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Review

A Review of the Microbial Dynamics of Natural and Traditional Fermentations of Table Olive

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Abstract: The traditional fermentation of table olives is a complex and dynamic, process, carried out by a consortium of microorganisms that interact with each other and contribute to the uniqueness and attractiveness of the final product. Fermentation is conducted by yeasts and lactic acid bacteria (LAB) that coexist in olive fruits. The succession of one microbial population to the detriment of others depends on internal and external factors that affect the process, e.g., the maturation degree of fruits, cultivar, endophytic, or epiphytic state of microorganisms, pH, water activity, temperature, and salt concentration. Thus, studying microbiota evolution and their identification in natural table olive fermentations is paramount. This review aims to provide an overview of the knowledge on the natural fermentation of table olives, namely regarding microbial dynamics, as to report the main species involved in the fermentation process, highlight the influence of the olive oil ecosystem on the origin of the microbiota and consequently on the obtaining of the final product. The results report a total of 97 yeast species and 45 LAB species described in olives and brine over the last few decades.

Keywords: fermented product; edible olives; brine; microorganisms; species diversity

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1. Introduction

Table olive has great economic importance worldwide. More than a fermented product table olive is currently considered an important food source, being described as the food of the future [1,2] and rich in nutrients and has a high content of bioactive compounds that provide important health benefits [3]. According to data provided by the International Olive Oil Council (IOC), production in the 2020/21 crop year points to 2,661,000 t of table olives, down 10.1% on the previous year. Among IOC member countries, Spain produced 20.5% of the world's table olives, with a volume 19.3% higher than the previous year. Egypt produced 18.8% of the total, which is 23.1% less than it produced in the 2019/20 crop year [4]. Estimates for the 2021/22 crop year point to a 7% increase with production reaching 2,846,500 t. Consumption is set to rise by 1.2% compared to the 2020/21 crop year.

In nature, olive fruit is acquired from the olive tree *Olea europaea* L. Still, it is considered unsuitable for consumption, due to the bitter component (oleuropein), low sugar content (2.6–6%), and high oil content (12–30%), depending on the time of the year and the variety [5]. Some characteristics prevent the olive be consumed directly from the tree, requiring a sequence of processes to make them an edible product much appreciated. The processing methods used are essentially based on how the bitter taste is eliminated and their preservation (ICO, 2004). The choice of method often depends on particular preferences, local traditions, and desired flavor profiles. Among different preparation processes, the most relevant worldwide are Sevillian or Spanish, Californian, and Greek styles, also known as natural or traditional fermentation [6]. In the present work, we will focus on the Greek-style, a traditional process that has been performed over several generations. Conducted only by autochthonous microorganisms present in olives, the removal of phenolic compounds is slow and incomplete, without very significant physicochemical changes in the olives [7]. As a result, naturally fermented table olives are the ones that have higher nutritional value, a balanced profile of polyunsaturated and monounsaturated fatty acids, and a high content of health-promoting phenolic compounds [8].

2. Greek-Style of Table Olives

Greek-style tables olives is a traditional method, which is fundamentally based on fermentation in water/brine, that results from the empirical knowledge, tradition, and intergenerational transfer of knowledge, which is responsible for the desired characteristics of the final product.

This production originated in the Mediterranean region and is one of the oldest biotechnological applications in food processing [9]. The main aim is to remove the bitterness from the olive flesh, hydrolyze the phenolic compounds, mainly the oleuropein, and acquire specific flavors, textures, and aromas distinct from products fermented in other regions [10]. In natural olives, the fruits are picked by manual harvesting systems, such as manual shakers or shaking combs, regardless of their maturation state when reach their normal size and with a reasonably firm texture [11].

The olives must be carefully transported immediately after being picked, followed by selection by size (sorting) and ripening index, eliminating the defective ones, those attacked by pests and diseases, as well as remaining leaves and twigs from the field. Then, the olives are washed under running water to remove surface dust, agrochemical residues, and undesirable microorganisms from the surrounding environment (for example, spoilage yeasts, associated with fruit deterioration during fermentation) [12].

In certain regions, the olives can be sweetened (periodic washing of the olives), followed by salting (gradual addition of salt up to 10%, without changing water [13]. However, the most usual is to place the olives directly in a brine solution, which can range from 6% to 10% NaCl or slightly lower (6%) in cooler production areas [14]. No acidity regulators or preservatives are normally added. This process naturally causes the brine to reach a pH of less than 4.5, ideal for preserving the olives in good microbiological conditions, flavor, and consistency.

The fermentation process occurs without full prediction, very slowly over several months in wooden vats or plastic containers (production on a small scale) or in cylindrical/spherical polyester and fiberglass fermentative tanks (production on a big scale) at around 25 °C, and in anaerobic conditions [11]. During this period, the brine removes polyphenols from the olives, including oleuropein and others, which are solubilized, promoting a partial reduction in the bitterness of the olives. Additionally, oleuropein hydrolyzation is catalyzed by microbial and endogenous enzymes, for example, the β-glucosidase and esterase enzymes [15]. The brine stimulates the microbial action (mainly halophilic microorganisms) and the fermentation starts, which is mainly promoted by yeasts and lactic acid bacteria (LAB) naturally associated with the raw material as well as the microflora that may be attached to the internal surface of the containers.

This mixed fermentation (yeasts/bacteria) shows probiotic characteristics, essentially due to the production of LAB, which reduces the pH, acting as a natural protection against the development of undesirable pathogenic species [16,17]. However, Gram-negative bacteria, Enterobacteriaceae can also arise and interact with the microorganisms [18]. The presence of this family in fresh fruits is very common, causing food deterioration. In natural table olives, generally disappear in the first phase of the process due to their sensitivity to brine and phenolic compounds [19].

According to [20], the black olives obtained by Greek-style reach equilibrium in 8–12 months and comprise three distinct phases:

First phase: growth of Gram-negative bacteria, reaching maximum growth on the second day after adding the brine to the olives. After this, the population gradually decreases between 12 and 15 days.

Second phase: starts at the moment when the pH drops to 6.0. It is characterized by the fast growth of lactobacilli and yeasts and a decrease in Gram-negative bacteria. Since the fermentation process begins, fast LAB growth starts, occurring between 7 and 10 days, and slowly decreases until it disappears, which can occur between 60–300 days of fermentation.

Third phase: this phase extends until the exhaustion of the fermentative substrates. During the entire period of this phase, the yeast population is also present and their growth contributes to improving the sensory characteristics of the final product.

