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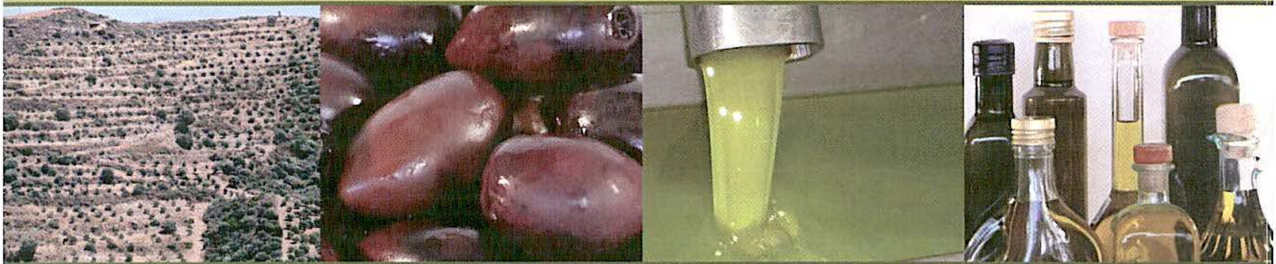

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BOOK OF ABSTRACTS

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Classification of olive cultivars using artificial neural networks

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Olive fruit classification according to their cultivar is of major importance to guarantee varietal authenticity. Usually, non-supervised or supervised statistical tools (such as Principal Component Analysis or Linear Discriminant Analysis, respectively) are used for this purpose, based on several physico-chemical data, namely table olive fatty acids profiles, dietary fiber, sugar, organic acids and mineral nutrient contents. In this work, quantitative morphological parameters of fruit and endocarp were evaluated. Seventy samples, containing each one around 40 olives, of the six most representative olive cultivars of Portuguese northeast region (Cobrançosa, Cordovil, Madural, Negrinha de Freixo, Santulhana and Verdeal Transmontana) were selected. The samples were collected in different groves and during four crop years. The biometrical data was used together with a Multilayer Perceptron Artificial Neural Network allowing the implementation and validation of a classification model. Its performance was compared with that obtained using a linear discriminant analysis. The best results were obtained using artificial neural networks, especially for the external validation procedure implemented. The satisfactory results achieved, even when compared with previous published works, regarding olive cultivar's classification, show that the neural networks could be used by olive oil producers as a preventive and effective tool for avoiding adulterations of Protected Designation of Origin or monovarietal olive oils with olives of non-allowed cultivars.

Keywords: *Olea europaea* L., Artificial Neural Networks, Linear Discriminant Analysis, authenticity, cultivars, Protected Designation of Origin

Classification of olive cultivars using Artificial Neural Networks

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Introduction and Objectives

Olive fruit classification according to their cultivar is of major importance to guarantee varietal authenticity. Supervised statistical tools (e.g. Linear Discriminant Analysis - LDA) are used for this purpose, based on several physic-chemical data, namely table olive fatty acids profiles, dietary fiber, sugar, organic acids and mineral nutrient contents.

In this work, quantitative morphological parameters of fruit and endocarp were used to create classification models based on LDA or Multilayer Perception Artificial Neural Networks (MLP-ANN) approaches. The results showed that MLP-ANN, based on biometrical data, allowed a better olive cultivar classification, especially for the external validation samples.

Material and Methods

During 4 crop seasons, 70 samples of the most representative olive cultivars (Cobrançosa, Cordovil, Madural, Negrinha de Freixo, Santulhana and Verdeal Transmontana) from Trás-os-Montes region (Northeast of Portugal), containing around 40 fruits (total 2787 olives) per sample, were collected.

Olive fruits and respective endocarps were characterized by 5 quantitative variables corresponding to the morphological data (length, maximum and minimum diameter, weight and shape – length divided by maximum diameter).

Two multivariate techniques were used to obtain predictive mathematical models of olive varietal classification using morphological parameters of olive fruit and endocarp: linear discriminant analysis (LDA) and artificial neural networks (ANN).

Results and Discussion

Table 1 – Quantitative data (mean ± sd) for olive fruits and endocarps of different cultivars.

