered by using microbiological data obtained after the professionalization of the cheese sector in 2013-2014. In both scenarios, the situation for the young (age group 0-14 year) and adults (> 14 year) consumers was assessed because a statistical significant difference was observed between those two age groups (p=0.034), and the risk on illness per and per year was

calculated.

3. Results, discussion, conclusion and recommendations

Considering the dose-response data of 10-10⁶ CFU/serving³, the percentage of infected consumers by direct consumption of boiled milk in milk shops was 0.1% per day and 8.4% per year. In households, 4.2% of young consumers were infected per day and 4.9% per year, whereas in case of adult consumers 4.3% were infected per day and 4.6% per year. For cheese consumption before 2012, 2.7% of children and 1.5% of adults were infected per year and after 2012, 1.7% of children and 1.2% of adults were infected per year. The whole Rwandan urban population was 27% in 2013, what leads to an estimate of 102 000 inhabitants of Musanze town, including all the age categories. The informal market being large with different sources of milk like mobile traders and direct purchase of milk from farms neighboring the town, an estimate of 25% (based on personal observations) can be made to have an idea of the number of inhabitants who purchase milk in milk shops. By taking this in consideration, 25 500 people buy milk in milk shops, and 40% of them, namely 10 200 people buy milk for consumption in households. For cheese consumption, the number of purchasers in supermarkets can be estimated to 2% of the whole district inhabitants taking into account the personal observation that it is consumed by people with high incomes, who are estimated at this percentage by the National Institute of Statistics. Therefore, in milk shops 7 consumers are infected per day, and 680 are infected per year. In households, 292 children and 496 adults are infected daily, and in one year 341 children and 535 adults are infected.

For cheese consumption, the risk for the adults is lower than for milk. This might be attributed the lower consumption frequency. In that case, 19 adults and 29 children are likely to get infected per year, in the current situation, after 2012. After continuous reports on illnesses incriminating cheeses, as confirmed by the competent authority namely the Rwanda Bureau of Standards, a ban was put on all cheese in 2013. The interventions on behalf of the government and its partners led to improved cheese quality and safety. The interventions focused on trainings of hygienic practices and provision of adapted processing equipments (pasteurizers, stainless steel cans, cooling tanks, etc). Before the interventions, the risk was indeed higher, being 27 infections in adults and 47 in children per year.

As a result of those interventions, the risk of salmonellosis was lowered by 30 % in adults and 38% in children. Thus, it appears clearly that the commercialization of cheese in the formal market led to tangible results. To our knowledge, no previous studies were performed on the exposure assessment on *Salmonella* in boiled milk. *S. aureus*, *E. coli* and *Enterococcus* spp. were estimated to cause illnesses in 652 raw milk consumers in Ivory Coast on a daily basis⁴. In Ethiopia, Makita⁵ estimated the annual incidence of staphylococcal poisoning at 20.0% per 1000 people consuming informally marketed home-made yoghurt.

In the Rwandan case, milk should be re-boiled once in households in order to mitigate the risk of infection. In milk shops, good practices especially hygiene of the personnel and cleaning of used utensils should be enhanced.

4. References

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