However, the Greek-style does not always behave this way. Several phases have been described in olive fermentations from different cultivars and with different maturation indexes. In Conservolea and Kalamata table olives, different phases were described during 180 days of fermentation [21], while the spontaneous fermentation of the Negrinha de Freixo cultivar carried out in 149 days was characterized by two distinct phases [22], and the fermentation of Nyons olives in 480 days, in four phases [23]. As described above, it seems that the fermentation period is conditioned by several factors, including the cultivar (cv.), maturation degree, the NaCl content, and the temperature.

The process is only completed when the fermentable compounds (mainly sugars) are diffused through the olive epidermis to the outside and are completely exhausted while NaCl diffuses into the fruits [24]. The equilibration rate for reducing sugars in olives increased as brine concentration decreased, reaching equilibrium in most cases between 8 and 12 months [25].

Microorganisms use these compounds (glucose, fructose, mannitol, and sucrose) as a carbon source and convert them into organic acids, namely lactic acid, acetic acid, and malic acid [26]. However, the end of fermentation is decided by producers when they consider the olives ready for consumption [25]. Edible olives still retain a slightly bitter taste, essentially due to the presence of residual polyphenols [18].

At the end of fermentation, the olives must have a pH value of less than 4.3 and a free acidity of more than 0.3% expressed as lactic acid [4,27]. Then, the olives are packed in a new acidified brine, which can be flavored with herbs and spices for later marketing.

As mentioned initially, the Greek-style of table olives has been performed over several generations by introducing certain practices, making it possible to control and enhance fermentation performance. Currently, it is possible to apply acidifying substances, such as lactic, acetic, and citric acids [22,28] or glucose and sucrose supplements [29] at the beginning of fermentation to adjust the pH and to avoid communities of spoilage microorganisms and organoleptic problems. Additionally, the injection of air into the fermenters allows for anaerobic fermentations [30], the temperature, and salt concentrations [31] as well as, the application of yeasts and LAB as starter cultures of indigenous strains from olives [32]. All these practices have improved the Greek-style and reduced the processing time. Nevertheless, this process is still mainly carried out by small producers because, due to spending time to eliminate the bitterness of the olives, more effort, and energy, the table olive industry does not produce large quantities of natural olives.

3. Different Variables Affect the Indigenous Microbiota of the Olive Fruits

In nature, the aerial part of the olive tree is colonized by a great diversity of microorganisms including yeasts and bacteria, that can be found inside the pulp (endophytes) [33] or on the surface of the olive skin (epiphytes) [34]. These communities lead the fermentation processes of table olives and play a crucial role in the final product. Extrinsic and intrinsic variables of the oleic ecosystem can affect the microbial structure core that inhabits fruits. Several studies report the importance of abiotic (climatic variables) and biotic (plant organs, cultivar) factors in the microbial assembly of the Mediterranean ecosystem. Between factors evaluated at the phyllosphere of olive tree level, the season, wind speed, rainfall, temperature, and plant organ, are considered the major drivers for fungal communities [35]. The geographical influence on the microbial core in fermented green olives was recently studied by [36] in the province of Seville. Likewise, studies carried out with Konservólia and Halkidiki [37] Picholine [38], and Gemlik [39] table olive cultivars reported a possible relationship between yeast microorganisms and their designation of origin. These findings suggest that different environments include different communities, which will participate, drive different fermentations, and produce unique and distinctive products.

Through other research, the potential effects of the cultivar on the fungal diversity of olive fruits Madural and Verdeal Transmontana were verified by [40] Studies conducted by [41] showed the contribution of reproductive organs and host cultivars (cvs.) on endophytic fungal communities. Recently, ref. [34] described that olive fruit fungal epiphytic communities are affected by different maturation stages, ref. [42] explored the tissue and cultivar effect in epiphytic and endophytic bacteria on olive tree phyllosphere and presented a variation in communities. The variation of bacterial community structure was attributed mainly to olive plant internal and external plant tissues. The microbial consortia that colonize the raw material (olives) are closely related to the condition of the olive tree ecosystem and its interactions with intrinsic and extrinsic variables. Additionally, the harvesting period [43] is also a critical factor of extreme importance that influences the quality of the fruits and consequently the effectiveness of the fermentation process. Olives harvested at the ideal time translate into products with high nutritional power, rich in phenolic compounds and other antioxidants [44]. Thus, the identification or mapping of the microbiota diversity that occurs during the fermentation process is extremely important, as it allows a clearer understanding of the role of each microorganism and justifies the changes that occurred throughout the fermentation process.

4. Microbiota Associated with Greek-Style Table Olive

In the last decade, works on identifying and describing the microbiota through the Greek-style revealed that the process is generally dominated by complex yeast consortia and LAB. The presence of filamentous fungi has also been occasionally detected among the microbiota of table olives at the start of the fermentation, however, the role of these microorganisms is of slight relevance [23].

These microorganisms coexist simultaneously, and the success of fermentation is obtained from the relationships established between them. Yeasts emerge as the dominant microorganisms throughout the process, degrade phenolic compounds, and produce vitamins that favor the development and growth of LAB [45]. They play an extremely important role in the fermentation of table olives, especially in the Greek-style. However, depending on the species involved, in addition to causing positive effects, they can also cause negative effects [46]. Production of volatile compounds and metabolites such as ethanol, glycerol, organic acids, carotenoids, glutathione, and tocopherol improve the flavor, aroma, and conservation characteristics of the fermented product. On the other hand, excessive growth of some yeast species can produce undesirable alterations like spoilage of olives, off-flavors, off-odors defects, gas pocket formation and clouding of the brines [47,48]. According to Ref. [49], this effect is related to the olive variety and the production phase. A species can be beneficial during fermentation and harmful in packaged samples.

Concerning LAB, they are Gram-positive bacteria with complex nutritional needs that grow only in nutrient-rich media, however, they have a high resistance capacity to stress conditions, being able to grow in environments with temperature variations and different salt concentrations [49]. These species play an important role in the natural table olive fermentation process, due to their ability to produce lactic acid and antimicrobial compounds (bacteriocins) [50]. These compounds promote rapid brine acidification and inhibit the development of pathogenic microorganisms, reinforcing the safety and shelf life of the final product. These microorganisms are also responsible for the degradation of oleuropein [45].

