



CHEMOMETRIC ANALYSIS IN CLASSIFICATION OF COLOMBIAN HONEYS ACCORDING TO PHENOLIC, REDUCTIVE CAPACITY AND ANTIRADICAL POTENTIAL

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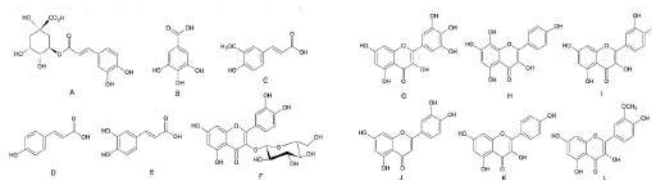


REMARKS

Honey is a complex natural product produced by bees from floral nectar and other extrafloral secretions, which they collect, transport, dehydrate, and store in the hive. Its composition includes more than 180 compounds, such as sugars, amino acids, vitamins, enzymes, and, most notably, polyphenols. Among these, phenolic acids and flavonoids stand out for their strong antioxidant capacity and their role in modulating diverse biological processes.



The quality and physicochemical characteristics of honey, as well as sensory attributes such as color, aroma, texture, and flavor, are closely influenced by its botanical origin, climatic conditions, and processing practices. The antioxidant activity refers to the analytical measurement of concentrations of radicals of different natures in a controlled oxidative system (Gallic, Caffeic, Ferulic, Chlorogenic, p-Coumaric, Protocatechuic, Sinapic and Vanillic acids; Quercetin, Kaempferol, Luteolin, Apigenin, Pinocembrin, Galangin, Naringenin, Chrysin and Isorhamnetin).



METHODS

This study aimed to quantify the total phenolic content (using the Folin-Ciocalteu assay) and flavonoid content (using the aluminum chloride assay) via UV-Vis spectrophotometry at 765 nm and 415 nm, respectively. The reducing power was evaluated through the FRAP assay (2,4,6-tripyridyl-s-triazine), while antioxidant capacity was determined using the ABTS assay (2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid)) in Colombian honeys from diverse geographic origins.



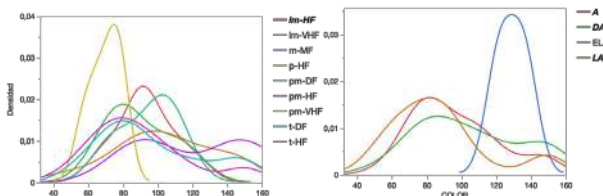
All measurements were performed using the Microwe 96-well microplate system. Ethanol extracts of honey were prepared by leaching, followed by filtration, centrifugation, and storage at 4°C until analysis. In Colombia, progress in the phenolic profiling of floral and monofloral honeys is still limited, and studies on this topic remain in the early stages.

RESULTS

Four types of honey were identified across different ecological zones and classified by the Pfund scale as Type A (38%), Type DA (19.6%), Type ELA (1.4%), and Type LA (40.6%). Color, a key quality attribute influenced by floral source and processing, was further assessed using the CIELab system, which measures lightness (*L*), red-green (*a**), and yellow-blue (*b**) coordinates.

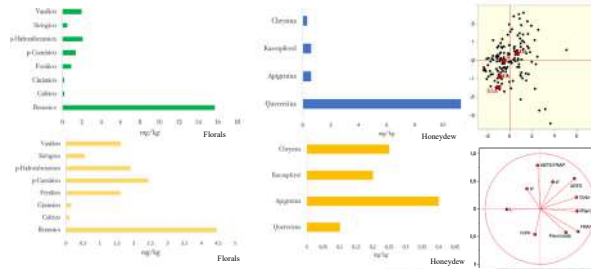


The pigment and soluble compound fraction present in honeys exhibits yellow to yellow-orange tones, which indicate the presence of chlorogenic acid (A), gallic acid (B), ferulic acid (C), p-coumaric acid (D), and caffeic acid (E). Isoquercetin (F), myricetin (G), herbacetin (H), quercetin (I), luteolin (J), kaempferol (K), and isorhamnetin (L), among others, are also found depending on the botanical origin, in addition to compounds generated through browning reactions.



