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Matrix-bound water retains the regional signature in cheese

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Understanding the source of food is relevant for brand fidelity of geographically protected foods, supply chain quality control and tracing pathogen-infected foods to their origin. Though natural abundance stable isotopes appear ideal to meet this goal, straightforward interpretation can be hampered by fractionation effects brought about during growth, processing and storage. Thus for isotopes to be practical from a commercial standpoint it is important to identify and understand 1- which isotope system best retains the regional signal of given food and 2- what can realistically be ascertained from that isotope system. Here, we explore stable isotopes of matrix-bound water (δD and δ^{18}O) in cheese. Matrix-bound water is chosen because an important step in the production of many cheeses is brining for up to two days. This highly saline water will carry the local isotopic signature allowing an easier correlation to Isoscape maps, and also makes up a significant portion of the final product (up to 40 % w/w). In addition, unlike other organic fractions used to provenance cheese (such as protein), the effect of biosynthetic-induced isotope fractionation during aging will not be as significant.

Water is extracted and analyzed in a single step using Induction-mediated Cavity Ring-Down Spectroscopy (IM-CRDS). In this technique, the sample (cheese) is placed in a metal holder, and a localized electric field rapidly heats the sample for the complete extraction of matrix-bound water. The water is then directed to the CRDS analyzer for measurement of δD and δ^{18}O. The average time of analysis is $\sim$ 10 minutes per replicate. Two cheese types were selected: a hard, wax-aged cheese (Cheddar) produced from nine different locations around the world, and three varieties of unripened cheeses (Chevre, Camembert, and non-descript "soft" variety) produced in four regions (three from Coastal California, one each from Central California, Wisconsin and France) from around the world.

The cheddar cheeses showed a remarkably linear relationship that reflected some evaporation during processing (δD = 6.5 [δ^{18}O] – 3.4 ‰ r^2 = 0.99). The measured isotope value of a sample compared well to its approximate meteoric isotope value and followed the predicted isotope trends. The distinction within similar Isoscape regions, however, was not great with samples labeled Vermont, New York, and Quebec were indistinguishable from one another. The soft, unripened cheeses did not follow the meteoric trend so closely. However the three cheeses from Coastal California were indistinguishable (δD = -27.89 $\pm$ 1.09 ‰ δ^{18}O = -2.27 $\pm$ 0.21 ‰) and were significantly ($p < 0.01$) different from the other three regions (Central California, Wisconsin and France). It is reiterated that the Coastal California cheeses are three varieties (Chèvre, Camembert, and a non-descript soft ripened cheese). The regionality of the signal is strong enough that species or variety had no impact on the isotope values of this particular type of cheese. Analysis of matrix-bound water via IM-CRDS should be explored as an option for the simple and rapid screening of cheese, as well as other products where matrix-bound water would strongly retain its Isoscape signature.