# Tracing the geochemical origin of fruits grown in different regions of Hungary with data analysis of metal content

**My Ban Thi[1*], Jordan Gyozo[2], Geza Hitka[1], Quang D. Nguyen[1]**

[1]*Hungarian University of Agriculture and Life Sciences, Institute of Food Science and Technology, Budapest, Hungary.*

[2] *Eötvös Loránd University, Budapest, Hungary*

*Corresponding author: banthimy@gmail.com*

## SUMMARY

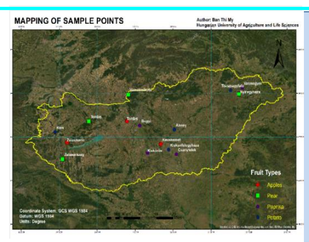
Food traceability is a critical aspect that has gained increasing interest in the global food supply chain at the international level. Among traceability methods, chemical analysis of soil and related food brings accurate results, where the interaction between soil and plants such as fruits can be represented. The soil versus fruit metal content is considered effective for food traceability related to geographical conditions, and it has shown promising tracing accuracy.

Hungary is the ninth-largest fruit producer in the EU, with about 1.27 million tonnes (3%) of total EU fruit production in 2020. Fruit output is an essential part of Hungary's economy, and it contributes to 4.4% of the agricultural output in 2020. In accordance with the sustainable development goal, and in response to the food safety needs and challenges facing modern business and food production, the GINOP project has been conducted to determine the fruit and vegetable origin grown in soils in Hungary. Based on the thorough soil and plant (apple and pear) sampling campaign in 6 regions, a model of environmental factors influencing the traceability is proposed, highlighting differences between the geographies of fruit-producing regions. Our results are performed by a systematic series of activities (experimental design, selecting sampling locations, developing sampling strategies and sample handling procedures, post-collection data processing, and advanced data analysis), indicating that the metal element content is applicable to distinguish the food geographies of fruits. Further origin tracing methods can be elaborated based on the analysis of a broader list of chemical elements studied, isotopic ratios, or based on the various forms of chemical elements in the soil-plant system.

## METHODS

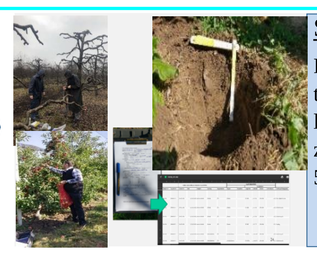

**STEP 1 – LITERATURE REVIEW:**

According to literature, geographical origin of foods can be traced by geochemical methods. In Hungary, food authentication is gaining interest, but requires adjustment to apply the same methods or approaches.




**STEP 2–SAMPLING STRATEGY:**

Samples were collected at 6 locations over Hungary, complying with the FOREGS Geochemical Baseline Program sampling protocol.



**STEP 3 –SAMPLING (2018 - 2021):**

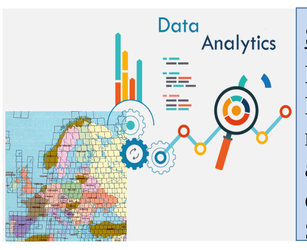
For each sampling point, three soil subsamples were taken, equidistant from each other and from 2 depth levels: top soil (uppermost 5 cm) and bottom soil (root zone: 40-50 cm). A composite fruit sample consisted of 5 fruit samples taken from the same tree.

**STEP 4 – PRE-TREATMENT:**

The samples were prepared in the laboratories of the MATE.

**STEP 5 – LAB ANALYSIS:**

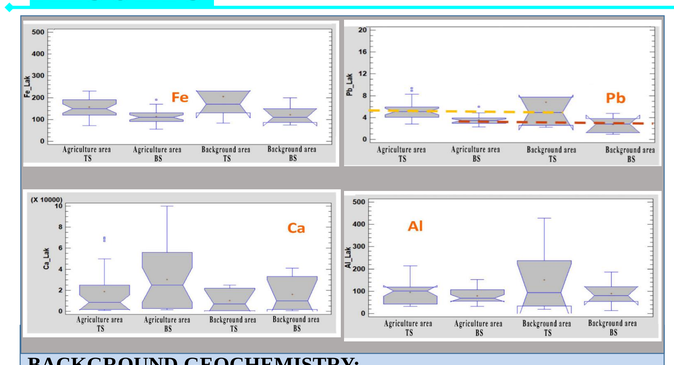
The chemical composition of the soil and fruit samples was measured by ICP-OES (Perkin Elmer Optima 8000) and ICP-MS (Agilent 7500ce ICP-MS) techniques according to MSZ EN 16943: 2017, MSZ EN 15763: 2010 and EPA Method. 6020A: 2007 standards.




