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Olive Oil in Brazil: Economic and Regulatory Control Aspects

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Abstract

The oil extracted from olives has characteristics that set it apart from other vegetable oils. Its exceptional sensory and nutritional attributes and its limited production are among the aspects that give it high market value. However, oils of different grades and quality are obtained from the fruit of the olive tree. Thus, producers are interested in improving and disseminating product quality control techniques. Brazil's domestic demand is met by imported olive oils, with Brazil being one of the world's main importers. Recently, the expansions of the market and the commercial production outlook have intensified the work of the Brazilian government in improving the legal requirements to control this product and enable laboratories to monitor quality. Despite government initiatives, the trade of this oil in Brazil has always been, and continues to be, marked by evidence of fraud and adulteration. The present work aims to provide an overview of the economic, regulatory, and inspection aspects involving the olive oil in Brazil, emphasizing the initiatives to improve the control of this important product.

Keywords: Olive oil, Monitoring, Adolfo Lutz Institute, Adulteration, Legislation

1. Introduction

The culture of the olive tree and the production of olive oil are the oldest agricultural activities in human history. Mediterranean countries such as Spain, Italy, and Greece are the main producers of this oil. The knowledge of this culture and its by-products, although ancient, has only recently become more widespread in Brazil. Oils of different grades and quality are obtained from the fruit of the olive tree. The Brazilian domestic demand for olive oil is met by imported oil, with Brazil being one of the world's big importers. This study aims to provide an overview of economic, regulatory, and inspection aspects involving the olive oil in Brazil.

The topics studied deal with legal limitations and practices in Brazil, control and inspection aspects, and the contribution over many years of the Adolfo Lutz Institute as a public health laboratory, monitoring the quality of commercial olive oil in São Paulo city.

2. Economic aspects

2.1. Diffusion of olive trees and olive oil (Brazil and abroad)

Olive cultivation certainly began prior to the sixteenth century BC. This culture spread to the Greek islands through the Phoenicians and was probably brought from Asia Minor and introduced into Greece, Libya, and Carthage.

Later, in the eighth and seventh centuries BC, olive cultivation expanded, and methods for the production and distribution of oil were organized. The climatic conditions of the Mediterranean countries were very favorable to the cultivation of the olive tree, and this culture spread quickly to all the countries of the Mediterranean Sea Basin in what is now a feature of the region [1].

The Phoenicians and Carthaginians were counted as deployers of olives in Spain, and this culture expanded to Portugal, the West Indies, and South America [2, 3]. The cultivation of the olive tree was extended to regions of the American continent where climate conditions are similar to those of the Mediterranean region [1, 3].

In North America, olive growing was brought by Spanish missionaries and deployed initially in California. In South America, this culture was introduced by Mediterranean immigrants, spreading to Argentina, Chile, Peru, Brazil, and other countries [1–3].

Olive tree cultivation was introduced in Brazil many centuries ago. Olive trees were found in several Brazilian states, such as Rio Grande do Sul, Parana, Santa Catarina, Minas Gerais, Espirito Santo, Rio de Janeiro, and São Paulo [2, 3]. The olive groves of the colonial period (sixteenth to nineteenth centuries) were eliminated by order of the King of Portugal who feared competition from Brazilian production [3]. Until recently, the olive tree cultivation and olive oil production were practically nonexistent in Brazil. Some initiatives were taken in the last decade to encourage the production of olive oil in Brazil, but currently, domestic demand is almost met by imported oil, especially from Spain and Portugal (about 90 % of total importation) and Argentina [4–6].

2.2. Current import and export scenario

The production of olive oil is focused on Mediterranean climate countries, which produce around 3.0 million tons of oil per year [7]. The three main olive-producing countries are Spain, Italy, and Greece. In the South American continent, the main production is from Argentina and Chile, both of which produce around 0.7 % of global production [7]. These countries are emerging as promising competitors in this market.

The Brazilian domestic demand is met by imported oils, with Brazil being one of the world's leading importers [7, 8]. Brazilian imports of olive oil are about 73,000 tons [7], and the state of São Paulo is responsible for more than 50 % of the imported volume [6]. The culinary habits of the Brazilian people, especially from the state of São Paulo, had a great influence on the colonizers (from Portugal) and the Italian and Spanish immigrants, and thus the use of olive oil in cooking is greatly appreciated. In the last decade, there was a significant increase in olive oil importation in Brazil (500 %) [8]. The following factors contributed for importation increase: the entry of more affordable products in the domestic market, the increase of the purchasing power of Brazilian social classes, and more information about the health benefits of olive oil in the diet [4]. Brazil is the world's third largest importer of oil, after the United States and the European Union, but the consumption per capita in Brazil is about 0.3 kg/habitant/year. This is very low when compared with countries such as Spain and Italy, where consumption is about 20 kg/habitant/year [7].

