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SPATIAL-TEMPORAL MODELS AND AUTHENTICITY MAPS TO REINFORCE COMMERCIAL VALUE OF ARGAN PRODUCTS: DISPLAYING REALMED FIRST RESULTS

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ABSTRACT

Concepts such as food traceability and authenticity should be priorities in the area of food quality. Even if they are not innovative concepts, their importance increases even more since increased consumer's sensitivity to origin and production practices of food. Mediterranean high-value products, including argan oil and the black Iberian pig, have in common provenance from Mediterranean semi-arid environments. REALMed project will enhance their intrinsic value by defining a Mediterranean label, by ameliorating tests on authenticity and by connecting to the process of production and environmental features. In the context of REALMed project, we investigated Argan oil and seeds a) through an innovative approach associated with a mechanistic framework and b) integrating the information on ecophysiological responses of Argan plants to semi-arid conditions (especially water uptake and carbon fixation). Based on GIS and statistical models, a relationship arises between isotope ratios and fractionation processes associated to local climate, soil conditions and metabolic peculiarities. This relationship is expressed from local to regional scales and visualised through isoscapes, a template to render complex isotopic ratio data analysis. Spatial-temporal models and authenticity maps differentiate between reference areas, even inside the Mediterranean basin. Differentiation turns into a reinforcement of the commercial value of local/national products.

Keywords: REALMed, food traceability, argan oil and seeds, ecophysiological responses

RESUME

Les concepts de la traçabilité et l'authenticité des aliments devraient être prioritaires dans le domaine de la qualité des aliments. Même s'il ne s'agit pas de concepts novateurs, leur importance augmente d'autant plus que les consommateurs sont de plus en plus sensibles de l'origine et aux bonnes pratiques de production des aliments. Les produits méditerranéens à haute valeur ajoutée, notamment l'huile d'argan et le porc ibérique noir, ont en commun une origine méditerranéenne semi-aride. Le projet REALMed renforcera leur valeur intrinsèque en définissant un label méditerranéen, en améliorant les tests d'authenticité et en se connectant au processus de production et aux caractéristiques environnementales. Dans le cadre du projet REALMed, nous avons étudié l'huile et les graines d'argan a) par une approche innovante associée à un cadre mécaniste b) en intégrant les informations sur les réponses écophysiologiques des plantes d'argan aux conditions semi-arides (en particulier l'absorption d'eau et la fixation du carbone). Sur la base des modèles statistiques SIG, une relation apparaît entre les ratios isotopiques et les processus de fractionnement associés au climat local, aux conditions du sol et aux particularités métaboliques. Cette relation est exprimée à l'échelle locale et régionale, visualisée à travers Isoscapes, un modèle permettant de rendre complexe l'analyse de données de ratios isotopiques. Les modèles spatio-temporels et les cartes d'authenticité différencient les zones de référence, même à l'intérieur du bassin méditerranéen. La différenciation se traduit par un renforcement de la valeur commerciale des produits locaux / nationaux.

Mots-clés: REALMed, traçabilité des aliments, huile et graines d'argan, réponses écophysiologiques

INTRODUCTION

REALMed is a European-funded project, under ARIMNet2, devoted to "Pursuing authenticity and valorization of Mediterranean traditional products". The project focuses on selected high premium products that identify the countries involved: Moroccan argan oil, Portuguese and Spanish meat products from black Iberian pigs pigs, Italian and Slovenian truffles and Tunisian lamb (Figure 1). The project involves activities

devoted to scientific in- depth analyses: by identifying and describing the combination ofstable (heavy,light) isotoperatios with the elemental profile, the product-specific chemical characterization, and the genetic characterization of cultivar/species involved. Distinctive methodologies are applied, as elemental profiling, isotope ratio mass spectrometry, and DNA-based genetic methods. Moreover, the project is intended to transfer results by vis-à-vis contact with local stakeholders, tailored workshops, participation at national and international scientific and stakeholders' meetings (Giovanetti et al., 2018). Activities started in 2017 and will be concluded in 2020. In the context of REALMed project, the two research groups of Morocco and Portugal have been actively involved in numerous shared activities, related with argan production fields sampling design and collection, as well geographical and climatic characterization, argan seeds and oils sample collection and isotopic and elemental fingerprinting. Argan oil is largely exploited commercially; however, few information are available on the authenticity and origin of this product. Similarly, knowledge on the peculiar producing methods and technologies that can claim a truly Moroccan identity and origin is scarce. This is therefore a perfect case-study for REALMed aims.

We investigated argan oil and seeds *a)* through a mechanistic framework and *b)* integrating the information on ecophysiological responses. On the one hand, carbon and oxygen isotopic composition of argan oil, and of any plant material in general, is linked to the climatic conditions (relative humidity, temperature, amount of precipitations) and geographical characteristics (distance from the sea or other evaporation source, altitude, latitude) of the area where the plants grow (Hermann *et al*., 2008, Rodrigues *et al*., 2011, 2012). On the other, $^{2}H/^{1}H$ and $^{18}O/^{16}O$ ratios of plant materials reflect the ratios of water uptake by the plant. They are therefore linked to latitude, elevation, distance from the evaporation source, temperature and amount of precipitation, the evaporative and diffusional effects during transportation, and the biosynthetic pathways including the isotopic exchange between organic molecules and plant water (Camin *et al*., 2010). Combining these two kinds of information is the innovation that REALMed consortium will achieve.