	Length (mm)	D_{max} (mm)	D_{min} (mm)	Weight (g)	Shape
Endocarps					
Cobrançosa	15.90 ± 1.38	8.12 ± 0.58	5.59 ± 1.70	0.62 ± 0.12	1.96 ± 0.15
Cordovil	16.08 ± 1.64	7.59 ± 0.69	3.99 ± 1.00	0.54 ± 0.15	2.12 ± 0.17
Madural	15.98 ± 1.47	7.79 ± 0.68	6.41 ± 0.98	0.60 ± 0.13	2.06 ± 0.17
Negrinha de Freixo	14.04 ± 1.69	8.01 ± 0.54	4.60 ± 0.86	0.51 ± 0.10	1.75 ± 0.18
Santulhana	18.39 ± 1.86	9.23 ± 0.66	3.95 ± 1.05	0.84 ± 0.16	2.00 ± 0.17
Verdeal Transmontana	16.00 ± 1.92	8.24 ± 0.72	7.30 ± 0.83	0.70 ± 0.14	1.94 ± 0.20
Fruits					
Cobrançosa	20.23 ± 1.78	14.15 ± 1.35	10.64 ± 2.94	2.49 ± 0.73	1.43 ± 0.08
Cordovil	20.96 ± 2.00	14.84 ± 1.30	9.61 ± 1.24	2.65 ± 0.08	1.41 ± 0.08
Madural	21.43 ± 2.34	15.50 ± 1.99	11.95 ± 1.87	3.14 ± 1.13	1.39 ± 0.08
Negrinha de Freixo	20.59 ± 2.09	17.11 ± 1.74	10.15 ± 1.45	3.50 ± 0.85	1.21 ± 0.10
Santulhana	24.10 ± 2.48	17.17 ± 1.83	8.88 ± 1.79	4.31 ± 1.04	1.41 ± 0.11
Verdeal Transmontana	21.51 ± 2.16	15.49 ± 1.60	12.76 ± 1.56	3.12 ± 0.82	1.39 ± 0.12

Legend: D_{max} - maximum diameter, D_{min} – minimum diameter

External validation results using data from olive samples not included in the models development

Global Sensibility and specificity around **70%** (from 45 and 97% for each cultivar - Table 2).

Linear Discriminant Analysis
vs.
Artificial Neural Networks

Global sensibility and specificity around **75%** (from 58 and 95% for each cultivar - Table 2).

Even considering the high variability of the experimental data (olives collected from different trees, in different groves, during different crop years) for the 6 cultivars:

- LDA was not a suitable classification tool
- ANN allowed differentiating the six olive cultivars

Table 2 – Sensitivities for the external validation dataset

Olive cultivar	LDA	ANN
Cobrançosa	73%	63%
Cordovil	75%	75%
Madural	55%	89%
Negrinha de Freixo	97%	95%
Santulhana	54%	69%
Verdeal Transmontana	45%	68%

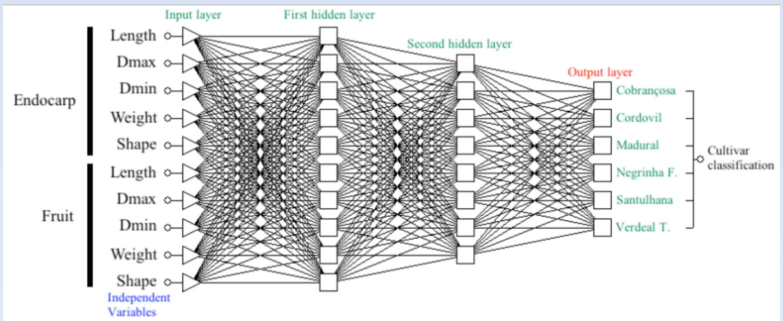

Figure 1 – Best Neural network with four layers obtained by using the biometrical data from the fruits and endocarps of the six most representative olive cultivars from Trás-os-Montes region.

The satisfactory results achieved regarding olive cultivar's classification, showed that the neural networks could be used by olive oil producers as a preventive and effective tool for avoiding adulterations of Protected Designation of Origin or monovarietal olive oils with olives of non-allowed cultivars.