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MULTIVARIATE TECHNIQUES AND FACTORIAL MULTIPLE MODELS IN CLASSIFICATION OF HONEYS FROM STATES OF LARA AND YARACUY (VENEZUELA)

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REMARKS

Honey is a natural product made mainly from the nectar of flowers; its final quality depends on its botanical and geographical origin. The variability is wide even for honey from the same region. The botanical and geographical origin of honey is still difficult to determine, so it is increasingly necessary to standardize analysis protocols that contribute to the verification of the quality of this important product of the beehive.

This study addresses the physicochemical properties and sensory attributes of tropical honeys from the Venezuelan states of Lara and Yaracuy. The research applies modern multivariate classification techniques, including cluster analysis, neural networks, discriminant methods, multiple factor modeling, and PLS-PATH methods.

MATERIALS AND METHODS

Venezuelan honeys from the states of Lara and Yaracuy were classified based on physicochemical and sensory parameters. Samples were collected from apiaries in the central-western region of the country, comprising a total of 30 honeys from nine localities: Lara (13 samples) and Yaracuy (17 samples), specifically from Crespo, Simón Planas, Palavecino, Jiménez, Morán, Andrés Eloy Blanco, Iribarren (west of Barquisimeto), Peña, and Urachiche. Analyses included color, CIELab chromaticity, pH, free acidity, total sugars, moisture, ash content, electrical conductivity, density, and water activity, combined with sensory evaluation and multivariate statistical methods.

Estate	Place	Altitude o.s.l.	Precicinitation mm/year	Termal sensation °C
Lara	Crespo	1220	500-800	23,5
	Simón Planas	283	1600	24,0
	Palavecino	1000	400-500	24,5
	Jiménez	500	400-500	22,0
	Morán	620	400	22,0
	A. E. Blanco	300	1680	21,0
	Iribarren	765	800	24,5
Yaracuy	J. A. Páez	340	1370	27,0
	Peña	675	1900	26,0
	Urachiche	477	1800-1900	25,0

Discriminant function analysis, seven predictor variables reflecting the overall quality of the honey types were considered: L, a*/b*, pH, moisture content (Xh), electrical conductivity (EC), and Pfund scale color (mm). Results associated with sample groups that generated classification functions with p-values below 0.05 were considered statistically significant. For cluster classification analysis, the parameters a*/b*, EC, moisture content (Xh), pH, dominant wavelength, and color purity were used.

In neural network system, the variables free acidity (X_{AL}), moisture content (Xh), total sugars (Xs), ash content, and pH were applied.

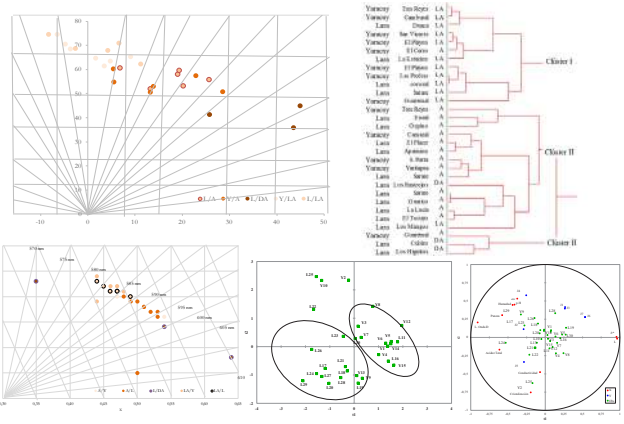
RESULTS AND DISCUSSION

Honeys from Lara and Yaracuy consisted of 50% amber, 40% light amber, and 10% dark amber multifloral types, with distinctive properties that allow differentiation by geographical origin. This region hosts diverse vegetation types, including xerophytic communities, deciduous and semi-deciduous forests, as well as areas dominated by thorny shrubs and *cardonales*. Deciduous forests are comparatively less diverse than humid forests.

	A (ds)	DA (ds)	LA (ds)	Total (ds)
%	50	10	40	100
n	15	3	12	30
*a**	16,1 (7,24)	38,0 (1,07)	1,26 (0,63)	12,3 (1,30)
*b**	54,8 (3,60)	40,7 (4,55)	67,8 (4,44)	58,6 (9,50)
CE (mS. cm^{-1})	0,773 (0,130)	0,672 (0,306)	0,616 (0,180)	0,700 (0,321)
Xw	20,4 (4,04)	21,3 (1,10)	19,9 (1,28)	20,3 (1,30)
pH	3,47 (0,11)	3,64 (0,12)	3,41 (0,16)	3,47 (0,15)
Pfund (mm)	98,8 (7,70)	128 (7,70)	71,3 (8,36)	90,7 (20,1)
L	47,3 (4,64)	29,8 (8,36)	64,0 (5,72)	52,3 (12,0)

The flora is mainly composed of species from the families *Mimosaceae*, *Caesalpiniaceae*, and *Capparidaceae*, represented by the genera *Prosopis*, *Acacia*, *Cercidium*, and *Capparis*. Emergent columnar cacti, particularly those of the genera *Stenocereus*, *Subpilocereus*, and *Pilosocereus*, are characteristic elements of the landscape. Other noteworthy taxa include *Croton*, *Opuntia*, *Jatropha*, and *Cnidoscolus*, together with herbaceous species from the genera *Lantana*, *Digitaria*, *Evolvulus*, *Sida*, and *Sporobolus*, complemented by cacti of the genera *Opuntia*, *Mammillaria*, and *Melocactus.*

The physicochemical and sensory analyses, combined with multivariate statistical methods, allowed for the classification and differentiation of Venezuelan honeys from Lara and Yaracuy according to their quality attributes and geographical origin.