3. Regulatory aspects

3.1. Olive oil categories

Oils of different grades and quality are obtained from the fruit of the olive tree [8]. The olive oil of the best quality is known as "extra-virgin" and is obtained from the first cold pressing, from healthy and fresh fruit. Other olive oil flavors and good taste quality, but with more acidity values, are classified as virgin olive oil. Lower quality categories include refined olive oil and olive oil, i.e., a mixture of virgin and refined olive oil. Lampante virgin olive oil is unfit for human consumption as it presents an undesirable flavor and aroma originating from poor-quality olives. Olive pomace oil (*orujo* or *pomace oil*) is obtained by solvent extraction of the olive-processing residue. Both lampante and olive pomace oil should be refined to become fit for human consumption.

The categories of olive and olive pomace oils are differentiated according to the raw material, the process of obtaining the oil, and other technological procedures applied. Defining each type of oil is a difficult task and often requires the implementation of a wide variety of analytical tests. Differentiating between types was studied and standards established with limits for different identities and quality parameters [9, 10].

The *Codex Alimentarius* presents a standard for olive oil and olive pomace with minimum levels of product purity and quality criteria for each category [11, 12]. Also, hygiene standards are established, along with packaging and labeling, as well as the application of recommendations of certain analytical methods [11].

In addition, olive oil is the only product in the oil and fat sector that has its own international trade agreement. The International Olive Council (IOC) is the intergovernmental organization responsible for the administration of this agreement. Purity criteria stipulated in the IOC trade standard for olive oil and olive pomace oil are constantly being discussed and are heeded, in most cases, in the review of Codex standards for products intended for human consumption [12].

3.2. Identity and quality parameters

The physical and chemical properties of oils and fats, which define the identity of the oil, are mainly related to the predominant molecular structures. A wide range of fatty acids (FA) constitute triglycerides (TAG). The desmethylsterols, which is in the minority fraction of the oil (unsaponifiable), also exhibit profiles themselves for each oil and are an excellent parameter for identifying vegetable oil [9, 10, 13]. The classical indices such as iodine, refraction, and saponification are related to the fatty acid composition ranges and exhibit characteristics for each different oil [9, 10].

The analytical determinations that differentiate olive oil quality categories and olive pomace oil are based on the identification or dosage of chemicals, which may characterize the process of maturation of the olives; extraction, storage, and deterioration of the oil; or other technological processes to which the oil was subjected. Parameters such as acidity index, peroxide value, specific extinction (232 and 270 nm), and impurities (insoluble matter, unsaponifiable matter, moisture) are evaluated to monitor the quality of olive oil. The contents of trans-fatty acids, stigmastadienes, wax, and alkyl esters (fatty acid methyl ester and ethyl ester) are also indicatives of olive oil quality [9, 10].

4. Legislation, control, and inspection in Brazil

Currently, control and inspection of the oil obtained from olives, sold in Brazil, include actions both from the Brazilian Health Ministry (MS) and the Brazilian Agriculture and Livestock Ministry (MAPA). The actions are supported by compatible and complementary laws.

By the late 1990s, before the creation of the Brazilian National Health Surveillance System and the National Health Surveillance Agency (ANVISA), the purity and quality standards of oils and fats were established under the MS. From the creation of the vegetable classification law of MAPA [14], it has the legal obligation to inspect and supervise the entire production chain, besides performing supervision techniques to ensure compliance with the requirements of official classification standards. In light of this legal requirement, the official standard classification of olive oil and olive pomace oil was elaborated. The preparation of the official standard for olive oil and olive pomace oil had the participation of researchers and technicians from the Brazilian MS and MAPA, universities, representatives of the productive sector, and consumer protection organizations. This joint work culminated in the publication of Normative Instruction no. 1, on 30/01/2012 [15]. This is the Brazilian Technical Regulation of Olive Oil and Pomace Olive Oil with the tolerance limits for various parameters of purity and quality. This document is based on trade standards of IOC and *Codex Alimentarius* standards. The official classification standard of the olive oil and olive pomace oil sold in Brazil was also established. **Tables 1–5** (Appendix) present the classification (group and type), quality requirements, sensory characteristics, and other complementary parameters of olive oil and olive pomace oil [15].