**STEP 6 – DATA ANALYSIS:**

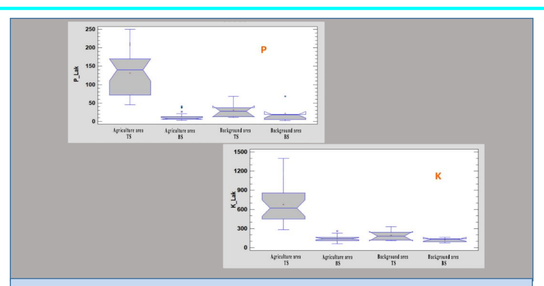
Data was structured into a GIS database. Different analysis tools (exploratory data mining, correlation analysis, clustering analysis) were applied on the chemical composition data, by QGIS, SPSS and Stagraphics.

## RESULTS



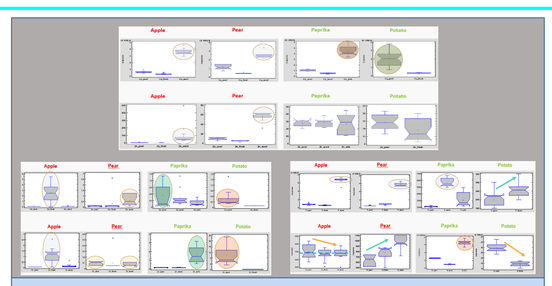

**BACKGROUND GEOCHEMISTRY:**

The Fe and Pb are higher in the top soils and both in the orchards and the background areas, indicating the anthropogenic airborne origin of these elements. Background soil samples enabled the delineation of the natural chemical composition of the sampled soils. Other elements (Ca, Al, etc.) are uniform representing the natural geochemical background (carbonates, clays).



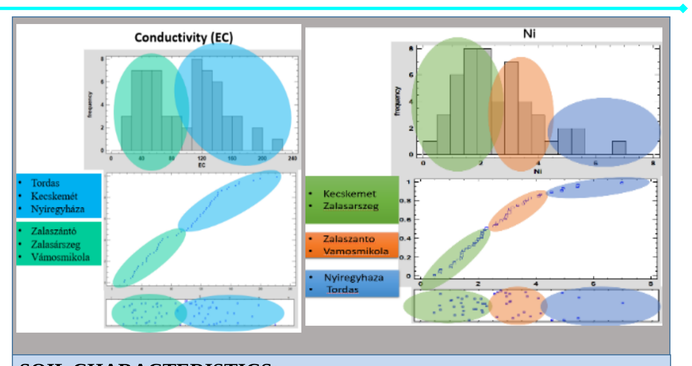

**FERTILIZER:**

Fertilizers can be recognized in significant quantity in the studied agricultural fields.



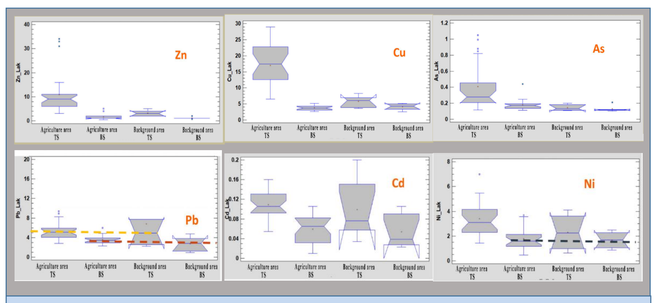

**CHEMICAL COMPOSITION IN DIFFERENT FRUITS:**

Each type of fruit/vegetable shows a characteristic ratio of major and trace elements.