In this review, the main microorganisms (Yeast/LAB) that have been isolated from the natural processing of whole table olives in the last fifteen years (from 2008 to 2023) are presented. The dominant yeasts belong to the genera *Candida*, *Cryptococcus*, *Debaryomyces*, *Pichia*, *Rhodotorula*, *Saccharomyces*, *Zygosaccharomyces* [21,25,47,51–56] and, in a small number *Aureobasidium*, *Citeromyces*, *Dekkera*, *Metschnikowia*, *Schwanniomyces*, *Sporobolomyces* and *Zygotorulaspora* [23,57–60]. Other genera appear exceptionally (new species) for example *Barnettozyma*, *Bullera*, *Brettanomyces*, *Cystofilobasidium*, *Galactomyces*, *Guehomyces*, *Kloeckera*, *Kluyveromyces*, *Lodderomyces*, *Meyerozyma*, *Nakazawaea*, *Ogataeae*, *Priceomyces*, *Rhodosporidium*, *Torulaspora*, *Trichosporum*, *Wickerhamomyces*, *Zygoascus* and *Zygowilliopsis* [22,37,47,54,59,61]

For the genera mentioned above, the species most often isolated from olives fruits/cultivars and the respective countries are described in Table 1.

Table 1. List of yeast identified in the natural fermentation of whole table olives in different cultivars and countries.

Yeast Species	Olives Fruits/Cultivar	Country of Origin	References
Aureobasidum pullulans	Aloreña	Spain	[57,58]
	Nyons	France	[23]
	Kalamata/Konservolia/Gemlik/ Cypriot	Greece	[28,37,39,52,59]
Aureobasidium spp.	Kalamata	Greece	[61]
Barnettozyma californica	Kalamata	Greece	[28]
Bullera variabilis	Black olives	Tunisia	[62]
Brettanomyces custersianus	Konservolia	Greece	[37,63]
Candida aaseri/butyri	Arbequina	Spain	[25]
	Gemlik	Turkey	[64]
	Nocellara messinese	Italy	[55]
	Konservolia	Greece	[59]
Candida atlantica	Nyons	France	[23]
	Gemlik	Turkey	[64]
Candida blattariae	Konservolia	Greece	[59]

Table 1. *Cont.*

Yeast Species	Olives Fruits/Cultivar	Country of Origin	References
Candida boidinii	Nyons	France	[23]
	Nocellara messinese	Italy	[55]
	Galega/Cordovil/Negrinha de Freixo	Portugal	[22,65,66]
	Arbequina	Spain	[25,67]
	Konservolia/Kalamata	Greece	[28,59]
	Gemlik	Turkey	[64]
	Bosana/Cellina di Nardò/Istrana nera/Peranzana/Nocellara del Belice/Nocellara Messinese/Leccino/Leucocarpa	Italy	[21,54–56,68]
Candida cf apicola	Aloreña	Spain	[57]
Candida citrea	Galega/Cordovil	Portugal	[66]
Candida diddensiae	Aloreña/Arbequina	Spain	[19,25,58]
	Bosana/Nocellara del Bellice /Nocellara messinese/ Cypriot/Kalamata/Picual	Italy	[52,54,55]
Candida ethanolica	Amfissis	Greece	[69]
Candida famata	Leucocarpa	Italy	[68]
	Gemlik	Turkey	[39]
Candida glabrata	Galega	Portugal	[65]
Candida glaebosa	Arbequina	Spain	[67]
Candida gropengiesseri	Arbequina	Spain	[67]
Candida intermedia	Leucocarpa	Italy	[68]
Candida ishiwadae	Cellina di Nardò	Italy	[56]
Candida krusei	Carolea/Leucocarpa	Italy	[68]
	Galega	Portugal	[65]
Candida membranaefaciens	Arbequina/Aloreña	Spain	[19,25,67]
	Gemlik	Turkey	[39]
	Negrinha de Freixo/Galega/Cordovil	Portugal	[22,66]
Candida molendinolei	Kalamata	Greece	[28]
Candida naeodendra	Kalamata	Greece	[28]
Candida norvegica	Negrinha de Freixo/Galega/Cordovil	Portugal	[22,66]
Candida oleophila	Galega/Cordovil	Portugal	[66]
Candida olivae	Konservolia	Greece	[59]
Candida parapsilosis	Arbequina	Spain	[25]
	Brandofino/Nocellara del Belice/Passanulara	Italy	[51]
Candida pelliculosa	Gemlik	Turkey	[39]
Candida sake	Galega/Cordovil	Portugal	[66]
Candida silvae	Galega/Cordovil	Portugal	[66]
	Konservolia	Greece	[59]
Candida sorbosa	Arbequina olives	Spain	[67]
Candida tartarivorans	Cellina di Nardò	Italy	[21]

Table 1. *Cont.*

Yeast Species	Olives Fruits/Cultivar	Country of Origin	References
Candida tropicalis	Negrinha de Freixo	Portugal	[22]
	Nocellara messinese	Italy	[55]
Candida utilis	Galega	Portugal	[65]
Candida valida	Galega/Cordovil	Portugal	[66]
Candida sp.	Kalamata	Greece	[61]
	Nyons	France	[23]
	Leccino	Italy	[21]
Citeromyces matriensis	Galega/Cordovil	Portugal	[66]
Citeromyces nyonsensis	Azeitera	Spain	[60]
	Nyons	France	[23]
Cryptococcus albidus	Black olives	Tunisia	[62]
	Gemlik	Turkey	[39]
	Leucocarpa	Italy	[68]
Cryptococcus carnescens	Nyons	France	[23]
Cryptococcus flavus	Arbequina	Spain	[67]
Cryptococcus laurentii	Gemlik	Turkey	[39]
	Black olives	Tunisia	[62]
Cryptococcus macerans	Aloreña	Spain	[57]
Cryptococcus magnus	Nyons	France	[23]
Cryptococcus saitoi	Gemlik	Turkey	[39]
Cystofilobasidium capitatum	Konservolia	Greece	[59]
Debaryomyces carsonii	Cellina di Nardò	Italy	[21]
Debaryomyces etchellsii	Leccino	Italy	[21]
Debaryomyces hansenii	Aloreña	Spain	[19,58]
	Konservolia	Greece	[59]
	Black olives	Tunisia	[62]
	Cellina di Nardò/Kalamata	Italy	[21,47,52]
	Negrinha de Freixo	Portugal	[22]
Dekkera bruxellensis	Black olives	Tunisia	[62]
Galactomyces reessii	Negrinha de Freixo	Portugal	[22]
Guehomyces pullulans	Kalamata	Greece	[47]
Kloeckera apiculata	Galega/Cordovil	Portugal	[66]
	Gemlik	Turkish	[39]
Kloeckera spp.	Galega	Portugal	[65]
Kluyveromyces lactis	Arbequina	Spain	[25]
Lodderomyces elongisporus	Aloreña	Spain	[58]
Metschnikowia pulcherrima	Konservolia	Greece	[59]
	Galega/Cordovil	Portugal	[66]
Meyerozyma sp.	Gemlik	Turkey	[64]
Meyerozyma guilliermondii	Cypriot/Kalamata	Italy	[52]
Nakazawaea molendini-olei	Bosana	Italy	[54]
Ogataeae spp.	Kalamata	Greece	[61]

