

# Chemical Characterization of ‘Arauco’ Olives (*Olea europaea* L.) Cultivated in Its Region of Origin La Rioja, Argentina

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## Summary

The objective of this study was to characterize the ‘Arauco’ variety and identify distinctive parameters to differentiate the variety, native to the province of La Rioja (Argentina). For this study, olive samples were collected from three different regions of La Rioja (Argentina), and the main nutrients were quantified by standard analytical methods. It was observed that the amount of carbohydrates varied between 7.6 and 10.5 g 100g of fresh matter (FM). Protein levels ranged from 1.4 to 1.9 g 100 g of FM, and ash levels ranged from 1.4 to 2.4 g 100 g of FM. The amount of total fat ranged between 9.7 and 15.5 g, dietary fiber between 1.4 and 5.3 g, and caloric value between 134 and 180 Kcal 100 g of FM. In addition, high concentrations of vitamin A (105.5 - 421.5 IU kg<sup>-1</sup>), vitamin E (63.2 - 92.5 mg kg<sup>-1</sup> of FM) and vitamin C (1.7 - 2.5 mg 100 g of FM), and polyphenols (911.7- 1756.2 mg kg<sup>-1</sup> of FM) were detected. From the analysis of the results, it is possible to suggest that the content of Vitamins A and E, polyphenols, dietary fiber and calories are distinctive variables in the characterization of ‘Arauco’ olives, grown in its region of origin La Rioja (Argentina).

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## Key words

‘Arauco’ cultivar, olive, nutritional profile, phytochemicals

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Received: July 31, 2024 | Accepted: December 16, 2024 | Online first version published: February 14, 2025

## Introduction

The olive tree (*Olea europaea* L.), is one of the most prevalent and extensively cultivated fruit trees in different countries of the world with moderate climatic conditions to produce mainly edible oil. La Rioja is one of the olive producing provinces, where there are many of these varieties (Guzzonato et al., 2024). However, 'Arauco' is relevant because it is the only variety of Argentine origin recognized in the "World Catalogue of Olive Varieties" of the International Olive Council, and it is very likely that it is the result of a genetic variant or cross of other varieties originating in southern Spain (Banco et al., 2021b). In the province of La Rioja (Argentina), cv. 'Arauco' is adapted to local agronomic conditions and is generally present in old plantations with low density and manual harvesting. This variety is traditionally used to produce table olives; its fruit is characterized by being firm, fleshy and with a high oil content. However, recent studies have reported a high quality of its oil, associated with the profile of fatty acids and bioactive compounds (Bodoira et al., 2016). 'Arauco' is considered a late harvesting cultivar; consequently, fruits can be damaged at low temperatures (e.g. -0.4 °C), requiring earlier harvesting to obtain high quality oil because diseases easily affect fruits damaged by frost, they lose water and the oils obtained have low oxidative stability and altered organoleptic properties. Consequently, it is necessary to know the characteristics of the fruit harvested in its province of origin, La Rioja (Argentina), to increase its yield and the quality of the products obtained from it, such as table olives and oil (Conte et al., 2020). With the purpose of valuing a local genetic resource, with potential for expansion to new plantations in different geographic regions of the world (Bodoira et al., 2016; Rocha et al., 2020), the objective of this preliminary study is to analyse and compare the chemical-nutritional profile of 'Arauco' olive obtained in three different geographical regions of La Rioja, Argentina. These analyses are part of a preliminary study to characterize the 'Arauco' variety. In this first stage the aim is to identify particular parameters to differentiate the variety in its place of origin, and compare the results obtained in different producing areas of the province.

## Methodology

Ethanol 95% (Purocol, Almirante Brown, Argentina), dichloromethane (CH<sub>2</sub>Cl<sub>2</sub>), methanol (MeOH) and N-hexane (Cicarrelli, San Lorenzo, Argentina) analytical grade (Biopack, Buenos Aires, Argentina) were used and reagents were taken from (Sigma Chemical Co.). Some standards were purchased from Fluka (Fluka, Switzerland).

