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# Multielement composition and strontium isotope ratios used as provenance indicators for apples from different growing areas in Northern Italy

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The determination of the geographical origin of food products via a chemical fingerprint is an on-going challenge that scientists have explored in the last decades by implementing various analytical techniques. The aim is both to provide reliable and objective tools to fight food fraud and to protect the quality of regional products. The multielement and isotopic composition of food revealed to be an effective approach for discriminating food commodities with respect to their provenance. This chemical information provides regional fingerprints reflecting the local soil compositions. Geographical information can be unveiled by looking for specific soil markers that are transferred during growth to the vegetal tissues in case of horticultural products that undergo no or only little processing. Bioavailable inorganic nutrients are taken up by plants mainly through roots from the soil solution and are translocated to the different plant parts. Several aspects, such as soil properties, plant variety, transfer factors or biopurification processes, together with environmental and anthropogenic conditions, contribute to the overall elemental composition of vegetal tissue. Therefore, evaluating the distribution and the presence of specific elemental pattern can provide valuable information about the origin, especially when non-essential elements are considered. The strontium isotope ratio (87Sr/86Sr) has gained substantial interest as origin tracer asides the classical C-O-H-N-S systems. The 87Sr/86Sr of the bioavailable Sr in the soil depends on the underlying bedrock and hence different geological areas show a different isotopic composition. Sr isotopes do not fractionate significantly during the soil-plant transfer. Consequently, a direct relationship between soils and plants is preserved via this unique fingerprint.

The aim of this work is to discriminate the provenance of apples collected from various production areas located in Northern Italy. These areas are characterized by different geologies including alluvial deposits, metamorphic rocks and magmatic rocks. The results of the multielement and strontium isotope composition lead to a specific fingerprint for each area. The combination of maps of soil properties and geology with chemical landscapes of the multielement composition and a Sr isoscape will provide a tool to predict provenance of apples. Their discrimination power for areas sharing common geological features, such as those of the vast area of the Po alluvial plain, will be evaluated. In addition, the applicability of novel isotopic tracers for agrifood origin determination, such as boron and lead isotope ratios, will be considered. The combination of the results will provide a discrimination tool based on soil-derived traceability markers to identify the geographical origin of horticultural products.