Table 1. *Cont.*

Yeast Species	Olives Fruits/Cultivar	Country of Origin	References
Pichia anomala/ Wickerhamomyces anomalus	Gemlik	Turkey	[39,64]
	Arbequina	Spain	[25,67]
	Bella di Cerignola/Cellina di Nardò/Bosana/Brandofino/Passanulara/Nocellara dell'Etna/Nocellara messinese	Italy	[21,47,51–56]
	Negrinha de Freixo	Portugal	[22]
	Nyons	France	[23]
	Konservolia	Greece	[37,59,69]
Pichia carsonii	Arbequina	Spain	[67]
Pichia farinosa	Black olives	Greece	[62]
Pichia fermentans	Galega/Cordovil	Portugal	[66]
Pichia galeiformis/Pichia manshurica	Peranzana/Nocellara del Belice, Cellina di Nardò	Italy	[56]
	Manzanilla/Hojiblanca/Gordal/Aloreña	Spain	[57,70,71]
	Konservolia/Kalamata	Greece	[28,37,59]
	Negrinha de Freixo	Portugal	[22]
Pichia kluyveri	Arbequina	Spain	[25,67]
	Konservolia	Greece	[59]
	Brandofino/Castriciana/Manzanilla/Nocellara del Belice/Passanulara	Italy	[51]
Pichia kudriavzevii	Nocellara messinese	Italy	[55]
	Gemlik	Turkey	[64]
Pichia membranifaciens	Kalamata	Greece	[47]
	Nyons	France	[23]
	Gordal	Spain	[71]
	Konservolia	Greece	[37,69]
	Galega/Cordovil	Portugal	[66]
	Cellina di Nardò/Leccino	Italy	[21]
Pichia mexicana	Nocellara messinese	Italy	[55]
Pichia rhodanensis	Arbequina	Spain	[25]
Pichia sp.	Aloreña	Spain	[57]
	Kalamata	Greece	[61]
	Cellina di Nardò/Leccino	Italy	[21]
Priceomyces carsonii	Nyons	France	[23]
Rhodosporidium capitatum	Galega/Cordovil	Portugal	[66]
Rhodotorula diobovatum	Konservolia	Greece	[59]
Rhodotolura glutinis	Arbequina olives	Spain	[25]
	Negrinha de Freixo	Portugal	[22]
Rhodotolura graminis	Negrinha de Freixo	Portugal	[22]
Rhodotorula mucilaginosa	Konservolia	Greece	[59]

Table 1. *Cont.*

Yeast Species	Olives Fruits/Cultivar	Country of Origin	References
Saccharomyces cerevisiae	Nocellara dell'Etna/Bosana/Cellina di Nardò/Leccino/Istrana nera, bianca/Peranzana/Nocellara del Belice/Bella di Cerignola/Nocellara messinese/Kalamata	Italy	[52–56]
	Aloreña/Manzanilla	Spain	[19,57,58]
	Negrinha de Freixo/Galega/Cordovil	Portugal	[22,66]
	Kalamata/Konservolia	Greece	[21,28,47,59,63]
	Gemlik	Turkey	[39]
	Nyons	France	[23]
Saccharomyces dairensis	Arbequina olives	Spain	[67]
Saccharomyces kluyveri	Gemlik	Turkey	[39]
Saccharomyces paradoxus	Nyons	France	[23]
Saccharomyces sp.	Gemlik	Turkey	[64]
	Kalamata	Greece	[61]
	Peranzana Alta Daunia	Italy	[49]
Schwanniomyces etchellsii	Gemlik	Turkey	[64]
	Nyons	France	[23]
	Konservolia	Greece	[37]
Sporobolomyces roseus	Black olives	Greece	[62]
	Galega/Cordovil	Portugal	[66]
Torulaspora delbrueckii	Galega/Cordovil	Portugal	[66]
	Black olives	Greece	[62]
Trichosporum pullulans	Galega/Cordovil	Portugal	[66]
Wickerhamomyces sydowiorum	Konservolia	Greece	[37]
Wickerhamomyces spp.	Kalamata	Greece	[61]
Zygoascus hellenicus	Gemlik	Turkey	[64]
	Nocellara messinese	Italy	[55]
Zygoascus meyerae	Nocellara messinese	Italy	[55]
Zygosaccharomyces bailii	Black olives	Greece	[62]
Zygosaccharomyces mrakii	Gemlik	Turkey	[39]
	Aloreña	Spain	[19,57]
	Leccino	Italy	[21]
Zygosaccharomyces bisporus	Cypriot	Italy	[52]
Zygosaccharomyces sp.	Gemlik	Turkey	[39]
Zygotorulaspora mrakii	Nyons	France	[23]
	Aloreña	Spain	[54,58]
Zygowilliopsis californica	Konservolia	Greece	[59]

The isolation of the microbiota allowed the identification of a total of 97 species, of which 31 belong to the genus *Candida*, 11 to the genus *Pichia*, 7 to the genus *Cryptococcus*, 5 to the genus *Saccharomyces* and, to a lesser extent, 4 to the genus *Rhodotorula* and *Zygosaccharomyces* and 3 to the genus *Debaryomyces.*

The level of *Candida* genus, the most frequent species were *C. aaseri*, *C. boidinii*, followed by *C. diddensiae* and *C. membranaefaciens* during olive fermentation in different countries. These species are among the most referred to in the literature, due to their abundant presence in naturally fermented table olives, and also in the pulp of naturally turning color olives from the traditional market [65]. Highlight for the species *C. boidinii* and *C. diddensiae* found intensely in Italian varieties, namely in Bosana; Cellina di Nardò; Istrana near; Peranzana; Nocellara del Belice; Nocellara messinese; Leccino and Leucocarpa [21,54–56,68].

