



# Multivariate classification of honeys from Corrientes (Argentina) according to geographical origin based on physicochemical properties



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## ABSTRACT

Honey is the natural sweet substance produced by *Apis mellifera* bees and is studied in different countries and zones because of the interest of consumers in origin and quality of food. The Corrientes Province (Argentina) produces and exports honey from different rural zones; therefore, the aim of this paper was to study the physico-chemical parameters of honeys using multivariate methods in order to classify honeys according to the geographical origin. Nine standard physico-chemical parameters were determined according to the international legislation. The results obtained were in agreement with international regulations. Then, the results obtained were analyzed by principal component analysis and linear discriminant analysis applying forward selection. The chemometric analysis allowed grouping samples according to their geographical origin by using only five parameters.

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## 1. Introduction

Honey is the natural sweet substance produced by *Apis mellifera* bees from the nectar of plants or from secretions of living parts of plants or excretions of plant-sucking insects on the living parts of plants, which the bees collect, transform by combining with specific substances of their own, deposit, dehydrate, store and leave in honeycombs to ripen and mature (Communities, 2002). Honey is a complex product composed majority by monosaccharides and minority by components such as amino acids, enzymes, vitamins and minerals. The composition is influenced principally by the plant species that bees visit; and furthermore by geographic area, soil, weather conditions, and contribution of the beekeeping practices.

Argentina is among the main five producers of honey in the world, it is after China, Turkey, USA and Ukraine. According to FAO (Food and Agriculture Organization of the United Nations), Argentina produced 60,000 t of honey in 2011. Corrientes is one of the 12 provinces of Argentina that export honey. Because of a wide rural area as well as significant planted forests areas (Elizondo & Mestres, 2009), Corrientes Province produces mainly honey of native forest, citrus, eucalyptus, and esters and islands. The natural

resource and the optimum utilization allow the production of honey without antibiotics, and a minimum stress for the bees (Haberle, 2013). In recent years, there has been a significant increase in honey production due to an increasing demand and interest by consumers in natural products, good climatic conditions and governmental action promoting beekeeping.

Producers, consumers, the food industry and regulatory authorities are interested in correct labeling of origin, traceability, and quality of honeys. For honey, quality is a multi-factorial parameter linked to botanical and geographical origin, which affects its commercial value; and Protection Denomination Origin (PDO) register is an added value that promotes and protects name of quality honeys. The geographical origin criterion is a quality parameter to produce certified honey with designation of origin. Hence, a regional classification of honeys according to its zones of production would increase its commercial value (Silvano, Varela, Palacio, Ruffinengo, & Yamul, 2014). In this context, although there are powerful methods to prove honey adulteration, concerning the botanical origin of honey quality, rapid, reliable, and cheap analytical approaches applicable for the authentication of honey should be developed (de la Guardia & Illueca, 2013). Focusing in this aspect, researches have been proposed for authentications of honey the chemometric evaluation of classical physico-chemical parameters (Arvanitoyannis, Chalhoub, Gotsiou, Lydakis-Simantiris, & Kefalas, 2005; Jandrić et al., 2015; Yücel & Sultanoglu,

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2013).

Currently, numerous studies about honey produced in different countries, also mentioning Argentina have been published (Baroni et al., 2009; Belay, Solomon, Bultossa, Adgaba, & Melaku, 2013, 2015; Can et al., 2015; Chua, Abdul-Rahaman, Sarmidi, & Aziz, 2012; Conti et al., 2014; Conti, Stripeikis, Campanella, Cucina, & Tudino, 2007; Feás, Pires, Estevinho, Iglesias, & De Araujo, 2010; Karabagias, Badeka, Kontakos, Karabournioti, & Kontominas, 2014a, 2014b; Pellerano, Uñates, Cantarelli, Camiña, & Marchevsky, 2012). But only few studies have shown physico-chemical characteristics of honeys from Northeast of Argentina (Acquarone, Buera, & Elizalde, 2007; Lancelle, Fechner, Moresi, Armua, & Badan, 2013; Salgado & Maidana, 2014). However, at the moment no information is available concerning classification of honeys from Corrientes Province. In this context, this work explores the possibility to implement a protected geographical indication of origin system in order to promote and protect the reliability of international market of Argentinean honeys. The aim of this paper was to study the physico-chemical parameters of honeys using multivariate methods in order to classify honeys according to the geographical origin. In addition, to validate the proposed model, we included honey samples from a neighbor production region that were not considered for the training step.