Currently, the MAPA challenge is the establishment of a collaborative network for analyzing oil coming into the country. On the other hand, under the Brazilian Health Ministry, the actions

of sanitary supervision together with the public health network laboratory are already a well-established practice. Resolution 270/05 of the National Health Surveillance Agency (ANVISA) [16] is a technical sanitary regulation for vegetable oils, which must be met in health inspections. It came into effect before the Normative Instruction No. 1 of MAPA and emphasizes the health risk aspect. Currently, the Normative Instruction No. 1 of the MAPA as the resolution 270/05 must be met in enforcement actions in Brazil.

Considering the limits of some parameters, such as alpha-linolenic acid (18:3 n3) and campesterol, adopted in the standards for olive oil and pomace oil, some observations must be made. Several studies have demonstrated that limitations established in IOC standards on the alpha-linolenic acid (18:3 n3) and campesterol contents are restrictive and do not reflect the variability among cultivars grown in other areas outside the Mediterranean region [13]. Mailer [17] published a study showing that Australian olive oil can present the range for alpha-linolenic acid from 0.42 to 1.91 %. For this component, oils exceeded the maximum linolenic acid level of 1.0 % recommended by the IOC. In current revision of *Codex Alimentarius* standard of olive oil and olive pomace oil, the limit for alpha-linolenic acid (18:3 n3) was not established due the aspects discussed above [11].

Campesterol content is a valuable tool to detect adulteration with commodity oil. The concentration of this desmethylsterol in many commodity oils, such as sunflower or soybean oils, is higher than in olive oil [18]. The IOC trade standard includes a decision tree for evaluating the authenticity of samples which show campesterol concentrations between 4.0 and 4.5% of total sterols. This includes the following conditions to consider the authenticity of an olive oil: stigmasterol contents ≤ 1.4 % and delta-7 stigmastanol < 0.3 % [12].

Brazilian law adopted the limits of the IOC trade standard of 1 % for alpha-linolenic acid content (18:3 n3) and ≤ 4.0 % for campesterol to prevent practices of adulteration with, for example, soybean oil, which is a commodity with low commercial value in Brazil [15].

Some discrepancies may be noted for some parameters in Brazilian olive oil and olive pomace standard (**Tables 1–5 - Appendix**), in comparison with IOC provisions [12]. For example, the limit of stigmastadiene content in virgin and extra-virgin olive oil is 0.15 (mg/kg) established in Brazil. In current IOC standard, it is different and more restrict, i.e., in extra-virgin olive oil and virgin olive oil, the contents must be less than 0.05 and in ordinary virgin olive oil less than 0.10 [12, 15]. These differences will likely be resolved in the future with the improvement of the Brazilian technical regulation for olive oil and olive pomace oil.

4.1. Monitoring of commercial olive oil at the Adolfo Lutz Institute

The Adolfo Lutz Institute was founded in 1940 and has operated since its foundation as a research government institute and also as a public health laboratory in the state of São Paulo. It is part of the Brazilian Public Health Laboratory Network, working in epidemiological surveillance in the study and diagnosis of diseases such as dengue, Zika, AIDS, hepatitis, and meningitis, among others. The laboratory also gives support to health surveillance, monitoring the quality of food samples including commercial olive oils.

Olive oil, among the food products analyzed at the Adolfo Lutz Institute, is one most frequently subjected to allegations of fraud and adulteration. According to the rules of the Brazilian Ministry of Agriculture and Livestock, the olive oil to be marketed in the country, either in bulk or bottled in the country of origin, must obtain a classification document [15]. The inspection for correct classification is done by MAPA inspectors. The inspection in retail is performed by inspectors either from the Brazilian Health Ministry or the Brazilian Ministry of Agriculture and Livestock to verify the adequacy of identity and quality. According to Brazilian Federal Law 986/69 [19] and Resolution No. 22 of 03/15/00, ANVISA [20], the producer or importer of olive oil is obliged to inform the municipal health surveillance at the beginning of importation or marketing and arrange the collection of the sample for analysis. The analyses are carried out in official laboratories. The Adolfo Lutz Institute is the health laboratory of the state of São Paulo. Companies that manufacture, sell, offer for sale, or otherwise deliver to the consumer corrupted, adulterated, counterfeit, altered, or damaged food will incur in a sanitary infraction subject to the penalties of the law [19].