These species were also the most abundant in Arbequina olives [25,67] in brines of Aloreña and Negrinha de Freixo olives [22] as well as Kalamata and Nyons black olives [23].

Candida aaseri was identified in different brines of the Arbequina, Gemlik, Nocellara messinese, and Konservolia table olives [25,55,59,64]. As regards, *C. membranaefaciens* is a common yeast in different fermentations, isolated from brined olives Negrinha de Freixo, Galega and Cordovil (Portugal), Aloreña and Arbequina (Spain), and Turkish Gemlik olives [19,22,25,39,66,67].

These species are able to synthesize a series of bioactive compounds that function as antioxidants. An example of this activity is the production of carotenoids, tocopherols, and citric acid [72]. They also have lipolytic capacity causing an increase in the amount of free fatty acids in the brine [70]. Moreover, they have pectinolytic activity changing the composition and quality of fermented olives. As seen in Table 1, other species were also found in a smaller percentage, such as *C. atlantica*, *C. blattariae*, *C. cf apicola*, *C. citrea*; *C. ethanolica*, *C. famata*, *C. glabrata*, *C. globose C. gropengiesseri*, *C. intermedia*, *C. ishiwadae*, *C. krusei*, *C. molendinolei*, *C. naeodendra*, *C. norvegica*, *C. oleophila*, and *C. olivae*, among other. These findings show the great diversity or heterogeneity of species found in natural olive fermentation. It was observed that different species were identified in different cultivars.

The presence of *C. norvegica*, *C. oleophila*, *C. sake*, *C. utilis*, and *C. valida* was only detected in brined olives of Portuguese Galega, Cordovil, and Negrinha de Freixo cvs. at the end of fermentation [22,66]. In research conducted by [66], *C. oleophila* specie showed oleuropeinolytic capacity (β-glucosidase enzymatic production), as well as mycogenic action against specific microorganisms.

Candida olivae was characterized for the first time as a novel yeast species from 'Greek-style' black olive by [59]. *Candida molendinolei* was recognized as a new species isolated from olive oil and its derivatives, characterized by high tolerance to salt (NaCl) and its ability to assimilate DL-lactate [73].

The genus *Cryptococcus* comprises a diverse group of organisms considered yeast-like fungi, which are found in soil, trees, and bird excrement. Species of this genus are recognized for producing a range of enzymes, such as proteases, urease, phos-hpolipase, and nuclease [74]. Although *Cryptococcus* sp. is considered nonfermentative yeast, several species have been identified in fermentative processes associated with table olives. The species *Cry. albidus*, *Cry. laurentii* and *Cry. saitoi* are the most prominent in Turkey's Akhisar and Iznik regions (Gelmik cv.) and Tunisia (black olives). Ref. [39] focused on exploring the effect of regional differences on the yeast microbiota of naturally fermented Turkish Gemlik olives and found a greater diversity in the Akhisar than Iznik region. On the other hand, studies carried out in the *Olea europaea* Leucocarpa cv. by [68] showed great diversity in yeasts, being *Cry. albidus* and other microorganisms were more related to the cultivar than to the environment.

Recently, also [23] were identified *Cry. carnescens* and *Cry. magnus* for the first time in French PDO Nyons black table olives. However, as far as we know, the impact of these microorganisms on table olive fermentation is unknown.

Regarding the genus *Debaryomyces, D. hansenii* was the dominant specie at the beginning of spontaneous fermentation in black table olives produced following the Greek style [59] halotolerant yeast produces enzymes that degrade the olive cell wall, showing "killer" activity against spoilage yeasts [12,75]. In Portugal and Spain, many studies showed the high frequency of this specie during the processing of green and turning color olives table olives [19,22,58] and table olives in Tunisia, Italy and, Greece [21,62]. Within the genus, *Pichia*, *P. anomala*, synonymy *Wickerhamomyces anomalus*; *P. galeiformis* (also seen as *P. manchuria*), *P. kluyveri* and *P. membranifaciens* are the most described species in the Mediterranean region throughout different faces of fermentation. Inclusive, some authors considered *W. anomalus* and *P. membranifaciens* as dominant yeasts of the core microbiota in the Greek-style of olives green, turn color and black [22,23,67] in addition, they also appear in the storage process [70].The presence of the *P. membranifaciens* strain was detected in the early stages of the storage period of Hojiblanca olives while *P. galeiformis* was present throughout the process. These species have been evaluated as probiotics [76] and starter cultures [77,78] owing important proprieties for the food industry. The fact that these species adhere to the surface of the fruit and form biofilms makes olives a product with high probiotic power, leading to a new functional food.

Studies carried out to evaluate the probiotic effects and technological characteristics of indigenous yeasts isolated from different table olives, Galega and Cordovil [66], Negrinha de Freixo [76], and cv. Kalamata natural black olive [28] demonstrated that vitamin production, mycogenic and antimicrobial activity, as well as oleuropeinolytic activity are some of the characteristics that make *P. membranifaciens* a promising candidate as multifunctional starter cultures [66].

Greek-style offers a rich source for new manufacturing yeasts with biotechnological potentialities due to resulting metabolic products [79]. Nevertheless, in the Greek-style, several changes can occur due to the uncontrolled proliferation of these microorganisms, which results in atypical fermentations. Some microbial changes during olive processing are detectable by sensory analysis. *Pichia manshurica* and *P. anomala* are among other microorganisms, responsible for producing gas-pockets (fish-eye and alambrado) in fruit surface, resulting in the rupture of the cuticle, softening olives, and biofilm in the course of fermentation and after packing [12].

From the *Rhodotorula* genus four species; *R. diobovatum*, *R. glutinis*, *R. graminis*, and *R. mucilaginosa* were also found. *R. glutinis* and *R. graminis* were identified in Negrinha de Freixo and Arbequina, while *R. diobovatum* and *R. mucilaginosa* species appear in Konservolia table olives. The presence of *R. glutinis* and *R. graminis* species was identified during the first stages of fermentation and after that, they disappeared [22,25]. Their occasional detention has been associated with raw material surfaces, not being directly involved in the fermentation process, However, more research is needed to assess these occurrences. Although these species favor nutrient diffusion, their presence is undesirable. Thus, requires special attention in the olive preparation process, since these are associated with polygalacturonases production that causes olive softening [12] This activity was exhibited by *R. minuta* pink yeast in green olives fermentation [75].

