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Microbial quality and safety of fresh and dried *Rastrineobola argentea* from Lake Victoria, Tanzania

Zebedayo Baniga [a, b, *], Anders Dalsgaard [c], Ofred J. Mhongole [a, b], Henry Madsen [c], Robinson H. Mdegela [a]

[a] Department of Veterinary Medicine and Public Health, College of Veterinary and Medical Sciences, Sokoine University of Agriculture, P. O. Box 3021, Chuo Kikuu, Morogoro, Tanzania
[b] National Fish Quality Control Laboratory-Nyegezi, Department of Fisheries Development, P. O. Box 1213, Nyegezi, Mwanza, Tanzania
[c] Department of Veterinary Disease Biology, Faculty of Health and Medical Sciences, University of Copenhagen, Groennegaardsvej 15, DK-1870, Frederiksberg C, Denmark

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ABSTRACT

Rastrineobola argentea (silver cyprinid/sardines) is an important commercial fish species found in Lake Victoria. It is an important protein source for consumers in several African countries including Tanzania. A cross-sectional study was conducted using standard methods to assess the bacteriological quality of fresh and dried sardines from Lake Victoria. Sardine samples were randomly collected from main landing sites and retail markets in the city of Mwanza. Total viable counts (TVC) in fresh sardines were in the range of 5.18–7.90 $\log_{10}$ cfu/g while those dried on racks contained 3.13–4.85 $\log_{10}$ cfu/g which were 0.75% of those dried on sand with 4.80–7.13 $\log_{10}$ cfu/g ($p < 0.001$, 95% CL: 0.40%–1.42%). Thus, rack dried sardines had mean TVC below the national acceptable food standard of 5 $\log_{10}$ cfu/g. Faecal contamination with *E. coli* in fresh sardines ranged from 2.38 to 5.38 $\log_{10}$ mpn/g and those dried on sand contained 1.18–3.32 $\log_{10}$ mpn/g, however, sardines dried on racks, did not contain any *E. coli.* Similar findings were found in the two types of dried sardines from the retail markets. Prevalence of *Salmonella* spp. in fresh *R. argentea* was 25% (n = 40), sand dried sardines at landing sites contained 30% (n = 20) and those from the markets contained 15% (n = 20) *Salmonella* spp. *Salmonella* spp. were not detected in sardines dried on racks. To conclude, sun drying of sardines on racks is an effective drying method providing a safe product for human consumption.

1. Introduction

Rastrineobola argentea (silver cyprinid/sardines) are among the most important commercial fish species found in Lake Victoria (Lake Victoria Fisheries Organization, 2013). They are commonly named *dagaa* in Tanzania, which is the collective Swahili name for all species of sardines. They are fished during the night in dark phase of the moon using a purse seine net and open peddled canoes or motorized boats with paraffin lanterns attracting the sardines (McHenry, Doepel, Onyango, & Opara, 2014; Sharpe, Wandera, & Chapman, 2012). *Rastrineobola argentea* catches are high during the total dark phase of the moon compared to the early and late dark phase which causes variations and delayed time of landings (Lake Victoria Fisheries Organization, 2013). Due to large volumes, harvested sardines are piled in nets hanging on the sides of the boats without use of ice until the time of landing in the morning at the shore of the lake. Sardines are veritable source of protein and essential micronutrients for humans and an important ingredient in animal feed (Sifuna et al., 2009). People traditionally remove heads and bellies of sardines, though the sardines may be consumed as whole which make them good source of not only protein but also calcium and magnesium (Oduho, Baker, & Tuitoek, 2005). The heads of sardines are believed to contain sand due to the fact that, sardines are dried direct on the sand. There are different ways of preparing sardine meals, but in most cases dagaa are roasted and consumed as a side dish preferably with the stiff porridge (*ugali*) made of cereal flours.

The sardine market is currently expanding and changing

* Corresponding author. Ministry of Agriculture, Livestock and Fisheries, National Fish Quality Control Laboratory, P. O. Box 1213, Nyegezi, Mwanza, Tanzania.
E-mail addresses: zebe_02@yahoo.co.uk (Z. Baniga), adal@sund.ku.dk (A. Dalsgaard), ofredjonas@gmail.com (O.J. Mhongole), hmad@sund.ku.dk (H. Madsen), mdegela@suanet.ac.tz (R.H. Mdegela).

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especially at regional level which is attributable to a high demand from consumers in Sub-Saharan African countries, as well as, the accessibility and affordability over other sources of proteins (Kirema-Mukasa, 2012). Therefore, growing market of sardines is of significant importance to the national economy. According to Tanzania Fisheries Statistical data, the capture of sardines in 2013 constituted about 72.3% of the total landings from Lake Victoria equivalent to the weight of 170,000 tons which valued 677 million Tanzania shillings and this is a significant increase from the 94,000 tons (39.3% of total landings valued by 350 million Tanzania shillings) landed in 2012. The decline of the Nile perch (*Lates niloticus*) fishery in Lake Victoria has led to the promotion of the sardine fisheries with many fishermen shifting from Nile Perch to sardine fishery. This shift is also driven by increased demands for different products of *R. argentea* affordable to a range of consumers in Eastern, Central and Southern African countries, e.g. South Sudan and Democratic Republic of Congo (Kabahenda, Amega, Okalany, & Heck, 2011; Kirema-Mukasa, 2012). However, a main challenge for the marketing of sardines include poor quality and questionable safety of the different sardine products attributable to existing handling and drying methods (Kabahenda & Hüsken, 2009).