The exceptional sensory and nutritional attributes of olive oil and its limited production are among the aspects that give it high market value. Olive oil trade in Brazil has always been, and continues to be, marked by evidence of fraud and adulteration. So it has long been of interest to researchers of the Adolfo Lutz Institute to increase the scientific knowledge of this product to improve quality control.

Some studies were published in the 1970s and 1980s either by researchers of the Adolfo Lutz Institute, universities, or other scientific institutions [21–23]. These studies indicated frauds in olive oil, by adding commodity oils such as soybean, coconut, and babassu. The classic index and the fatty acid profile detected the adulteration. At this time the gas chromatographic technique to analyze fatty acid methyl esters began to be implemented in institutions. However, only in the early 1990s, at the Adolfo Lutz Institute, a more comprehensive study was developed focusing in detail on the different categories, the characteristics of identity and quality of olive oil, and the wide range of analytical tests designed to differentiate them. The physical-chemical, analytical, and regulatory aspects were addressed to differentiate the various types of oils from olives. A special emphasis was given to spectrophotometric techniques and derivation of the ultraviolet spectra obtained from vegetable oils [9].

At the beginning of the 1980s, the Brazilian trade market was opened with the Mercosur countries (Southern Cone Market), which intensified the import of Argentinian olive oil to the local market. A study carried out at the end of the 1990s, in the Adolfo Lutz Institute laboratories, evaluated the quality and identity of 23 oil brands in the trade of São Paulo, 13 from Europe and bottled in the country of origin, and 10 Argentine oils, with 5 bottled in Brazil. Five samples were adulterated with other vegetable oils, and two of them (bottled in Brazil) were probably adulterated with partially hydrogenated oil. This finding illustrated the importance of the details of the composition of fatty acids of vegetable oil, taking the geometric isomers into consideration, to help detect an uncommon type of adulteration [24].

In the period 2001–2014, the proportion of frauds or adulterations verified in samples declared as olive oil and analyzed at the Adolfo Lutz Institute was higher than in the period before (**Figure 1**). An improvement in controlling analysis in Adolfo Lutz Institute, with the implementation of new analytical methodologies, was observed in this period. A study published in 2008 with 15 samples showed that although the samples presented the fatty acid profile of authentic olive oil, the analysis of the difference of ECN 42 showed adulteration of samples with edible commodity vegetable oils. The oils were added in low quantity (less than 3 %) and were rich in linoleic acid (18:2 9,12 *cc*), such as soybean, maize, or sunflower oil [25]. In addition, in another study more elaborate fraud was evidenced, i.e., the replacement of virgin olive oil by probably pomace oil. The evidence was generated by a combination of the analysis of trans-fatty acids, stigmatadiene content, specific extinction at 270 nm, and the difference of ECN 42 [26].