As reported in the literature, within the *Saccharomyces* genus, *S. cerevisiae* is the most commonly identified and known as one of the yeasts associated with olive fermentation [70]. It has been detected in different olives varieties fermentations, especially Bosana, Gemlik, Negrinha de Freixo, Nocellara, Nyons, Kalamata; and Konservolia originating from specific regions in the Mediterranean basin.

Saccharomyces cerevisiae strain prevails throughout the olive process being identified in several phases, including in the last days of fermentation [22] and also in olive packed [80]. This species may play an important role in the conservation of table olives, protecting the final product from the oxidation of unsaturated fatty acids [75]. However, ref. [81] refer to undesirable effects for olives, when present in amounts greater than 7 log CFU/mL, due to the increased production of carbon dioxide, which can penetrate the olives, damaging them. This change was reported by [82], in the fermentation of black olives. Despite this, strain exhibits a set of crucial features that make a potential candidate as a starter culture to use in processing table olives [83]. They tolerate low pH and oxygen availability. High salt and ethanol concentrations influence LAB growth, promote greater acidification in the medium, help degrade phenolic compounds (oleuropein), and favor table olives' sensory attributes [84].

In addition, *S. cerevisiae* is the only yeast species recognized as safe, then, for this reason, is considered by many authors the one natural fermenter [85]. Concerning to *Zygosaccharomyces* genus, *Z. bailii*, *Z. mrakii*, and *Z. bisporus* are the species described in brines during the fermentation of olives at the green and black stage of maturation. These species were isolated occasionally; *Z. mrakii* was identified in brines from Aloreña [19,57], Iznik-Gemlik and Leccino fermentations [21], whereas *Z. bailii* and *Z. bisporus* were mentioned in Greek-style black olives [62] and Cypriot green olives [52]. Species of the *Zygosaccharomyces* genus are found naturally in products that have high levels of sugar, low pH, and water activity and are considered spoilage species. Of the three species identified in olive fermentation, *Z. bailii* is the most related to the spoilage of foods and drinks [86]. Species of the *Zygosaccharomyces* genus are found naturally in products that have high levels of sugar, low pH, and water activity and are considered spoilage species [86]. It has a high resistance capacity in adverse environments, which becomes a considerable problem in terms of the production and conservation of foods. However, as far as we know, there are no reports associated with the Greek-style of table olives.

Relatively the genera that appear in smaller numbers (*Aureobasidium*, *Citeromyces*, *Dekkera*, *Metschnikowia*, *Schwanniomyces Sporobolomyces*, and *Zygotorulaspora*) we have to consider fermentative and non-fermentative species.

Emphasis to *Aureobasidium pullulans* non fermentative specie is a ubiquitous black yeast-like fungus associated with the olive endosphere [87]. Previously isolated from hypersaline waters, defined in the literature as a microorganism of halophilic and halotolerant nature [88]. Due to the biochemical characteristics it exhibits, this specie is considered by many authors a potential candidate for use in biotechnological applications [89] This species was identified as highly dominant in the early stages of green [57] and black [23] traditionally fermented table olives. Other less widespread species, but equally important were found; *C. matriensis*, *C. nyonsensis*, *D. bruxellensis*, *M. pulcherrima*, *S. etchellsii*, *S. roseus*, and *Z. mrakii.*

Similar to yeasts, over the past 15 years several LAB isolates have been identified. According to studies by [90] and with the recent classification and description of the Lactobacillaceae family, 23 new genera of *Lactobacilli* have been identified to date. However, in terms of Greek-style table olives, only 7 genera have been described to date: *Enterococcus*, *Lactobacilli*, *Lactococcus*, *Leuconostoc*, *Pediococcus*, *Streptococcus*, and *Weissella. Enterococcus*, *Lactococcus*, *Pediococcus*, and *Streptococcus* are homolactic genera, that produce only lactic acid, acidifying the product, while *Leuconostoc* and *Weissella* are heterolactic genera, which additionally produce other metabolites such as acetic acid, ethanol and carbon dioxide. The *Lactobacilli* genus may present both homolactic/heterolactic [91].

Table 2 summarizes the main genera and species that appear in Greek-styles of whole olives in different cultivars from different countries. Among the genera identified during the fermentation, *Lactobacilli* appears as the largest number of species (31), followed by *Leuconostoc* (6), *Enterococcus* and *Pediococcus* (5), and finally *Lactococcus*, *Streptococcus*, and *Weissella* (1). As it is possible to verify, *Lactobacilli* is the main isolated genus from the most diverse olive tree cultivars, in green or black olives and the predominant species are *Lactiplantibacillus plantarum* and *Lactiplantibacillus pentosus*, followed by *Lactiplantibacillus paraplantarum* (Table 2). Italy is the country with the greatest biodiversity of olive cultivars and the presence of *L. plantarum* and *L. pentosus*, has been intensely reported during traditional fermentation Sicilian style [92–96]

Table 2. List of lactic acid bacteria identified in the natural fermentation of whole table olives in different cultivars and countries.

Identified Species	Olives Fruits/Cultivar	Country of Origin	References
Enterococcus casseliflavus species group	Bella di Cerignola	Italy	[97]
Enterococcus durans	Cellina di Nardò/Itrana bianca/ Bella di Cerignola	Italy	[48]
Enterococcus faecalis	Green olives	Italy	[5]
Enterococcus faecium	Cypriot	Cyprus	[98]
	Green and black olives	Tukey	[99]
	Tonda di Cagliari	Italy	[100]
Enterococcus italicus	Bella di Cerignola	Italy	[97]
Ligilactobacillus acidipiscis	Black and green olives	Turkey	[99]
Companilactobacillus alimentarius	Black olives	Turkey	[99]
Lacticaseibacillus brantae	Picual	Cyprus	[101]
Levilactobacillus brevis	Black olives/Chemlal/Hamra/Sigoise	Algeria	[102]
	Green olives/Bella di Cerignola	Italy	[97]
	Gemlik	Turkey	[103]
	Cypriot/Kalamata/Picual	Cyprus	[52]
Lacticaseibacillus casei	Green olives/Bella di Cerignola/Cellina di Nardò/Itrana nera/Nocellara del Belice/Itrana bianca/Nocellara Etnea/Grossa di Spagna	Italy	[94,97,104,105]
Lacticaseibacillus casei ssp. *tolerens*	Black olives/Chemlal/Hamra/Sigoise	Algeria	[102]
Secundilactobacillus collinoides	Green olives/Tonda di Cagliari	Italy	[100]
Loigolactobacillus coryniformis	Green olives/Bella di Cerignola/Geracese/Nocellara del Belice	Italy	[93,97,105]
	Aloreña	Spain	[57]
Latilactobacillus curvatus	Black olives/Chemlal/Hamra/Sigoise	Algeria	[102]
	Cypriot/Kalamata/Picual	Cyprus	[52]
Lactobacillus delbrueckii	Cypriot/Kalamata/Picual	Cyprus	[52]
Companilactobacillus farciminis	Green olives	Turkey	[99]
Limosilactobacillus fermentum	Black olives/Peranzana/Bella di Cerignola	Italy	[104]
Lactobacillus helveticus	Black olives/Cellina di Nardò	Italy	[104]
Lactobacillus japonicus	Picual	Cyprus	[101]
Lentilactobacillus kefiri	Cypriot/Kalamata/Picual	Cyprus	[52]
Liquorilactobacillus mali	Natural green olives Bella di Cerignola	Italy	[97]
Lacticaseibacillus manihotivorans	Picual	Cyprus	[101]