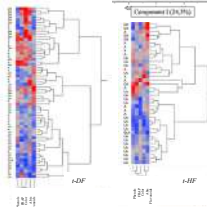
The phenolic and flavonoid content in tropical honeys is closely related to their color. It is a good indicator of their bioactive compounds. Darker honeys tend to be richer in these compounds, with higher antioxidant capacity, nutritional value, and greater resistance to oxidative degradation. Pfund < 50 mm: Total phenols: 20–40 mg GAE/100 g with flavonoids: 5–15 mg QE/100 g; 50–85 mm ≈ 40–80 mg GAE/100 g with 15–30 mg QE/100 g; > 85 mm ≈ 80–120 mg GAE/100 g with 30–50+ mg QE/100 g

Type	n	Phenols (mg/100 g)		Flavonoids (mg/100 g)		Flavonoids/Phenols	
		Media	EEM	Media	EEM	Media	EEM
A	55	94,5 ± 47,6	6,42	8,71 ± 5,90	0,80	0,11 ± 0,08	0,011
DA	28	96,5 ± 79,5	15,0	9,40 ± 7,00	1,30	0,13 ± 0,09	0,016
ELA	2	64,7 ± 25,2	17,8	5,78 ± 3,48	2,46	0,09 ± 0,021	0,014
LA	58	81,1 ± 50,8	6,64	8,14 ± 4,50	0,60	0,13 ± 0,09	0,012



Type	n	ABTS (mg GAE/100 g)		FRAP (mg GAE/100 g)	
		Media	EEM	Media	EEM
A	55	13,1 ± 3,60	0,48	29,1 ± 9,52	1,28
DA	28	14,6 ± 4,20	0,79	33,6 ± 13,3	2,55
ELA	2	9,70 ± 0,02	0,02	17,6 ± 0,30	0,21
LA	58	11,2 ± 3,30	0,45	27,2 ± 9,00	1,18

Total phenolic and flavonoid content in Colombian samples is known for some honeys, such as those from *Weinmannia tomentosa* L.f. (Encenillo), with values of 157 ± 1.40 mg GAE/100 g and 12.9 ± 0.12 mg QE/100 g, respectively, and from *Eucalyptus* sp., with 76.6 ± 1.47 mg GAE/100 g and 5.96 ± 0.17 mg QE/100 g.



Chemometric analysis in classification of Colombian honeys according to phenolic, reductive capacity and antiradical potential

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Honey is a natural food product and sweetener that is known for many medicinal and biological properties including antioxidant, antibacterial, anti-inflammatory, and wound healing capabilities, on the other hand biological and medicinal properties are attributed to chemicals profile of honey that contains a variety of enzymes, sugars, vitamins, minerals, phenolic compounds. The antiradical, antioxidant, and reducing capacities of honeys, depend on its geographical origin, climatic conditions, as well as processing, storage, and handling. However, its botanical origin is considered to have the greatest influence on these properties. This research work consider floral, monofloral and honeydew samples from different biogeographical associations in Colombia. Honeys that were analyzed in terms of color, CIELab parameters, phenols (Folin-Ciocalteu), flavones and flavonols, (flavones and flavonols by aluminium trichloride), ferric reducing power (FRAP), and free-radical scavenging (ABTS) assays. Physicochemical parameters were also examined to assess the overall quality of the honey. All data were processed using Principal Component Analysis (PCA), Hierarchical Cluster Analysis (HCA), Linear Discriminant Analysis (LDA) and Neural networks. Amber, (A), Dark Amber (DA), Light Amber (LA) and Extra Light Amber (ELA) honeys showed the highest content of bioactive compounds and reductive capacity and antiradical potential. The global classification accuracy responds to biogeographical origin. The study shows a strong relationship between color shades and bioactive compound profile, which consolidates as an objective approach in the preliminary evaluation of the properties of Colombian tropical honeys.