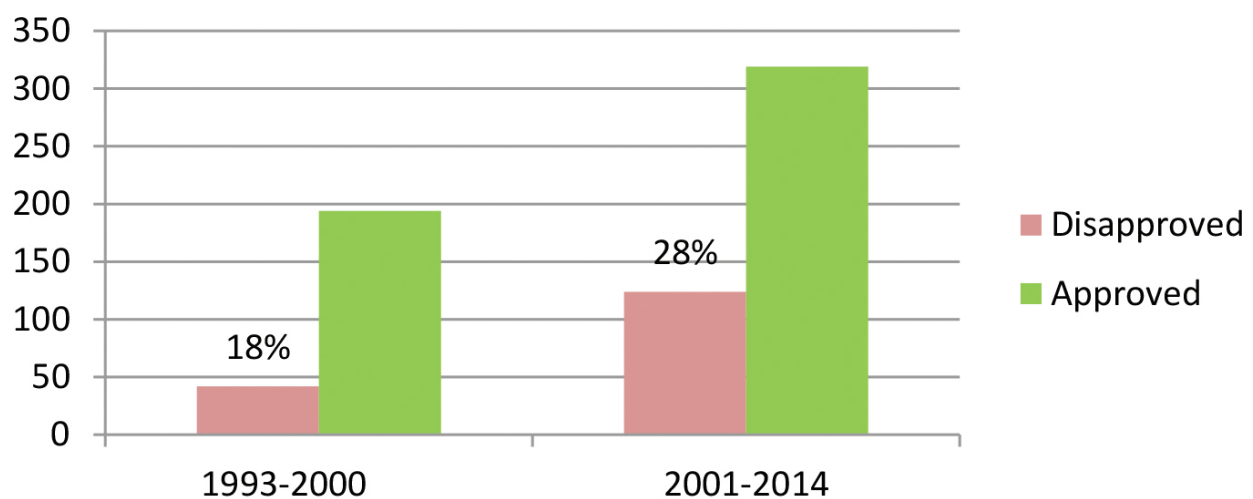


Figure 1. Commercial olive oil samples analyzed at Adolfo Lutz Institute.

The latest study of monitoring carried out at the Adolfo Lutz Institute took place between the years 2012 and 2014. Fifty-four samples of 14 different brands were analyzed. Twenty-five samples were sent by sanitary surveillance of the state of São Paulo, to attend a program of the National Health Surveillance Agency (ANVISA). Of the total, 38 were declared as extra-virgin olive oil and the others as olive oil. The parameters studied were composition of fatty acids, acid value, peroxide index, and specific extinction at 270 nm. The adequacy of nutrition labeling was also verified. Since 2003, Brazil has adopted mandatory nutrition information on the label of packaged foods as a strategy to prevent chronic disease [27]. Nutrients required on the label of edible vegetable oils are total fat, saturated and trans-fatty acids, but the producers have also declared monounsaturated and polyunsaturated fatty acids. Twenty-eight samples (52 %) of 11 brands showed no characteristic olive oil profile of fatty acids. Twenty-four samples that were adulterated probably with soybean oil were declared as extra-virgin olive oil. Thirty-one samples (57 %) had monounsaturated fatty acid and/or polyunsaturated fatty acid contents varying by more than 20 % from the declaration on the label. All the adulterated samples were bottled in Brazil, highlighting the need for tighter control in the trade

and distribution of the product with a view to a more secure product which is increasingly consumed by the population

5. Technical support of the International Olive Council for analytical improvement

In 2000, during a technical visit by IOC representatives to Brazil and, in particular, to the Adolfo Lutz Institute, a technical cooperation agreement was made that enabled the inclusion of the laboratory in the annual proficiency-testing scheme organized by the IOC. Since 2002, the institute has received annually samples of the rounds for vegetable oils, which include several determinations that help in ensuring the analytical quality of various tests performed by the laboratory. During this period it was possible to implement some methods in the laboratory such as stigmatadiene content and the difference of ECN 42. In addition, it was possible to monitor the quality of the results generated in these trials and routine testing such as the composition of fatty acids, including trans-fatty acids, acidity index, peroxides, humidity, impurities, absorbency in ultraviolet at 232 and 270 nm and Delta K, tocopherol contents, unsaponifiable matter, and others.

6. Final considerations

Edible olive oil is greatly appreciated by the Brazilian population. Knowledge of Brazilians about the health benefits for olive oil consumption and about the different levels of quality of this product is increasing. The Brazilian position as the world's third largest importer of olive oil, combined with a history of fraudulent practices in this product, has led the Brazilian government to implement its legislation bringing an increase perspective to improve the product inspection. However, there are many technical challenges to be overcome, including the structuring of a national network with effective provisions for inspection and supervision, supported by qualified laboratories in the control of this product.

Appendix

Normative Instruction No. 1, 30/01/2012

Brazilian Ministry of Agriculture and Livestock—MAPA

Classification, quality requirements, sensory characteristics, and other complementary parameters of olive oil and olive pomace oil (**Tables 1–5**)

Group	Virgin olive oil			Olive oil	Refined olive oil	Pomace olive oil	Refined pomace olive oil
Type	Extra-virgin	Virgin	Lampante	Unique	Unique	Unique	Unique
Acid value (%)	≤0.80	≤2.00	<2.00	≤1.00	≤0.30	≤1.00	≤0.30
Peroxide value (mEqv/kg)	≤20		(*)	≤15	≤5	≤15	≤5
E							
270	≤0.22	≤0.25	(*)	≤0.90	≤1.10	≤1.70	≤2.00
DK	≤0.01		(*)	(*)	≤0.16	≤0.18	≤0.20
232	≤2.5	≤2.6	(*)	(*)	(*)	(*)	(*)

(*) Not applied

E: specific extinction in the ultraviolet

Table 1. Limits of olive oil and olive pomace oil quality parameters.