Table 2. *Cont.*

Identified Species	Olives Fruits/Cultivar	Country of Origin	References
Levilactobacillus namurensis	Black olives	Turkey	[99]
Lacticaseibacillus paracasei	Green olives/Bella di Cerignola	Italy	[97]
Secundilactobacillus paracollinoides	Green olives/Geracese	Italy	[105]
	Green olives/Aloreña	Spain	[57]
Lentilactobacillus parafarraginis	Picual	Cyprus	[101]
Lentilactobacillus parakefiri	Picual	Cyprus	[101]
Companilactobacillus paralimentarius	Cypriot/Kalamata/Picual	Cyprus	[52]
Lactiplantibacillus paraplantarum	Black olives/Conservolea/Kalamata	Greece	[106]
	Green olives/Tonda di Cagliari	Italy	[5,100]
	Black olives/Galega/Cobrançosa	Portugal	[16,17]
	Green olives/Arbequina	Spain	[25]
Lactiplantibacillus pentosus	Black olives/Conservolea/Kalamata/Amfissis	Greece	[18,63,106]
	Green and black olives/Bella di Cerignola/Cellina di Nardò/ Itrana nera/Peranzana/Nocellara del Belice/Itrana bianca/Bella di Cerignola/Tonda di Cagliari/Giarraffa/ Grossa di Spagna/Nocellara Etnea	Italy	[5,93–97,100,104,107]
	Cobrançosa	Portugal	[17]
	Green and black olive	Turkey	[108]
	Arbequina/Aloreña Gordal/Manzanilla	Spain	[25,57,67,71,109]
Lactiplantibacillus plantarum	Chemlal/Hamra/Sigoise	Algeria	[102]
	Conservolea/Kalamata/Halkidiki/Bella di Cerignola	Greece	[11,37,47,97,110]
	Cellina di Nardò/Leccino/Green olives/Itrana nera/Peranzana/Itrana bianca/Nocellara del Belice/Bella di Cerignola/Nocellara Etnea/Geracese/Tonda di Cagliari/Giarraffa/Grossa di Spagna	Italy	[5,21,93–97,100,104,105, 107,110,111]
	Cobrançosa/Galega	Portugal	[16,17]
	Arbequina/Aloreña/Manzanilla/Gordal	Spain	[19,25,67]
	Cypriot/Picual/Kalamata	Cyprus	[52,101]
	Black and green olives	Turkey	[99]
Lacticaseibacillus rhamnosus	Nocellara Etnea/Bella di Cerignola	Italy	[97,107]
Paucilactobacillus suebicus	Aloreña	Spain	[57]
Lactobacilli sp.	Aloreña	Spain	[57]
Paucilactobacillus vaccinostercus	Bella di Cerignola	Italy	[97]
	Aloreña	Spain	[57]
Lactobacilli veridesens	Chemlal/Hamra/Sigoise	Algeria	[102]
Lactococcus lactis	Aloreña	Spain	[57]
	Cypriot/Kalamata/Picual	Cyprus	[52]
Leuconostoc cremoris	Gemlik	Turkey	[103]

Table 2. *Cont.*

Identified Species	Olives Fruits/Cultivar	Country of Origin	References
Leuconostoc carnosum	Cypriot/Kalamata/Picual	Cyprus	[52]
Leuconostoc mesenteroides	Chemlal/Hamra/Sigoise	Algeria	[102]
	Conservolea/Kalamata/Amfissis	Greece	[47,63,106,110]
	Bella di Cerignola/Green olives/Grossa di Spagna	Italy	[5,96,97]
Leuconostoc mesenteroides ssp. *mesenteroides*	Kalamata	Greece	[112]
Leuconostoc paramesenteroides	Gemlik	Turkey	[103]
Leuconostoc pseudomesenteroides	Conservolea/Kalamata/Amfissis	Greece	[63,106]
	Aloreña	Spain	[57]
Pediococcus acidilactici	Green olives	Italy	[113]
Pediococcus ethanolidurans	Conservolea	Greece	[106]
Pediococcus parvulus	Green olives/Geracese/Tonda di Cagliari	Italy	[5,100,105]
	Aloreña	Spain	[57]
	Cobrançosa	Portugal	[17]
Pediococcus pentosaceus	Nocellara del Belice	Italy	[93,111]
Pediococcus sp.	Aloreña	Spain	[57]
Streptococcus thermophilus	Geracese	Italy	[105]
	Cypriot/Kalamata/Picual	Cyprus	[52]
Weissella paramesenteroides	Bella di Cerignola	Italy	[97]
	Cypriot/Kalamata/Picual	Cyprus	[52]

Although with lesser frequency these microorganisms were also described in olive fermentations of Arbequina, Aloreña, Manzanilla, Gordal (Spain); Conservolea, Kalamata, Halkidiki, Bella di Cerignola (Greece); in Chemlal, Hamra and Sigoise (Algeria) Cobrançosa and Galega (Portugal), and occasionally in Cypriot, Picual, and Kalamata (Cyprus) cvs. (Table 2).

On the other hand, the strain *L. paraplantarum* is often associated with Kalamata and Conservolea, Galega, and Italian Tonda di Cagliari. According to some authors, the occurrence of these species is genetically related, being referred to as a group [94,95].

Recent studies carried out by [37], on fermented Greek table olives belonging to the Konservolia and Halkidiki varieties, point to the existence of biogeographic patterns of microbial populations. However, ref. [52] when evaluating the bacterial profile of varieties from different regions of Cyprus, found a high similarity between the population, both for the varieties and for the regions studied. In this study, *Lactobacilli* is also one of the most abundant genera. Its origin seems to be more directly associated with the raw material (olives), being considered by several authors as the main responsible for the fermentation of fruits and vegetables [114].