## Fruit Material

Sampling was carried out during the "embero", in the month of April due to the productive cycle of the plant. 'Arauco' samples were obtained from fields located at the departments of Aimogasta ('Arauco') (28°34'10"S 66°47'56"O), Chilecito (29°10'00"S 67°30'00"O), La Rioja-Capital (29°26'00"S 66°51'00"O), all in the Province of La Rioja, Argentina. In the Capital, two zones (denominated as A and B) were sampled, and two different samples were collected in each (numbered as 1-4).

## Sample Conditioning

Three trees with similar crown volume and high fruit load were selected and harvested for sampling. A 3 kg sample was taken from each tree. The material obtained was immediately placed in a dry place protected from light. The percentages of moisture were determined gravimetrically. The vegetal material was subdivided into several fractions for various types of analysis.

## Evaluation of Nutritional Assets of 'Arauco' Olive

For the analysis, the methodology described in the National Institute of Industrial Technology (INTI, Argentina) Reference Procedures was used, with some modifications (SOT-2423(1) / 2423(2); 86-9569 and 23-3612). Contents of ash, fats and total dietary fiber (soluble and insoluble) were determined employing standard methods (IUPAC 1992, AOAC 1990, AOAC 2000).

The nitrogen content was determined by the Kjeldahl method.

The protein content was estimated as the nitrogen content multiplied by 6.25 to give the percentage protein (Ramirez et al., 2022).

The concentration of total sugar was measured by the 3,5-dinitrosalicylic acid method after acid hydrolysis with 1.2 M HCl, at 65 °C for 15 min and neutralization with 1 M NaOH (Maldonado et al., 2008).

The determination of vitamins was done using high performance liquid chromatography (Schuep 1997).

Crude fiber was obtained from loss in weight on ignition of dried residue remaining after digestion of fat free samples with 1.25% each of sulphuric acid and sodium hydroxide solutions. The carbohydrate content was determined by subtracting the total crude protein, crude fiber, ash and crude fat from the FM (Ramirez et al., 2022).

The caloric value estimation was done by summing the multiplied values for crude protein, crude fat and carbohydrate (excluding crude fiber) by their respective water factors. Polyphenols were quantified by high-efficiency liquid chromatography (PerkinElmer, USA), according to scientific literature, with some modifications (Mousavi et al., 2022).

## Statistical Analysis

Chemical determinations were made in triplicate. Descriptive statistics were used to find percentages (%) mean and standard deviation values of quantitative data of samples. Comparison of mean values of measured parameters was performed by a one-way ANOVA (Infostat Software, version 2020) using Tukey test, for the level of significance  $P \leq 0.05$ .

## Results and Discussion

The objective of this preliminary study was to characterize the 'Arauco' olive variety grown in the province of La Rioja and to contrast the results obtained in the different production zones of the province. As shown in Table 1, moisture content was determined in the present work, yielding values were 61.3 and 68.9% (per 100 g of fresh weight of original olive), which coincides with the values reported by other authors (Rocha et

