Review

Quantitative assessment of the microbiological risk associated with the consumption of attieke in Côte d'Ivoire

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ABSTRACT

Attieke is produced and consumed throughout the entire territory of Côte d'Ivoire. It is a food made by lactic fermentation of cassava and prepared in advance. It is the first ready-to eat meal sold in the towns of Côte d'Ivoire and increasingly in other African countries. For those reasons, we studied the quantitative assessment of the microbiological risk associated with this product. The objectives were firstly to appreciate the microbiological quality of attieke sold on the markets of major cities, and secondly, to quantitatively assess risk for *Clostridium perfringens* in attieke. To achieve these objectives, a microbiological analysis of attieke samples sold on the open markets was carried out in order to enumerate *C. perfringens* and some indicator microorganisms of the microbiological quality of the food: Aerobic mesophiles, total coliforms, *Escherichia coli* and *Staphylococcus aureus*. A household survey was also conducted to estimate the daily attieke consumption per individual. Statistical analysis of the average concentration for each microorganism in attieke reveals a great variability generally highly significant ($p < 0.01$) between the markets. Some concentrations were exceeded the acceptable microbial limits. This was the case for *E. coli* ($>10^2$ cfu/g) at Daloa and Abengourou, and *S. aureus* on all areas or towns ($>10^5$ cfu/g) except Yamoussoukro. Concerning the results about the quantitative risk assessment for *C. perfringens*, 38% of servings sold contain concentrations exceeded the acceptable limit of 10^5 cfu/g for the ready-to eat meals. Using Monte-Carlo simulations, the probability of ingesting a dose greater than 10^9 bacterias of *C. perfringens* varied between 1.27% and 2.80%. This means that for every 100 000 individuals consuming per day attieke sold in retail, 1270 to 2800 could be potential victims of foodborne illness outbreaks caused by *C. perfringens* only.

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1. Introduction

In Côte d'Ivoire, cassava is a strategic food resource. It is the second (2,342,000 t) 3 most consumed product after yam (5,500,000 t) and before plantain banana (1,511,000 t) and rice (1.3 million t) (Le partenaire, 2009). It is in fact one of the most cultivated food crop in Côte d'Ivoire. There are a wide variety of food products made from cassava. One of the booming products is attieke which is steamed cassava semolina with an agglomerated appearance, made from fresh cassava roots according to a well-defined manufacturing process (CODINORM, 2013). Originally produced by the lagoon ethnic groups in the south of Côted'Ivoire (Adioukrou, Alladjan, Ebrié, Avikam and Ahizi), attieke is now produced and consumed throughout the entire territory of Côte d'Ivoire. It is a food prepared in advance and also it is the first ready-to eat meal sold in the cities of Côte d'Ivoire and increasingly in other African countries. It is also exported to Europe in dehydrated form (Aboua, 1989). However its production, distribution and sale systems are provided at 80% by informal and unprotected work (Yobouet Bassa, 2013). Today, this food is very popular among urban populations, all social classes and ages. Its consumption is so high that many women' associations such as processors, wholesalers and retailers or resellers have been formed. The revenues from this activity provides the basic needs of their families (children school fees, food, clothes, rent payment, etc.). This informal sector has become essential in the cities and has inspired numerous studies about its manufacturing process (Akely, Azouma, & Amani, 2010; Kouadio, Mosso, Kouakou, & Agbo, 1991), its physico-chemical and microbiological characteristics (Coulin, Farah, Assanvo, Spillmann, & Puhan, 2006; Assanvo, Agbo, Behi, Coulin, & Farah, 2006; Djeni, N'Guessan, Toka, Kouame, & Dje, 2011) and its economy activity (Diop, 1992, p. 146) etc. However, none of these studies has carried out the health risk assessment associated with consuming attieke in Côted'Ivoire.

There are two general approaches to achieve risk assessment: qualitative and quantitative assessments (Ferrier, 2002; L. Jaykus, 1996; Chen, Jackson, Chea, & Schaffer, 2001.). While the qualitative risk assessments are descriptive or categorical treatment, quantitative assessments are mathematical analysis of numerical data. A quantitative risk assessment is preferred if the information and input quantitative resources are available to estimate the risk. These input parameters are for example the initial contamination, the parameters influencing the contamination, the consumed servings, etc. (Cornu, Bergis, Miconnet, Delignette-Muller, & Beaufort, 2003, pp. 33–42). The advantage of the quantitative risk assessment is the obtaining of a numerical value of the risk to a population facing the hazard (Assidjo et al., 2013; Delhalle, Saegerman, Farnir, Korsak, & Daube, 2008).

Quantitative risk assessment can be modelled either by a deterministic method, where a mean value is used for each input parameter, or by a probabilistic method, where the distribution of each input parameter is used (Toma et al., 1991, p. 365). The deterministic method is simpler and faster to implement because mathematical methods are more affordable but provides only a specific result without any information about rare cases (Cornu et al., 2003, pp. 33–42). The probabilistic method requires probability distributions to represent the variability or uncertainty of the parameters. This method is sometimes difficult but leads to a probability distribution of risk and refines the interpretation of the results of the model (Delhalle et al.,2008; Assidjo et al., 2013). When the model of each variable (or input parameter) is determined, it is possible to perform variable probability distributions using the Monte-Carlo simulations (Cornu et al., 2003, pp. 33–42; Thrusfield, 2007, p. 610). Quantitative microbiological risk assessment related to various widely consumed food products has been carried out and published in different countries (Chen et al., 2001; Morgan et al., 1993). There was the case of *Escherichia coli* O157:H7 in hamburgers in Canada (Cassin, Lammerding, Todd, Ross, & McColl, 1998); *Listeria monocytogenes* in cheese in France (Bemrah, Sanaa, Cassin, Griffiths, & Cerf, 1998); *Campylobacter jejuni* in chicken products in Denmark (DVFA, 2001); *Salmonella enteritidis* in eggs and egg products in USA (RIVM, 2001) etc. Unfortunately, most of the studied cases concern Western countries. In these developed countries, national agencies for food safety and their laboratories were involved in the characterization and monitoring of microorganisms that caused foodborne illness outbreaks (FIO). Corrective measures subsequently implemented by the public-health institutions or governments have resulted in a major reduction of biological hazards, describing the foodborne pathogens (Salmonella, Listeria, etc.) and biological hazards that are generally well controlled in food (ANSES, 2013). The main microorganisms responsible for foodborne illness outbreaks are *Staphylococcus aureus*, Salmonella, Campylobacter, *Yersinia enterocolitica*, and the bacteria *Clostridium perfringens* and *Bacillus cereus* (ANSES, 2013). In the case of a food prepared in advance and large amounts, the main biological hazard to consider is *Clostridium perfringens* (ANSES, 2010; Rosset, Morelli, Noël, & Poumeyrol, 2011). This study is a contribution for the strengthening of national food safety measures in Côte d'Ivoire. The main purposes of this work were firstly to assess the microbiological quality of attieke sold in the open markets, and secondly, to quantitatively evaluate the microbiological risk associated with *Clostridium*