At the level of the food industry, they have been widely explored for their numerous multifunctional characteristics, including enzymatic activity [115]. In olives, *L. plantarum* and *L. pentosus* have an enzymatic activity that helps degrade oleuropein and other phenolic compounds reducing fruit bitterness [116]. On the other hand, they are responsible for the production of lactic acid which causes a drop in the pH of the brine, preventing the growth of deteriorating microorganisms and pathogens [50]. Studies performed by [25] in spontaneous fermentations of the *Arbequina* cultivar indicated the presence of this group of microorganisms varies during fermentation, *L. pentosus* remains throughout the fermentation process while *L. pentosus* appears in the initial phase and *L. paraplantarum* in the final phase. Ref. [17] mention *L. paraplantarum* with good adaptation to the sweetening stage of the spontaneous fermentation of the Cobrançosa olives. In addition, several types of research have shown a succession of the bacterial community in olives and brine during fermentations [17,23]. The benefits of these microorganisms as starter cultures in controlling traditional fermentation and producing high-quality table olives are immense. The reduction of pathogens and spoilage microorganisms, reduced debittering time, better flavor and aroma, preservation of food, and increased nutritional value. So, its application is highly recommended [12,13,117]. In this sense, they promote fermented products' preservation and shelf life.

Several studies have shown that *L. plantarum* and *L. pentosus* can improve the nutritional quality of olives by increasing the content of bioactive compounds, such as phenolic compounds, vitamins, and minerals additionally have been recognized as shown to have probiotic properties, which can benefit human health [101]. While these species emerge as generalists and persistent, others show specificity by cultivar, geographic origin, and, maturation rate. And even some that appear occasionally and to a lesser extent. Examples of other species of *Lactobacilli* genus, which appear in lesser abundance are *L. brevis*, *L. casei*, *L. coryniformis*, *L. curvatus*, *S. paracollinoides*, and *L. vaccinostercus*. To highlight the presence of *L. casei* exclusively in Italian cvs. a fact that was described very early by [105], as a dominant species in Greek-style s of Sicilian green olives. The literature reports other species described sparsely in several countries, such as eg. *S. collinoides*, *L. delbrueckii*, *L. farciminis*, *L. fermentum*, *L. helveticus*, *L. japonicus*, *L. kefiri*, *L. mali*, *L. paracasei*, *L. rhamnosus*, and *P. vaccinostercus* among others (Table 2).

The bacterial dynamics were well evidenced in fermentations of green olives cv. Bella di Cerignola throughout the fermentation process, resulting from the presence of several stirpes of *L. brevis*, *L. casei*, *L. coryniformis*, *L. mali*, *L. paracasei*, *L. pentosus*, *L. plantarum*, *L. rhamnosus*, *P. vaccinostercus* throughout the fermentation process [97]. Within the *Leuconostoc* genus, the species *L. cremoris*, *L. carnosum*, *L. mesenteroides*, and *L. mesenteroides* ssp. *mesenteroides*; *L. paramesenteroides*; *L. pseudomesenteroides* have been described. In Greece and Spain, *L. mesenteroides* and *L. pseudomesenteroides* were the most recovered from fermented olive and brine samples.

Enterococcus genus also appears closely associated with black and green olives of Italian cultivars. So far, the species *E. casseliflavus* (in Bella di Cerignola cv.), *E. durans* (in Cellina di Nardò, Itrana bianca, and Bella di Cerignola cv.) *E. faecalis* (in green olives) *E. faecium* (in Tonda di Cagliari) and *E. italicus* (in Bella di Cerignola). Among these species, only *E. faecium* appeared simultaneously in fermentations of Cyprus and Turkey olives [98,118].

Pediococcus genus is also present in smaller numbers in olive table fermentation and it showed four species; *P. acidilactici*, *P. ethanolidurans*, *P. parvulus*, *P. pentosaceus,* and *P. parvulus*, *P. pentosaceus* are the species most relevant to the fermentation of cobrançosa olives [17] and Nocellara del Belice [99] in sweetening and bringing stages.

Finally, *Lactococcus*, *Streptococcus*, and *Weissella* are the genus less identified in natural olive table fermentation. *L. lactis*, *S. thermophilus*, and *W. paramesenteroides* were isolated from five olive cvs.; Aloreña; Cypriot, Kalamata, Picual, and Bella di Cerignola. The high variability of identified species indicates how complex and uncertain is fermentation the process. On the other hand, these species make olives a product of high-potential probiotic and antifungal properties [111]. Fermented olives harbor the microbial flora largely adhered to the surface, which when consumed regularly confer several health benefits.

5. Conclusions

The Greek-style promotes table olives of high microbiological and nutritional quality, currently being described as a functional product. For this reason, researchers have focused their studies on the isolation, identification, and characterization of the microbial community. In this review, we focused on the description of research work carried out in the last years related to the identification and characterization of microorganisms in the fermentation process. Here, we report the main microorganisms identified in natural olives fermentations from different cultivars, distributed in Mediterranean countries. The high abundance and diversity of species found reflect the complexity of the process. Each microorganism is unique and may present a general behavior, appearing in fermentations of olives from different cultivars. This finding may be related to the cultivar, physical-chemical characteristics, and their brine behavior. In addition, olives from different cultivars showed different properties, from skin thickness to phenol content, which affect the evolution of fermentation. Likewise, this trend was verified in several previous studies which correlated the cultivar genotype and the quality of the fermented products. Among the yeast genera mentioned in the bibliography; *Candida*, *Cryptococcus*, *Debaryomyces*, *Pichia*, *Rhodotorula*, *Saccharomyces*, and *Zygosaccharomyces*, appear the most reported. It was found that the dominant microorganisms are undoubtedly yeasts, having identified 97 species so far. The bacteria appear in smaller numbers represented by a total of 45 species, highlighting the genera *Lactobacilli*, *Leuconostoc Enterococcus*, and *Pediococcus*. Yeasts are present throughout the process while LAB may in some cases appear in the initial phase and disappear at the end of fermentation. Several authors consider that some strains have a high potential biotechnological and can be used alone or combined as multifunctional starters to improve the fermentation process. So, the Greek-style brings together a universe of factors that are interconnected with a core of indigenous microorganisms that carry out the process of obtaining table olives.

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