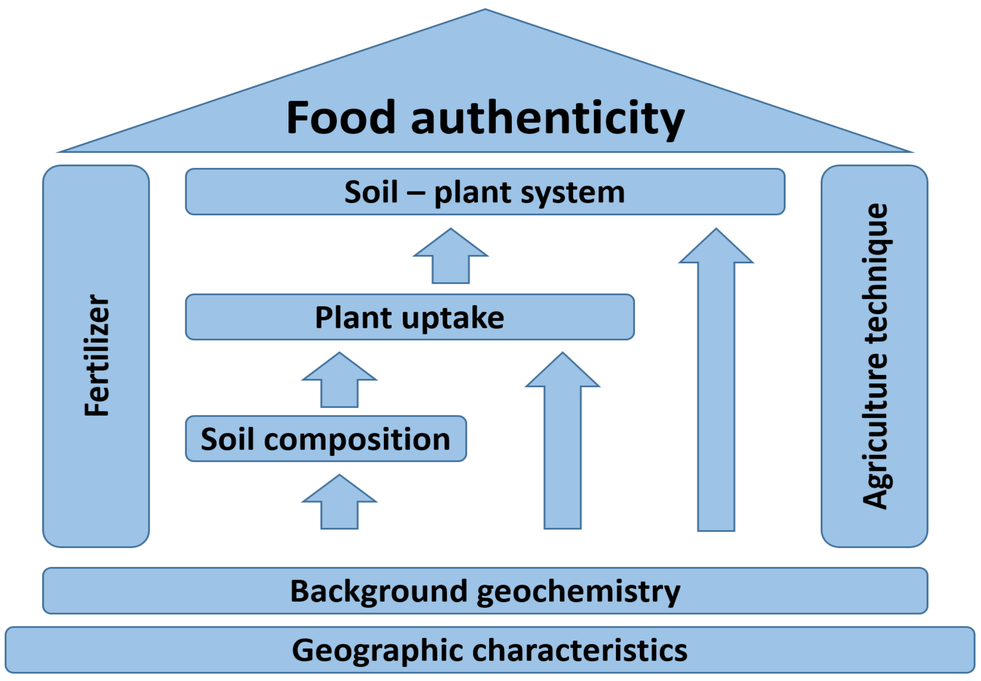

**SOIL CHARACTERISTICS:**

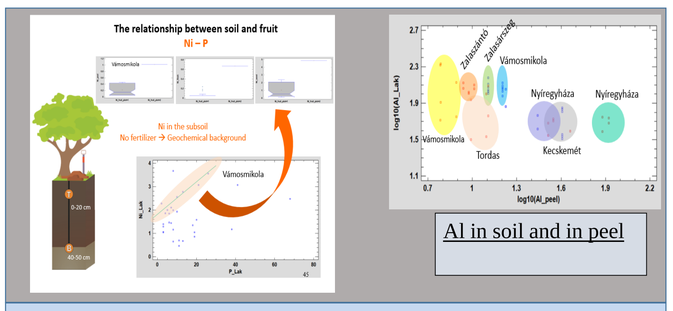
Univariate analysis of soil samples revealed statistically significant differences among the various locations or groups of locations.




**AGRICULTURAL TECHNIQUE:**

Cu, As, and Ni, in addition to Zn and Cd, have significantly higher concentrations in the orchards' top soils only, but not in the background areas, indicating that the main source of these metals comes from the agricultural activities, such as fertilizers. Although pollution, this information may be used for locality identification.



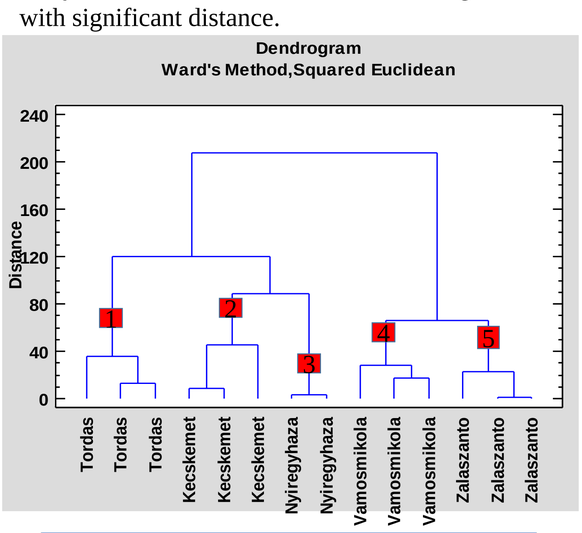

Al in soil and in peel

**PLANT UPTAKE:**

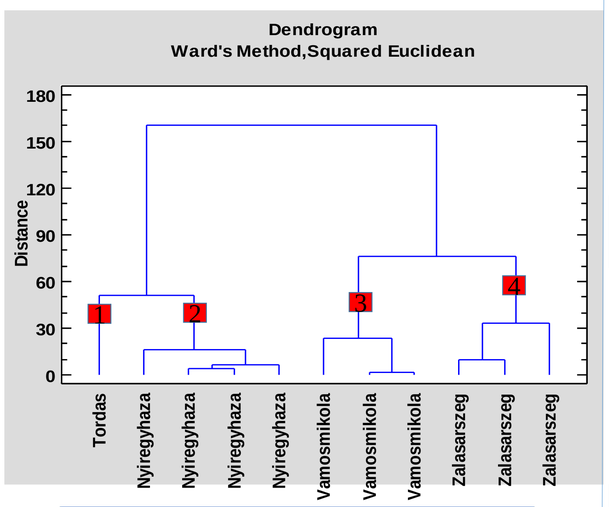
As a preliminary result, all sampled sites could be identified (fingerprinted) as separate localities based on the chemical composition of soils and fruits. Finger printing might be carried out not only on the basis of elemental composition but based on the site-specific soil and soil-plant processes modeled by regression analysis.