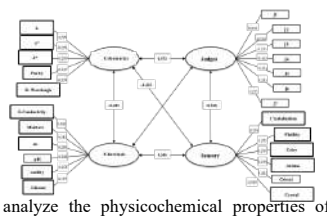
Physicochemical, sensory, and hedonic parameters of Venezuelan honeys.

Samples	VE05.	VE09...	VE12	VE16.	VE28.	VE29
Physicochemicals	Yaracuy			Lara		
L	72,9	41,3	51,3	56,4	63,8	32,3
a*	6,50	28,5	5,50	11,2	4,20	45,0
b*	74,6	50,9	54,7	62,2	68,0	45,0
D. Wavelent (mm)	577	590	580	583	577	605
Xc	0,23	0,28	0,23	0,24	0,23	0,64
CE (mS. cm^{-1})	0,528	0,816	0,525	0,737	0,533	1,290
Moisture	20,0	20,7	20,0	20,7	21,5	21,5
a_w	0,50	0,60	0,60	0,60	0,60	0,60
pH	3,40	3,60	3,50	3,50	3,90	3,50
AT (meq. kg^{-1})	25,8	28,9	32,2	30,8	29,6	31,4
Glucose/water	1,60	1,60	1,40	1,60	1,60	1,40
Sensory						
Fluidez	5,90	4,40	8,30	5,30	4,40	6,50
Color	3,60	5,30	5,10	3,90	6,00	7,70
Aroma	4,90	5,40	7,30	4,40	6,60	6,50
Cristal	0	0	4,00	1,30	0	0
Taste	6,10	7,60	6,70	6,30	7,10	6,20
Hedonic						
J1	7	8	6	3	8	9
...	...	...	...	...	...	...
J7	9	8	7	5	9	5

Eigenvalues associated with principal component analysis

	Physicochemicals		Sesnsoy		Judges	
	EV	%Inercia	EV	%Inercia	EV	%Inercia
1	4,19	42,0	2,10	34,0	3,00	43,0
2	1,59	16,0	1,78	30,0	1,28	18,0
3	1,17	12,0	0,69	12,0	0,98	14,0
4	1,10	10,0	0,65	11,0	0,74	11,0

PLS-PATH relationships in the classification of honeys from the states of Lara and Yaracuy based on multiple factor analysis



The present study made it possible analyze the physicochemical properties of honeys, whose results allowed the formulation of classification criteria through the application of multivariate analysis techniques. This approach enabled the construction of a framework interrelating the intrinsic properties of Venezuelan honeys

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Multivariate techniques and factorial multiple models in classification of honeys from states of Lara and Yaracuy (Venezuela)

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Honey is as diverse as its botanical origin, nature, and composition, with varying color shades. It is a natural product with sweetening properties, produced by bees from the nectar of flowers and secretions from plants. Its physicochemical properties depend on the harvest season, environmental factors prevailing during that period, and biogeographic zones. The aim of this study focused on the characterization of honeys from Lara and Yaracuy (western-central region of Venezuela), specifically from nine localities in the states of Lara and Yaracuy, including the regions of Crespo, Simón Planas, Palavecino, Jiménez, Morán, Andrés Eloy Blanco, Irribarren (west of Barquisimeto), Peña, and Urachiche. The samples were studied and classified based on physicochemical parameters such as color, chromaticity from the CIELab system, pH, free acidity (XAL), total sugars (Xs), moisture (Xw), ash content (Xc), electrical conductivity (EC), density, and water activity (aw). Additionally, sensory attributes and intrinsic properties of the honeys were correlated for the classification of homogeneous honeys through multivariate analysis, multiple factorial modeling, and PLS-PATH. Light amber honeys exhibited delicate and subtle aromas with floral or fruity notes, characterized by a mildly acidic profile, a fragrant and persistent bouquet, sweet notes, and a pronounced aftertaste. The amber and dark amber groups displayed bright hues, with a pronounced floral aroma and a persistent aftertaste. In all cases, metallic notes were weak or absent, and subtle smoky notes were perceived, though they were not dominant. Most of the samples did not show granulation or sedimentation. In the crystallized samples, the aftertaste of sweetness and the fine, homogeneous granulation were predominant. This study allowed for the evaluation of the physicochemical properties of Venezuelan honeys, facilitating the use of new analytical tools for their classification.