

Multi-element and multi-isotope-ratio analysis to determine the geographical origin of foods in the European Union

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Determination of the geographical origin of food and beverages has been a growing issue over the past decade for all countries around the world, mostly because of the concern of consumers about the authenticity of the food that they eat. An increasing number of research articles in the past five years have investigated the elemental composition and the isotope ratios as indicators to determine the origin of food and beverages. The indicators commonly used are stable-isotope ratios of hydrogen, oxygen, nitrogen, carbon and sulfur, combined with isotope ratios of strontium and lead, and elemental concentrations.

This article reviews the application of multi-element and multi-isotope methods and the statistical tools used to determine the geographical origin of food and beverages in the European Union from 2008 to early 2012. We review 48 papers, divided between different food commodities.

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1. Introduction

Historically, food products have always been linked with a specific geographical origin. Food-consumption habits were created by the local natural resources and the social or cultural factors of the community. Such links have disappeared over the time for various reasons, mostly because of the globalization of the food industry, following the extensive growth in technological means over the past century. Thus, food consumption in a region no longer necessarily reflects food production of that area. However, in recent years, consumers have renewed their interest in food strongly identified with a place of origin. The reasons for this increasing interest of consumers vary from the global trend for organic and health products to their concern about animal welfare and environmental friendly methods of production [1]. Resulting from this trend, local products around the world regained their fame and brought

wealth to local producers, so product authenticity and authentication are emerging topics [2,3].

Consumers in developed countries demand food products of high quality, one of the basic parameters being origin. A modern trend is the consumption of food produced locally, in order to reduce energy footprint and pollution through transportation. It is quite difficult for many countries to achieve local production of some specific food products. For example, it is impossible to grow olive trees in Denmark, so consumers there need to know the origin of the olive oil that they buy.

Determination of food authenticity is an important issue in quality control and food safety. In recent years, many serious diseases appeared related to foodstuffs, so providing the motivation for the scientific community to work more intensively in this area. Authenticity is a quality criterion for food and food ingredients, and is required more and more worldwide, as a result of legislative protection for regional

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foods [4]. Food authentication may cover many different aspects, including mislabeling, misleading claims about origin, and adulteration, which is defined as a process by which the quality or the nature of a given substance is reduced by adding a foreign or an inferior substance and removing a vital element or characterization of the product [5].

European Union (EU) quality schemes identify products and foodstuff farmed and produced to exacting specifications. Product designations fall into two categories: those linked to a territory and those relating to a particular production method. Geographical indications and designations of origin are names identifying a product as originating in a given territory and testifying to a link between a given quality, reputation or characteristic of the product and its geographical origin. The EU regulation allows the application of the following geographical indications to a food product:

- (1) protected designation of origin (PDO);
- (2) protected geographical indication (PGI); and,
- (3) traditional specialties guaranteed (TSG).

PDO covers agricultural products that are produced, processed and prepared in a given geographical area using recognized know-how. Well-known PDO products are prosciutto di Parma from Italy and Kalamata olive oil from Greece.

PGI covers agricultural products and foodstuffs closely linked to the geographical area. At least one of the stages of production, processing or preparation takes place in the area. Typical products with recognized PGI are Scotch beef and Calcot de Valls from Spain.

TSG highlights traditional character in composition or means of production. Famous examples are mozzarella cheese from Italy and traditional Farmfresh Turkey from UK [6].

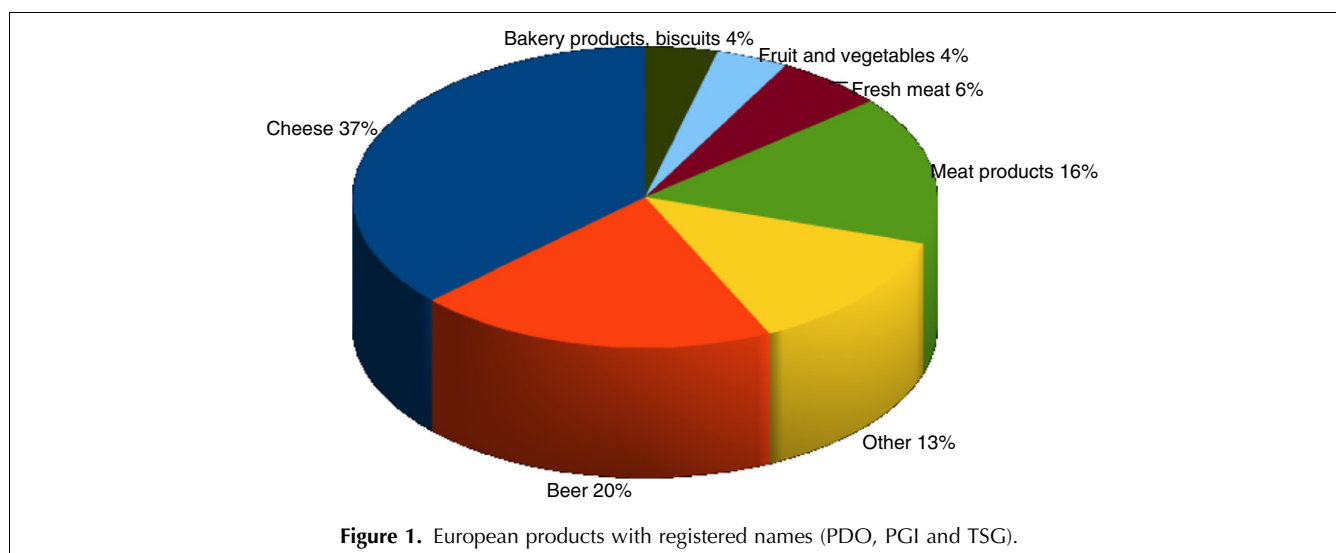
Fig. 1 [7] shows products with protected signature name in Europe, while Table 1 [8] shows the volume and

value of PDO and PGI products by type of product in the past few years. The EU has established regulations for every product available. Regulation CE 1760 17/07/2000 made the indication of origin on meat carcasses mandatory, Commission Directive 2001/110/CE posed the same condition for honey, Commission Regulation No 2065/2001 established rules for the application of Council Regulation 104/2000 to inform consumers about fishery and aquaculture products [9].

Published reviews have shown the growing interest in the determination of geographical origin of specific foods and beverages with wide consumption {e.g., honey [10], wine [11] and meat [12]}. Reviews of analytical methods for the determination of geographical origin of food and beverages have been published [13–15]. Methods based on elemental composition have been reviewed [4,16,17], as have methods based on isotope ratios [9,17,18]. Most of these publications also discussed statistical methods for data interpretation and visualization.

Strategies employed to detect adulteration have relied on instrumental techniques and have evolved through time along with technology and instrumentation. High-performance liquid chromatography (HPLC) [19–21], gas chromatography (GC) [22,23], nuclear magnetic resonance (NMR) [24], infrared spectroscopy (IR) [25,26], fluorescence spectroscopy [27,28], capillary electrophoresis (CE) [29] and more advanced techniques {e.g., proton transfer reaction mass spectrometry (PTR-MS) [30,31], electronic nose coupled with MS [32,33], DNA technologies [34,35] and sensory analysis [36,37]} have been proposed for food authentication.

However, organic components of a food-crop production depend on various conditions (e.g., fertilization, history of the field, climatic conditions in the year of cultivation, geographic location and soil composition), so it is not always possible to determine the origin of a product by analyzing the organic components. Despite



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