

Multi-stable isotope analysis (CNOH) as a tool for assessing the geographic provenance of food: a case study using buffalo's milk and cheese samples from Marajó island, Amazon basin, Brazil.

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ABSTRACT: The use of stable isotopes as natural tracers of origin and processes is becoming widely disseminated in the most varied fields of study, e.g. ecology, forensics, agronomy, geology and archaeology. One of the applications which attracted much attention in the last years is the geographic characterization and authentication of food, driven by a growing consumer interest in high-quality products from specific regions, i.e. with a controlled denomination of origin. While carbon and nitrogen isotope composition are mainly influenced by dietary and agricultural practices, oxygen and hydrogen are linked to the composition of ingested water, which in turn is influenced by geographical factors such as altitude, latitude and climate. We present the results of a pilot study conducted at the island of Marajó, Pará, Brazil, using buffalo's dairy products. Eighteen milk and eighteen cheese samples were collected from local producers, half from the municipalities of Soure/Salvaterra and half from the municipality of Cachoeira do Arari. One cheese sample from the state of São Paulo was also analysed for comparison. $\delta^{13}\text{C}_{\text{VPDB}}$ is very homogeneous for the whole Marajó dataset, in between -27‰ and -22‰, while the São Paulo sample yielded -14.78‰. $\delta^{15}\text{N}_{\text{AIR}}$ is also very homogeneous, from +4‰ to +8‰, although samples from Cachoeira do Arari tend to show slightly higher values. Unlike carbon, nitrogen shows a consistent milk-cheese fractionation by a factor of around +0.7‰. The São Paulo sample yielded +6.77‰, falling within the range of Marajó data. Isotope ratios of water (H and O) presented a higher variability. The Soure samples yielded $\delta^{18}\text{O}_{\text{VSMOW}}$ in between -2‰ and +2‰ for milk and from -14‰ to -4‰ for cheese, while Cachoeira do Arari samples yielded from 0 to +3‰ for milk and from -8‰ to -3‰ for cheese. $\delta^2\text{H}_{\text{VSMOW}}$ for the Soure samples is in between -19‰ and +13‰ for milk and in between -50‰ and -22‰ for cheese, and for Cachoeira do Arari it is in between -0.5‰ and +58‰ for milk and from -43‰ to -18‰ for cheese. Overall, H and O isotopes show a consistent milk-cheese fractionation of around -6‰ for $\delta^{18}\text{O}_{\text{VSMOW}}$ and -40‰ for $\delta^2\text{H}_{\text{VSMOW}}$. The São Paulo sample yielded $\delta^{18}\text{O}_{\text{VSMOW}}=-8.4\text{‰}$ and $\delta^2\text{H}_{\text{VSMOW}}=-53\text{‰}$. Taken together in bivariate diagrams, the isotope ratios allow a good distinction between producing areas. The subtle differences in $\delta^2\text{H}_{\text{VSMOW}}$ and $\delta^{18}\text{O}_{\text{VSMOW}}$ between the two localities could be due to differences in water supply: while Soure is closer to the Amazon mouth, Cachoeira do Arari receives mainly water from the Arari sub-basin, which is heavier due to inland evaporation. The light $\delta^{13}\text{C}_{\text{VPDB}}$ can be used as a distinctive parameter of buffalo's cheese from Marajó, once that C4 grass, which shows higher $\delta^{13}\text{C}_{\text{VPDB}}$ values, as observed for the São Paulo sample, is the most common pasture throughout Brazil. This pilot study, the first of its kind in Brazil, demonstrates the power of stable isotopes in assessing the geographic provenance of Marajó buffalo's cheese. This tool can play a major role in the development of a controlled denomination of origin plan for food products from the Amazon.

KEY-WORDS: STABLE ISOTOPES, FOOD PROVENANCE