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Tracing the Geographical Origin of Food Using Stable Isotope Analysis

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The types and amounts of available foods have been expanding globally, and consumers can now obtain products from all over the world. However, in recent years consumers have experienced numerous negative incidents such as unsafe levels of residual pesticide in exported fruits and vegetables, which has prompted greater awareness of geographical origin and chemical levels in food. Such concerned consumers prefer to buy foods directly from farmers even if the products are more expensive than exported equivalents. The increased demand for reliable food in the interest of better health and nutrition has greatly influenced industry practices. A valid traceability system to ensure the safety and high quality of food has been proposed. Regulations on food safety standards focus on quality control, process verification, labeling, and traceability. In accordance with law, packaging must be labeled to indicate product information such as cultivar, cultivation area, and year of production. However, it remains very likely that packages continue to be incorrectly labeled, either accidentally or intentionally. Thus, there is a need for a simple analytical method for checking the authenticity of food products.

Multi- stable isotope analysis has also become an important tool for determining the provenance of foods. Stable isotope analysis has become particularly useful in addressing authenticity problems. This method has been widely used to trace the origin of organic materials in various fields, such as geochemistry, biochemistry, archaeology, and petroleum chemistry. Generally, the isotopic compositions of plant materials reflect the isotopic compositions of source materials (e.g., CO2, H2O, NH4, and NO2) and their assimilation processes as well as growth environments. For example, the carbon isotopic compositions of plants depends on fractionation during diffusion of CO2 into the leaves and the subsequent photosynthetic metabolism and water use efficiency, suggesting that carbon isotope discrimination is associated with well-watered conditions. The nitrogen isotopic composition of plant materials mainly depends on soil nutrition. The oxygen isotopic composition mainly reflects that of local groundwater such as precipitation and meltwater. The sulfur isotope ratios are influenced by several factors such as fertilizers, sea spray, volcanic emissions, or lithology. The 87Sr/86Sr ratio in soils and the plants growing thereon depend on the geological age of the underlying rocks. Therefore, the Sr isotopic ratios of plants can provide site-specific signatures depending on the geologic history of the area. On this basis, isotopic compositions have been used to investigate the authenticity of food materials. For example, the adulteration of honey and juice can be identified by differences in the carbon isotopic compositions between authentic and adulterated products. Moreover, the geographical origin of food materials such as meat, dairy products, wine and cereal crops can be traced by using natural variations of the isotopic compositions. We review the applications to the discrimination of geographical origins of foods.

Keywords: foods, geographical origin, stable isotope analysis