## 2. Materials and methods

### 2.1. Samples

One hundred forty one honey samples were directly provided by the beekeepers. Honey samples were collected during the 2010, 2011 and 2012 harvest from the most important production areas in Corrientes Province (Argentina), which include different botanical origins and soil characteristics. We selected four honey production areas: Corrientes (CT,  $n=29$ ), Bella Vista (BV,  $n=29$ ), Goya (GY,  $n=23$ ) and Monte Caseros (MC,  $n=60$ ) (Fig. 1). All samples were unheated and were analyzed no later than 4 weeks after extraction from the hives by the beekeepers. In addition, 19 honey samples were collected from Formosa Province (Argentina) to validate the chemometric classification model proposed in this work. Even though the Northeast region of Argentina is formed by four provinces, in this work, we select East region of Formosa to

obtain samples for validation, because this region has similar climate characteristics as Corrientes Province: subtropical, wet, with hot summers and without dry season. In addition, this province shares with Corrientes the international boundary with the Southwest region of Paraguay, which is another significant producer of honey from South America.

Bee flora from Corrientes Province and from Formosa Province is different. In one hand, principal bee flora from Corrientes is *Eucalyptus* spp., *Citrus aurantium*, *C. limon*, *Eryngium elegans*, *E. horridum*, *Cordia* sp., *Baccharis punctulata*, *Mikania* sp., *Senecio gri-sebachii*, *Trixis antimenorrhoea*, *Thyreus praestans*, *Persea americana*, *Fragaria x annanasa*, *Acicarpha tribuloides*, *Acacia caven*, *Clematis montevidensis*, *Elephantopus mollis*, *Cirsium vulgare*, *Chorisia speciosa*, *Oenothera* spp., (Salgado & Pire, 1998). In other hand, principal bee flora from Formosa is *Bulnesia sarmientoi* Lorentz ex. Griseb., *Geoffroea decorticans*, *Copernicia alba*, *Eugenia uniflora*, *Prosopis alba*, *Schinopsis balansae*, *Schinus* spp. and *Ziziphus mistol* (C. Salgado & Cabrera, 2006).

### 2.2. Methods

The samples were kept in the dark at room temperature 20–25 °C in plastic flask before physical and chemical analysis. These analyses were performed following international recommendations.

#### 2.2.1. Moisture

Water content was determined by using a digital ABBE WYA-1S refractometer (ICSA, China) according to AOAC Official Method 969.38B (AOAC, 1996). The honey samples that were crystallized at the moment of analysis were previously heated until 40 °C. The measurement was done for three times and the results (refractive index) were displayed on the instrument. The refractive index values were converted to moisture contents from the Chataway table.

#### 2.2.2. Electrical conductivity (EC)

Electrical conductivity (EC) was measured at 20 °C using an ORION 3 STAR (Thermo Scientific, Beverly, USA) conductivity meter according to IRAM 15945, 1996. EC was measured in a 20% (w/v) solution of honey in CO<sub>2</sub>-free deionized water. The results were expressed as mS/cm. All measurements were performed in

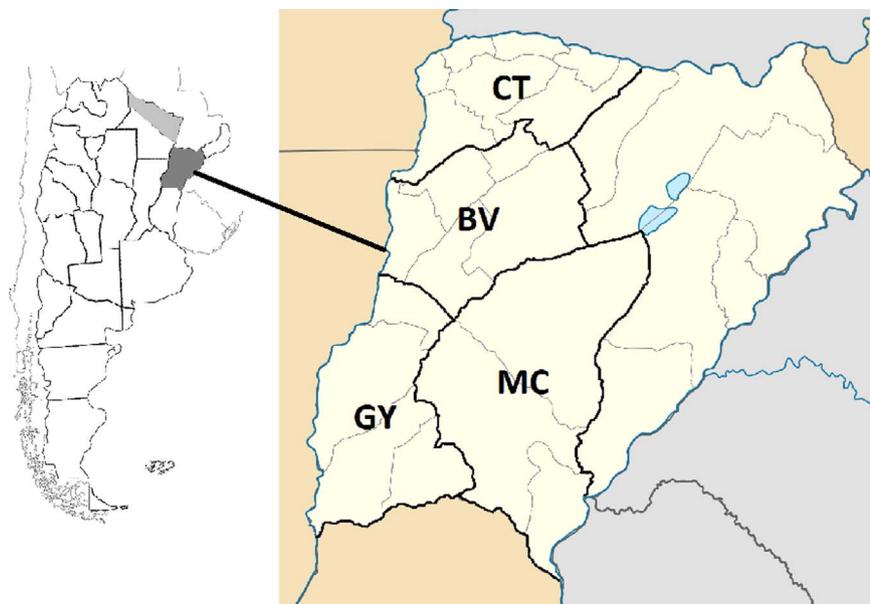


Fig. 1. Geographical origins of the honey samples from basins of Corrientes Province: BV (Bella Vista), CT (Corrientes), GY (Goya), and MC (Monte Caseros).

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