Fingerprinting Food: Using Neutron Activation Analysis for Provenance studies

Neutron activation analysis (NAA) is used worldwide for the elemental analysis of various sample types; one of the more interesting applications has been for determining the provenance of food.

Elementally, plants tend to reflect the soils and climate they grow in and this is no different for cultivated crops. Stable isotopes of water can indicate the climate crops have been exposed to, particularly through rainfall; inorganic elements may be linked to the soils the crops were grown in. As an example, trace elements only make up about five percent of the mass of coffee, yet it is these relatively small constituents that have the most discriminating power when determining the geological, agricultural and environmental conditions (Pohl et al., 2013).

Market samples of rice and coffee (pictures courtesy of Mr Johann Antoine, ICENS, Jamaica)

Coffee is one of the most popular beverages in the world, comparable only to tea and water. It is also one of the most important exports from the developing world. But it also has the distinction of being one of the most counterfeited food items. The large disparity between inexpensive varieties and premium single estate brands means that this commodity is rife for mislabeling and blending to take advantage of premium prices associated with specialty coffees (Teuber, 2010). Rice is one of the most cultivated and consumed crops in the world and like coffee, rice is also the subject of mislabeling and food fraud. Varieties such as Basmati rice are mixed with lower quality rice but sold at the same price point as the purely premium variety (Bligh, 2000) (Vemireddy et al., 2015). Both these commodities are of import to the Jamaican market for different reasons. Jamaican Blue Mountain coffee is an important export item and is one of the most expensive single origin coffees available on the world market. Conversely, rice is the most consumed staple in the Jamaican diet and since local cultivation ceased some time ago the rice on the market is entirely imported.

Coffee from several regions of Jamaica were sampled specifically to see whether results from several techniques including instrumental NAA (INAA) could be used to differentiate between Blue Mountain and non-Blue Mountain Coffee. The work was expanded to include international coffees as well. Later the dietary intake of minerals and trace elements from coffee was looked at.

Using INAA and complementary techniques, Mr Johann Antoine and collaborators from the International Centre for Environment and Nuclear Science (ICENS), Jamaica (Antoine et al., 2016), could separate Jamaican coffee from international coffee but also locally, Jamaican Blue Mountain coffee from non-Blue Mountain coffee. Although by simple observation one could see the differences in elemental content, this was not enough to determine significance. By applying advanced statistical evaluation, patterns in the data were illustrated in a way that allowed the determination of provenance. However, it was also possible to discriminate between instant (soluble) coffees and roasted and ground coffees (See figure 1) showing that the process affected the elemental concentrations. Several elements such as bromine, magnesium, potassium, and sodium were significantly elevated in all instant coffees. Some of these elements were uniform across all instant coffees irrespective of origin suggesting that processing was more important for these elements than the profile of the soil that the sample was grown in. The variety of coffee likely also played a role. The most commonly cultivated varieties of coffee are Arabica (*Coffea Arabica*) and Robusta (*Coffea canephora* or C*. robusta*). Robusta beans are typically utilized in instant coffee while Arabica is generally used in roasted and ground coffee. Variety, therefore, may also be a factor influencing the distinction between instant and roasted and ground coffees.

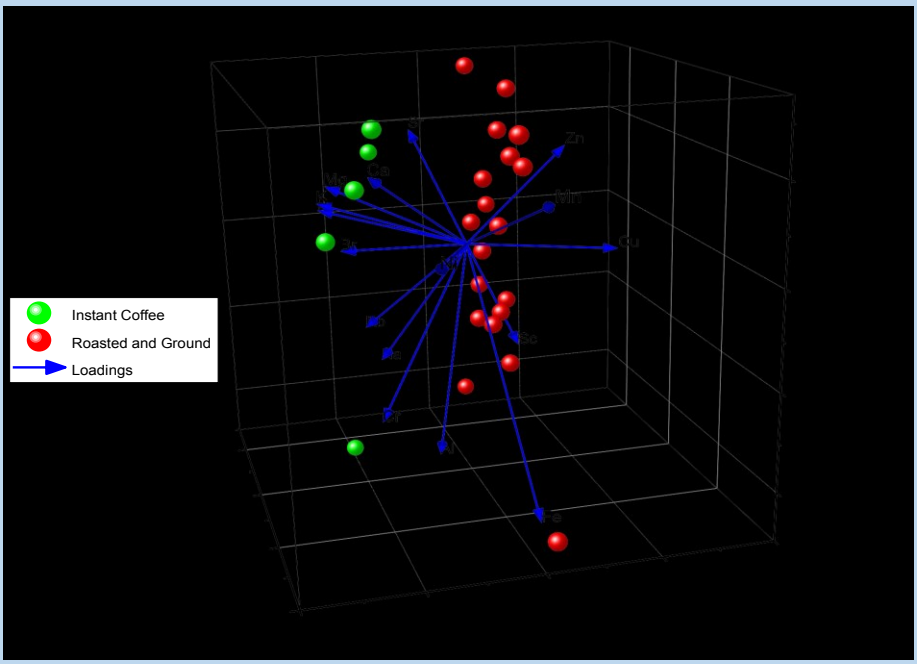

Figure 1: Principal Component Analysis showing discrimination between Instant and Roasted and Ground Coffee. (Figure courtesy of Mr Johann Antoine, ICENS, Jamaica).

A similar methodology was applied to the analysis of rice. It was noticeable that elemental concentrations distinguished polished (white) rice, brown rice and parboiled rice from one another. It appeared that the method of processing the grain was the most important factor in first separating brands. This was not necessarily a surprise as brown rice is a whole grain with the bran, germ and endosperm. The bran and germ have more vitamins and minerals than the endosperm. In polished rice, the bran and germ is removed and with that much of the nutrient content including minerals. In parboiled rice the process pushes some of the nutrients, including minerals from the bran to the endosperm. So elementally there would be differences in the three process forms of rice. An interesting finding was how one rice brand labeled brown rice clearly clustered with white. Was this a case of adulteration or rather over-milling (Grant et al., 2013)?

While INAA is one of several techniques that can be used to determine the elemental content of food samples it has some characteristics that make it particularly useful for provenance studies. It is not only a highly accurate technique but also displays high precision. By applying statistical analysis to analyse the data it was possible to distinguish between processes and growing origins and even varieties of both coffee and rice. This technique can and has been applied to other foods and sample types to determine provenance.

References

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