MATERIALS AND METHODS

Argan oil samples came from different locations: Provinces of Essaouira, Taroudant, Chtouka, Ait Baha, Agadir, Tafraout and Tiznit. The oil was extracted by IGP certified co-operatives following traditional procedures and located in the three climate areas (arid, semiarid and Saharan) that represent all the area of argan trees distribution in Morocco. Samples were stored in the dark at room temperature until the day of analyses. The plastic containers, used for storing and treating the samples and Teflon microwave digestion vessels, were treated with nitric acid and milli-Q water to avoid contamination with traces of any metal. The analysis of stable isotope Carbon, Oxygen and Nitrogen (13C/12C, 18O/16O and 15N/14N) ratios of bulk argan oils have been performed in Water and Climate Unit of National Energy Center of Sciences and Nuclear Techniques (CNESTEN) laboratories and Stable Isotopes and Instrumental Analysis Facility (SIIAF), Centre for Environmental Biology, Faculty of Sciences, University of Lisbon, Portugal, using an isotope ratio mass spectrometers Delta V connected to an elemental analyser. The stable isotopes were determined for the all samples

RESULTS AND DISCUSSION

Based on GIS and statistical models, a relationship arises between isotope ratios and fractionation processes associated to local climate, soil conditions and metabolic peculiarities. In fact, the isotopic values of $\delta^{13}C$ of seed and paste of argan (starting from samples intended for the food or cosmetic) varied from -24.3 ‰ to -28.6 ‰ (± 0.2 ‰). These values were enriched in relation to the correspondent argan oils that ranged from -27.3‰ to - 29.9‰ (±0.2‰). Instead, the values of $\delta^{18}O$ ranged from 27.9‰ to 31.3‰ (±0.2‰), being within the range to the correspondent argan oils that ranged from 22.7‰ to 25.7‰ (±0.2‰). In conclusion, the

results of the isotopic analyses ($\delta^{13}C$, $\delta^{18}O$ and $\delta^{15}N$) of the samples of oil, seed and paste show a broad variation of the isotopic abundance. This confirms the importance of carbon, oxygen and nitrogen stables isotopes for the traceability study (Danezis *et al*., 2016). In the main geographical area of the argan, the variability of $\delta^{13}C$ and $\delta^{18}O$ values suggest differences in water availability to plants, and the respective physiological adaptation to drought. The argan oils coming from the northern Morocco regions (Essaouira, Tamanar and Agadir), show significantly lower values for $\delta^{13}C$, reflecting the more temperate climate due to the nearness to the sea.

Preliminary results indicate that it is possible to differentiate producing areas (cooperatives) and reinforce the quality and commercial value of some of these plant products and sub-products. The relationship is expressed from local to regional scales and visualised through isoscapes, a template to render complex isotopic ratio data analysis. Figure 2, for examples, highlights throughisoscapes how ^{18}O values change, according to origin of samples. Inland areas characterized by higher temperature and dry climate, as Taroudant and Tafraout, point out a greater enrichment in ^{18}O than those produced generally in other region located near the sea (Essaouira, Agadir ait baha and Tiznit).

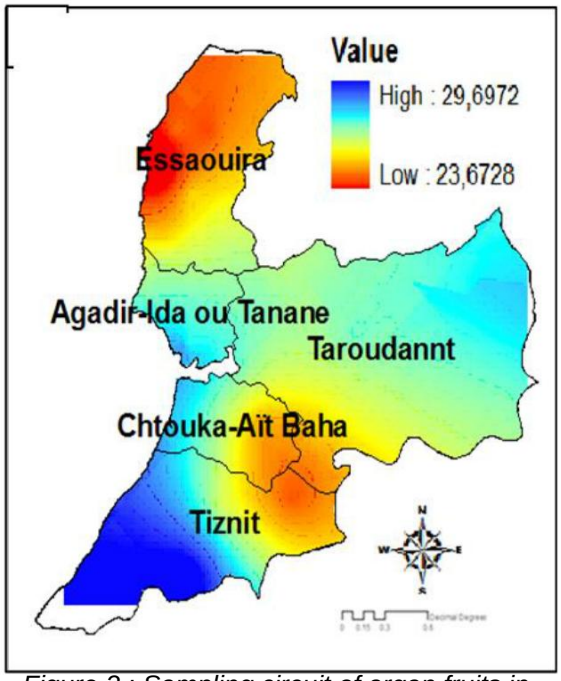

Figure 2 : Sampling circuit of argan fruits in Morocco and correspondent argan oil δ18O values obtained from differences areas (Essaouira, Agadir, Taroudant and Tiznite)

CONCLUSIONS

From 2017 to 2019, REALMed already achieved its first results. Partners carried out a targeted sampling so to combine new data with existing ones: this allowed to start attempts to create a multivariate and geospatial data analysis for each product. The aim of this approach is to illustrate existing correlations between isotopic composition of plant and animal tissues and environmental variables. All information will be harmonised and combined in a large user-friendly database, that will serve as a base to test each product and to confirm its origin. REALMed will, as expected, impact these high-value products by linking their monetary value to the peculiar environmental conditions in which they develop. Regional economies and populations will benefit from it. Indeed, food products have to respond to current ethical, environmental and socially sustainable claims. This

is particularly critical in the Mediterranean region, where several unique and traditional food products of an exceptional quality play a fundamental role in local socioeconomic activity and in the conservation of cultural and natural heritage. Argan oil is produced from the kernels of argan tree (*Argania spinosa* L.), a species endemic to southwestern Morocco protected by UNESCO (2007). Argan oil production plays a key role in the environmental and social-economic Moroccan context. Indeed, the integrated value of this product relies on Mediterranean biodiversity, traditional knowledge and heritage, and also on social organization and promotion of territorial products. The understanding of its origin will enforce consumer's trust and, through a cascade, it will also increase local economy, especially that of Berber women that have historically used it for cosmetic and cooking.

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