Multivariate analysis of heavy metals content of beef from Soroti, Uganda

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Abstract

Information about food hygiene and quality in the sub-Saharan African countries remains scarce at a time when many of their citizenry are beginning to acquire the much coveted middle income status. Compounding this are challenges linked to monitoring the safety of food produced by such lucrative industries as the beef industry on a continuous basis. The objective of the study was to begin some how the process of encouraging changes to the status quo and showing by example how a start in that direction might look like. Using heavy metal contents of representative beef samples from butcheries in Soroti, Uganda typical of a sub-Saharan country, we demonstrate how relationships and common sources of metals could be identified among samples in a multivariate space. Beef samples from 40 sites were analyzed by atomic absorption spectrometry for iron (Fe), zinc (Zn), nickel (Ni), chromium (Cr), lead (Pb), copper (Cu), cobalt (Co) and cadmium (Cd). The study showed that all beef samples contained these metals, the extent of which were in the order: Fe > Zn > > Ni, Cr > Pb > Cu, Co > Cd. By correlation analysis, the pairs Ni and Cr, Cd and Co, Ni and Fe or Cr and Fe were most likely coming from the same sources. We also found that there are at least three distinct characteristics of beef consumed in Soroti, a distinction perhaps arising from three major categories of feedlots used to raise donor cattle. The incremental risk of children or adults developing cancer over a lifetime was estimated and found to fall into three categories, two of which are separately explained by the presence of Cr or Ni. The sources of these metals remain a matter of speculation on our part. More studies are needed to determine these sources and to understand the nature of cancer risk in the three categories of beef identified here.

1. Introduction

Food contamination in developing countries, sources of which range from food-borne biologicals and physical agents in food to chemical contaminants, is a major public health concern (Grace, 2015). In a country such as Uganda, heavy metals (defined as any metal that can induce toxicity in living systems regardless of atomic mass; Kamunda et al., 2016; Nkwunonwo et al., 2020; Singh et al., 2011)) originating from water, soil, food containment methods and particulates in the air (Anna et al., 2019; Kamunda et al., 2016; Kasozi et al., 2019; Yabe et al., 2010) are the causes of anxiety. Beef contamination is particularly a serious problem in the sub-Saharan region of Africa because of the loosely regulated manners in which donor animals are raised and how their carcasses are handled. For example, roasted meat sold on street walks in Kampala (Uganda) was shown to be heavily contaminated with lead (Pb), arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), zinc (Zn) and iron (Fe) (Bamuwamye et al., 2015). In Nigeria and Ghana, beef, mutton, caprine, pork and chicken were found to contain Cd, Cr, Cu, Fe, Pb, Zn or manganese (Mn) at times above the recommended levels by international standards (Nkansah & Ansah, 2014; Odoh et al., 2016). Confounding this public health concern is the inability to acquire the necessary capacity to remove or treat heavy metal toxicity, more so during this time when the eating habits of most sub-Saharan African families are changing in line with an increase in family income. It goes therefore without saying that without fully understanding the health risk attributed to food contamination in Africa, an impending health hazard might be on the verge of emerging.

Our goal in this study is, in part, to assemble statistical tools easily accessible to poor countries in Africa for analyzing contamination data irrespective of how the data were collected. The premises here is that some data is better than the status quo in informing food safety policies. At this time, most of the data available in Africa are collected using instruments with low precision detection limits, yielding subsequently unreliable results.

In this second of a two-part study (Kasozi et al., 2021), we particularly address – by way of example – the incremental lifetime cancer risk (ILCR) of consuming beef from Soroti District, Uganda with the aid of multivariate statistical tools. ILCR in our context represents the potential cancer risks of being exposed orally to heavy metals in beef. In general practice, the numerical range of acceptable risks is set between 10^{-6} and 10^{-4} (US EPA, 2001). Risk values above 10^{-4} are considered a cause of concern, hence requiring mitigation (US EPA, 2008). For this study, we asked whether it is possible to distinguish potential drivers of cancer risk in a community from a low-resolution set of data. This question arises from