al., 2020, Conte et al., 2020). The carbohydrate content showed similar trends in all the samples studied, although a decrease in the average values was detected, particularly in two of the samples from the Capital area (7.6 to 10.5 g · 100 g<sup>-1</sup> of FM). This data is not relevant since carbohydrates are practically absent in table olives due to their transformation during table olive processing (Rocha et al., 2020). The values obtained for proteins in the present work vary from 1.4 to 1.9 g · 100 g<sup>-1</sup> of FM, respectively (Table 1). These values are in agreement with the amounts reported by other authors ranging from 1.0 to 2.2 g · 100 g<sup>-1</sup> of FM (Conte et al., 2020). It should be noted that the nutritional contribution of olives is not significant; however, the proteins present in olive fruits contain all the essential amino acids, including aspartic and glutamic acids (Boskou et al., 2015, Boskou, 2017). Ash content presented values ranging from 1.4 to 2.4 g · 100 g<sup>-1</sup> of FM (Table 1); there were significant differences between samples from the same geographical region but from different zones (A and B). These significant differences in ash quantification may be the result of the interaction of several factors, such as the cultivation sector and the fruit load of the olive plant (Mousavi et al., 2022). In addition, the energy value of 'Arauco' olives was calculated, obtaining values ranging from 134 to 180 kcal 100 g for FM olive (Table 1), which are in agreement with data from the scientific literature (Rocha et al., 2020). Considering that a basic diet provides 2000 kcal, the food group belonging to oils, fats and oilseeds should provide an energy value of 300 kcal in total, that is, an average of 100 kcal per serving (Fernández Poyatos et al., 2021). It is therefore possible to suggest that the consumption of 'Arauco' olives would provide a caloric intake of good nutritional quality to be incorporated into the human diet. Lipids are known to be the most important macronutrients that provide nutritional value to table olives, as shown in Table 2. Geographical region has a significant effect on the lipid content of 'Arauco' olives (Rocha et al., 2020) obtaining values ranging from 9.7 to 15.5 g · 100 g<sup>-1</sup> of FM for sample values in agreement with the literature previously described (Boskou et al., 2015, Boskou D. 2017). It is known that the sugar content in the olive represents between 3.5 to 6 g · 100 g<sup>-1</sup> of FM, that is, a

small amount compared to other drupes, which in turn decreases during the ripening process of the fruit (Rocha et al., 2020). The values obtained for total sugars in the present work vary from 2.4 to 6.2 g per 100g of FM, respectively (Table 2), these values being in agreement with the literature on the chemical composition of the olive (Conte et al., 2020). It should be noted that the highest concentration was detected in the samples obtained in zone A of La Rioja (Capital) and the lowest in the samples collected in the department of Aimogasta ('Arauco'). In the present study, vitamin A quantification was performed, with yielding values different from those of previous studies (Fernández Poyatos et al., 2021). Values ranging from 105.5 to 421.5 IU · kg<sup>-1</sup> of FM were obtained (Table 2). Similarly, vitamin C and vitamin E were quantified, with values ranging from 1.7 to 2.5 mg 100 g and 92.5 to 42.2 mg · kg<sup>-1</sup> of FM, respectively; these values are in agreement with data from the scientific literature (Conte et al., 2020). However, significant differences in the concentration of vitamins A and E were detected in samples from different regions. The observed differences could be attributed to the different agroclimatic conditions prevailing in each region and, to a lesser extent, to fruit ripening rates (Mousavi et al., 2022). The values obtained for phenolic compounds in the present work ranged between 911.7 and 1756.2 mg kg<sup>-1</sup> of FM respectively, while the highest concentration was detected in the sample from the department of Aimogasta (1756.2 mg · kg<sup>-1</sup>), where the production of olives of this variety is concentrated, as an emblem of regional production (Table 2). In contrast, in samples from the Capital and Chilecito departments, the values ranged between 911.7 and 1429.8 mg · kg<sup>-1</sup> of FM respectively, which is in accordance with the results reported by Mousavi et al. (2022). However, they differ from those reported by Bodoira et al. (2021a, 2021b), who analyzed the concentrations of phenolic compounds throughout the ontogeny of 'Arauco' fruits produced in the province of San Juan (Argentina). This finding may be related to certain factors such as the form of cultivation, agronomic characteristics of the growing region and/or ripening time of the olive tree (Fernández-Poyatos et al., 2021., Jiménez-López et al., 2020.).