## EXAMPLE 1: SOIL ANALYSIS WITH METAL ELEMENTS

The data were collected in apple orchards from five regions and pear orchards from four regions. Cluster analysis method with soil data can distinguish 100% of different regions.The clusters are far from each other with significant distance.




**5 different groups of apple regions**

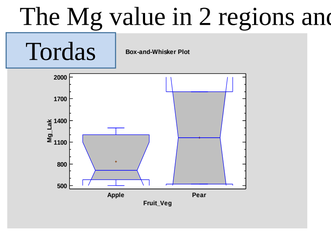



**4 different groups of pear regions**

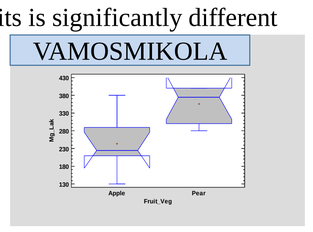
## EXAMPLE 2: COMPARE TRACE ELEMENT CONTENT IN 2 REGIONS

The Mg value in 2 regions and 2 fruits is significantly different

Tordas

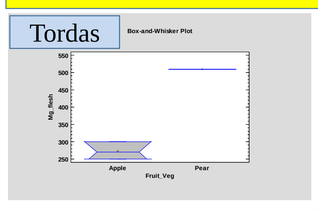



VAMOSMIKOLA

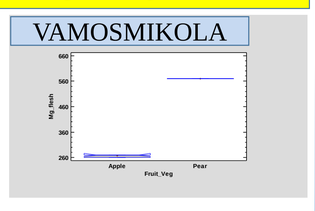



**Mg value of apple orchards and pear orchards in Todas is higher than Vamosmikola. Besides, the variation in Tordas region is higher**

Tordas




VAMOSMIKOLA

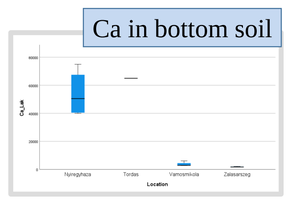



**Mg value of apple flesh is always lower than in pear in both regions. Although the Mg value in pear orchards soil in Tordas was higher than of Vamosmikola, the Mg value in pear flesh in Tordas was lower than in Vamosmikola**

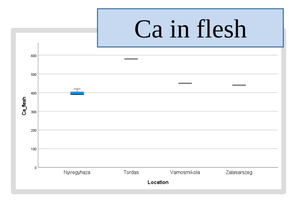
## EXAMPLE 3: Ca IN PEAR

The $Ca^{2+}$ composition of the soil from four pear regions and its yielded pear are traced. Different soils show different ratios in fruit uptake.

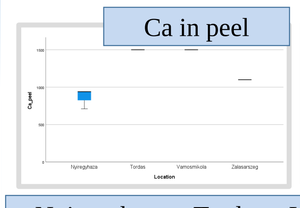
Ca in bottom soil



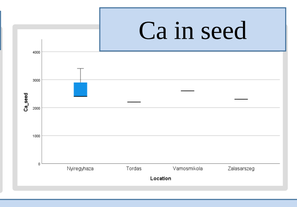

Ca in flesh




Ca in peel




Ca in seed




Nyiregyhaza – Tordas – Vamosmikola - Zalasarszeg

**Nyiregyhaza is always been recognized with a higher variation of Ca in soil and in its products.**

## CONCLUSION

**Metal element content is applicable to distinguish the food geographies of fruits.**

**A model of environmental factors influencing the traceability of fruits is proposed.**

**Further origin tracing methods can be elaborated on the analysis of a broader list of chemical elements, or isotopic ratios, or based on the various forms of chemical elements in the soil-plant system.**

## ACKNOWLEDGEMENTS

This work is supported by the New Széchenyi Plan Project No. EFOP-3.6.3.-VEKOP-16-2017-00005, the projects No. GINOP-2.2.1-18-2020-00025, and No. NKFIH-831-10/2019, TKP2021-NVA-22 as well as by the Doctoral School of Food Science, Hungarian University of Agriculture and Life Sciences.