After capture, sardines are processed and preserved by different drying methods which include, sun-drying on sand, on grasses, on rocks, on old fishing nets placed on the beach sand and on racks. Other methods are frying, smoking and salting (Ibengwe & Kristófersson, 2012). Drying on raised racks is a preservation method that prevents contamination with sand particles, other physical hazards and reduces microbial contamination. In most cases, however sardines are dried directly on the sand along the beaches with high risk of physical and microbial hazards contamination, e.g. birds are always seen on the beaches representing risks for faecal contamination with *Salmonella* spp. and other enteric pathogens (Ibengwe & Kristófersson, 2012; Onyango et al., 2015; Onyuka et al., 2011; Sifuna et al., 2009). Since dried sardines products sometimes are consumed directly as snacks, it is important to ensure quality and safety of the products (Acha & Szyfres, 2003). Currently, limited information is available about the microbial quality and safety of sardines dried by different methods.

The aim of the present study was therefore, to determine the microbial quality and safety of fresh and dried sardines from Lake Victoria, Tanzania.

2. Materials and methods

2.1. Study site

The study was conducted in Lake Victoria basin in Mwanza region, Tanzania (Fig. 1). Samples of fresh and dried sardines were collected at four landing sites from the Lake Victoria shore, i.e. Bwiru, Igombe, Kijiweni and Kigangama, and at four retail markets in Mwanza; i.e. Kirumba fish market and Nyakato in Ilemela District, Mwanza city and Mkuyuni markets in Nyamagana District (Fig. 1). The landing sites and markets selected represented sites with large volumes of landed and sold *R. argentea*, respectively.

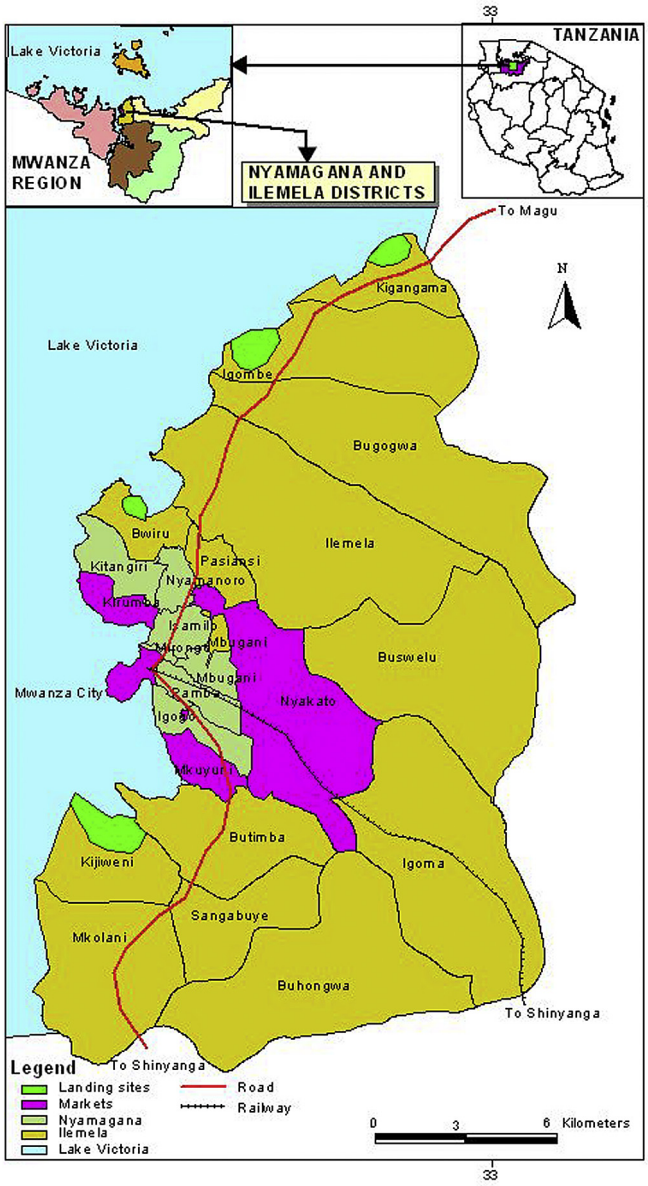

Fig. 1. Study sites showing sampling points.

2.2. Design and sampling

This cross-sectional study was conducted from October 2014 to April 2015. A total of 120 samples including 40 fresh sardine samples obtained from landing sites, 40 dried sardine samples collected at the landing sites and 40 dried sardines obtained from the markets. Approximately 300 g of each sample of fresh and dried sardines were collected. At each of the four landing sites, 10 samples of freshly landed sardines, 5 samples of sardines dried on raised racks and 5 samples of sardines dried on beach sand were collected from different fishermen and processors. Fresh sardines were collected randomly from fishermen boats at the landing sites. They were collected around 5–6 a.m. when fishermen were returning from fishing. Sardines dried on sand and on racks were obtained from processors at the beach and vendors at the retail markets. Though, sardines are also occasionally dried on grass and rocks in some places; no samples from these two drying processes were collected for analysis in this study. At each of the four markets, 5 samples of sardines originally dried on raised racks at the landing sites and 5 samples of sardines dried on the sand beach at the landing sites were collected. The sardine samples were collected by hands with sterile gloves and put into sterile plastic bags and thereafter stored in an insulated cool box with cooling elements and immediately transported to the National Fish Quality Control Laboratory (NFQCL) Nyegezi for analysis. Dried sardine samples at landing sites were collected directly from the drying beds (sand and on racks) before they were packed and transported to the retail markets, at 1:00–3:00 p.m. depending on weather condition of the day. Dried sardine samples were stored and transported in disinfected box. At