**Table 1.** Olive characteristics of the native cultivar 'Arauco', harvested in different regions of La Rioja, Argentina

Sample	Regions					
	La Rioja - Capital				Chilecito	Aimogasta
	Zone A		Zone B		N°5	N°6
	N°1	N°2	N°3	N°4		
Humidity % FM	68.1 ± 2.01	67.1 ± 3.11	66.8 ± 1.94	62.3 ± 0.98	68.9 ± 1.04	61.3 ± 1.08
Crude fiber g·100g <sup>-1</sup> FM	7.1 ± 0.07 <sup>b</sup>	6.4 ± 0.09 <sup>b</sup>	6.1 ± 0.06 <sup>b</sup>	11.4 ± 0.07 <sup>a</sup>	7.8 ± 0.11 <sup>b</sup>	10.2 ± 0.10 <sup>a</sup>
Carbohydrates g·100g <sup>-1</sup> FM	10.5 ± 0.16 <sup>a</sup>	7.6 ± 0.19 <sup>b</sup>	9.2 ± 0.20	8.4 ± 0.21 <sup>b</sup>	10.3 ± 0.23 <sup>a</sup>	10.5 ± 0.26 <sup>a</sup>
Proteins g·100 g <sup>-1</sup> FM	1.8 ± 0.12	1.5 ± 0.15	1.9 ± 0.09	1.8 ± 0.11	1.4 ± 0.15	1.5 ± 0.10
Ashes g·100 g <sup>-1</sup> FM	1.4 ± 0.02	1.9 ± 0.04	1.7 ± 0.02	2.4 ± 0.00 <sup>a</sup>	1.9 ± 0.07	1.8 ± 0.05
Caloric value Kcal·100 g <sup>-1</sup> FM	149 ± 0.45 <sup>c</sup>	176 ± 0.54	173 ± 0.61	164 ± 0.49 <sup>b</sup>	134 ± 0.33 <sup>c</sup>	180 ± 0.46 <sup>a</sup>

Note: Different letters in the same line mean significant difference between samples (mean ± standard deviation), by Tukey test at  $P \leq 0.05$ . N1 - N4 = subzones. FM = Fresh Matter.

**Table 2.** Olive characteristics of the native cultivar 'Arauco', harvested in different regions of La Rioja, Argentina

Sample	Regions					
	La Rioja - Capital				Chilecito	Aimogasta
	Zone A		Zone B			
	N°1	N°2	N°3	N°4	N°5	N°6
Total Fiber g·100 g <sup>-1</sup> FM	11.1 ± 0.08 <sup>b</sup>	15.5 ± 0.07 <sup>a</sup>	14.3 ± 0.09	13.7 ± 0.06	9.7 ± 0.10 <sup>c</sup>	14.7 ± 0.12
Total Sugar g·100 g <sup>-1</sup>	3.6 ± 0.04	6.2 ± 0.09 <sup>a</sup>	3.4 ± 0.06 <sup>b</sup>	4.2 ± 0.08	3.2 ± 0.08 <sup>b</sup>	2.4 ± 0.06 <sup>c</sup>
Vitamin A UI·kg <sup>-1</sup> FM	421.5 ± 0.02 <sup>a</sup>	105.5 ± 0.03 <sup>c</sup>	336.1 ± 0.01 <sup>b</sup>	345.7 ± 0.02 <sup>b</sup>	205 ± 0.01	412.4 ± 0.02 <sup>a</sup>
Vitamin C mg·100 g <sup>-1</sup> FM	2.0 ± 0.01	2.0 ± 0.03	2.5 ± 0.02 <sup>a</sup>	1.7 ± 0.01	1.8 ± 0.04	2.1 ± 0.02
Vitamin E mg·kg <sup>-1</sup> FM	92.5 ± 0.03 <sup>a</sup>	74.1 ± 0.02 <sup>b</sup>	76.2 ± 0.02 <sup>b</sup>	63.2 ± 0.01 <sup>c</sup>	42.2 ± 0.03 <sup>c</sup>	43.6 ± 0.03 <sup>c</sup>
Total Phenolic mg·kg <sup>-1</sup> FM	1112.2 ± 0.57 <sup>c</sup>	911.7 ± 0.31 <sup>c</sup>	1100.1 ± 0.68 <sup>c</sup>	1429.8 ± 0.58 <sup>b</sup>	1149.9 ± 0.68 <sup>c</sup>	1756.2 ± 0.47 <sup>a</sup>
Dietary Fiber g·100 g <sup>-1</sup> FM	3.1 ± 0.04 <sup>b</sup>	1.4 ± 0.02 <sup>c</sup>	2.9 ± 0.02 <sup>b</sup>	5.3 ± 0.01 <sup>a</sup>	4.8 ± 0.04	3.6 ± 0.03

Note: Different letters in the same line mean significant difference between samples (mean ± standard deviation), by Tukey test at  $P \leq 0.05$ . N1 – N4 = subzones. FM = Fresh Matter.