Group	Virgin olive oil			Olive oil	Refined olive oil	Pomace olive oil	Refined pomace olive oil
Type	Extra-virgin	Virgin	Lampante(**)	Unique	Unique	Unique	Unique
Median of the defect (Md)	0	>0 and ≤3.5	>3.5	(*)	(*)	(*)	(*)
Median of the fruity (Mf)	>0	>0	0	(*)	(*)	(*)	(*)

(*) Not applied

(**) Lampante virgin olive oil when obtained median defect (Md) of less than 3.5 and median fruity (Mf) zero

Table 2. Limits of the sensory characteristics of virgin olive oil.

Group	Virgin olive oil			Olive oil	Refined olive oil	Pomace olive oil	Refined pomace olive oil
Type	Extra-virgin	Virgin	Lampante	Unique	Unique	Unique	Unique
Stigmastadiene (mg/kg)	≤0.15		≤0.5			(*)	
Wax (mg/kg)	≤250		≤300	≤350		>350	
ECN 42 difference	≤0.2		≤0.3	≤0.3		≤0.5	
Fatty acid composition (%) (**)							
C18:1t	≤0.05		≤0.10	≤0.20		≤0.40	
C18:2t + C18:3t	≤0.05		≤0.10	≤0.30		≤0.35	
C14:0				≤0.05			

Group	Virgin olive oil			Olive oil	Refined olive oil	Pomace olive oil	Refined pomace oil
	Extra-virgin	Virgin	Lampante	Unique	Unique	Unique	Unique
C16:0				7.50–20.0			
C16:1				0.3–3.5			
C17:0				≤0.3			
C17:1				≤0.3			
C18:0				0.5–5.0			
C18:1				55.0–83.0			
C18:2				3.5–21.0			
C18:3				≤1.0			
C20:0				≤0.6			
C20:1				≤0.4			
C22:0			≤0.2				≤0.3
C24:0				≤0.2			

(*) Not applied; (**) percentage of total fatty acids

Table 3. Limits of olive oil and olive pomace oil complementary parameters.

Group	Virgin olive oil			Olive oil	Refined olive oil	Pomace olive oil	Refined pomace oil
	Extra-virgin	Virgin	Lampante	Unique	Unique	Unique	Unique
Desmethylsterols composition (%) (*)							
Cholesterol				≤0.5			
Campesterol				≤4.0			
Stigmasterol				Less than campesterol			
Brassicasterol				≤0.1			≤0.2
Beta-sitosterol + delta-5,23-estigmastadienol + clerosterol + beta-Sitostanol + delta-5-Avenasterol + delta-5,24-Estigmastadienol.				≥93.0			
Δ-7-Stigmastenol				≤0.5			
Erythrodiol and uvaol (**)				≤4.5			>4.5
Total sterols (mg/kg)				≥1.000		≥1,600	≥1,800

(*) Percentage of total desmethylsterols

(**) Olive oil with a wax content between 300 and 350 mg/kg is considered lampante virgin olive oil if the total aliphatic alcohol content is less than or equal to 350 mg/kg or the percentage of erythrodiol and uvaol is less than or equal to 3.5.

Table 4. Limits of olive oil and olive pomace oil complementary parameters.

Group	Virgin olive oil			Olive oil	Refined olive oil	Pomace olive oil	Refined pomace olive oil
	Extra-virgin	Virgin	Lampante	Unique	Unique	Unique	Unique
FAME + FAEE < 75 mg/kg or 75 mg/kg < FAME + FAEE < 150 mg/kg and FAEE/FAME < 1,5		(*)	(*)	(*)	(*)	(*)	(*)
Refractive index (20 °C)		1.4677–1.4705				1.4680–1.4707	
Saponification index (mg KOH/g)		184–196				182–193	
Moisture and volatile matter (%)		≤0.2				≤0.1	
Unsaponifiable matter (g/kg)		≤15				≤30	
Iodine index (Wijs)		75–94				75–92	
Arsenium (mg/kg)				<0.1			
Lead (mg/kg)				<0.1			
Iron (mg/kg)				≤3			
Copper (mg/kg)				≤0.1			

(*) Not applied; FAME, fatty acid methyl ester; FAEE, fatty acid ethyl ester

Table 5. Limits of olive oil and olive pomace oil other parameters.

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