As shown in Tables 1 and 2, both crude fiber and dietary fiber were quantified in this study, and yielding values coincided with most of the published works cited above (1.5 g 100 g e.p. to 3 g·100 g<sup>-1</sup>). The values obtained for crude fiber ranged from 6.1 to 11.4 g·100 g<sup>-1</sup> of FM, while the amount of dietary fiber ranged from 1.4 to 5.3 g·100 g<sup>-1</sup> of FM respectively. As shown in Tables 1 and 2, in the present work there are significant differences in the content of both types of fibers in the olive samples from the department of La Rioja-Capital but from different zones (A and B). These significant differences may be due to the agronomic characteristics of the areas where the olives were harvested. However, it is necessary to analyze other regions and a larger number of samples to draw definitive conclusions.

## Conclusion

In this paper the objective was to analyze the olive of the 'Arauco' cultivar, olive oil heritage of the province of La Rioja, through the study of its main components. The six samples studied showed a similar chemical profile but quantitatively different in terms of vitamins A and E, dietary fiber, polyphenols and caloric value, although information obtained on possible differentiating variables has to be taken into account in the characterization of the 'Arauco' variety produced in the province of La Rioja (Argentina). It is possible to suggest that the chemical characteristics of the fruit of this cultivar may vary considerably according to the region in which it is grown, especially because the agroecological conditions are optimal in the piedmont areas of the plains and valleys of 'Arauco' (Aimogasta) and present the best climatic conditions in La Rioja for a good development of the olive tree due to the mild summer.

## Acknowledgements

The authors are grateful to INTI and CONICET.

## CRedit Authorship Contribution Statement

**Federico Nowakowski and María Rosana Ramirez:** Conceived the project and supervised the work, conceptualization, investigation, performed most of the experiments, analyzed the data and drafted the manuscript. **Agostina Lorena Guzzonato:** Performed some of the experiments. **Agostina Lorena Guzzonato and María Rosana Ramirez:** Contributed to the editing of the manuscript.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## References

- Ahmad N., Anwar F., Zuo Y., Aslam F., Shahid M., Abbas A., Farhat L.B., Al-Mijalli S.H., Iqbal M. (2022). Wild Olive Fruits: Phenolics Profiling, Antioxidants, Antimicrobial, Thrombolytic and Haemolytic Activities. *Arab J Chem* 15: 12. doi: 10.1016/j.arabjc.2022.104241.
- AOAC (2000). Official Methods of Analysis, 17th ed. Gaithersburg, MD, USA: Association of Official Analytical Chemists.
- AOAC (1990). Official Methods for Analysis. 15 ed. (Section 967.22; 984,26:1059-1061).
- Banco A. P., Puerta C. M., Tentracoste E., R., Monasterio R. P. (2021). Oil Quality Characterization of the 'Arauco' Variety from the Main Olive Growing Areas of Mendoza (Argentina). *Grasas y Aceites* 72 (4): e429. doi: 10.3989/gya.0773201

- Banco A. P., Puertas M. C., Lucero V. A., González M. C., Trentacoste E. R. (2021). Fruit Characteristics and a Simple Estimate of Oil Content in Twenty-Six Olive Genotypes in Argentina. *J Agr Sci Technol* 23 (3): 617-629.
- Bodoira R., Torres M., Pierantozzi P., Aguade F., Taticchi A., Servili M. et al. (2016). Dynamics of Fatty Acids, Tocopherols and Phenolic Compounds Biogenesis during Olive (*Olea europaea* L.) Fruit Ontogeny. *J Am Oil Chem Soc* 93: 1289-1299. doi: 10.1007/s11746-016-2877-7
- Boskou D., Camposeo S., Clodoveo M.L. (2015). 8-Table Olives as Sources of Bioactive Compounds. In *Olive and Olive Oil Bioactive*. (Boskou D Ed.). Italy pp. 217-259. doi: 10.1016/B978-1-63067-041-2.50014-8.
- Boskou D. (2017). Table Olives: A Vehicle for the Delivery of Bioactive Compounds. *J Exp Food Chem* 3:1-7. doi: 10.4172/2472-0542.1000123
- Conte P. Fadda C., Del Caro A., Urgeghe P., Piga A. (2020). Table Olives: An Overview on Effects of Processing on Nutritional and Sensory Quality. *Foods* 9: 514. doi: 10.3390/foods9040514
- Fernández-Poyatos M. P., Llorent-Martínez E. J., Ruiz-Medina A. (2021). Effect of Ripening on the Phenolic Composition and Mineral Content of Three Varieties of Olive Fruits. *Foods* 10: 380. doi: 10.3390/foods10020380
- Ghanbari R., Anwar F., Alkharfy K. M., Gilani A.H., Saari N. (2012). Valuable Nutrients and Functional Bioactives in Different Parts of Olive (*Olea europaea* L.) A Review. *Int J Mol Sci* 13: 3291-3340. doi: 10.3390/ijms13033291
- IUPAC (1992). *Standard Methods for the Analysis of Oils, Fats and Derivates*. 7th Ed., Paquot C. and Hautfenne A. (Eds.), International Union of Pure and Applied Chemistry, Blackwell Scientific Publications Inc., Oxford.
- Jimenez-Lopez C., Carpena M., Lourenço-Lopes C., Gallardo-Gomez M., Lorenzo J. M., Barba F. J., Prieto M. A., Simal-Gandara J. (2020). Bioactive Compounds and Quality of Extra Virgin Olive Oil. *Foods* 9 (8):1014. doi: 10.3390/foods9081014
- Maldonado M. B., Zuritz, C. A., Miras N. (2008). Influence of Brine Concentration on Sugar and Sodium Chloride Diffusion during the Processing of the Green Olive Variety 'Arauco'. *Grasas y Aceites* 59 (3): 265-271.
- Mousavi S., Stanzione V., Mariotti R., Mastio V., Azariadis A. Passeri V., Valeri M. C., Baldoni L., Bufacchi M. (2022). Bioactive Compound Profiling of Olive Fruit: The Contribution of Genotype. *Antioxidants* (Basel) 11 (4): 672. doi: 10.3390/antiox11040672
- Guzzonato A. L., Nowakowski F., Ramirez M. R. (2024). Phenolic Compounds and Fatty Acid Content of Some Extra Virgin Olive Oils from North-West of Argentina (La Rioja). *Agric Conspec Sci* 89 (2): 159-163.
- Oğraş Ş. Ş. (2022). Comparative Study of Phenolic Compounds in Olive Oils from Different Geographic Regions. *Turkish Journal of Agriculture and Forestry* 46 (3): 5. doi: 10.55730/1300-011X.3005
- Ramirez M. R., Mohamad L., Alarcon-Segovia L. C., Rintoul I. (2022). Effect of Processing on the Nutritional Quality of *Ilex paraguariensis*. *Appl Sci* 12: 2487. doi: 10.3390/app12052487
- Rocha J., Borges N., Pinho O. (2020). Table Olives and Health: A Review. *J Nutri Sci* 9: 1-16. doi: 10.1017/jns.2020.50
- Schüep W. (1997). *Producción y manejo de datos de composición química de alimentos en nutrición*, Ed. C Morón, I Zacarias, S de Pablo, Capitulo 17, Santiago, Chile; Available at: <https://www.fao.org/3/ah833s/AH833S19.htm> [Accessed 19 May, 2024]