UNIVERSITÀ DEGLI STUDI DI PADOVA

Department of Agronomy Animal Food Natural Resources and Environment

Second Cycle Degree (MSc) in Italian food and wine

Pleurotus ostreatus: a focus on producer and consumer in conventional and organic farming

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Abstract

Nowadays the production of edible mushrooms is spread worldwide due to the successful implementation of technology linked with their nutritional, economic, and ecological value and medicinal properties. There are 300 edible mushroom species, but only 30 have been domesticated and 10 grown commercially. There are five main genera that constitute around 85% of the world's mushroom supply, among these the *Pleurotus* occupies the second position and one of the most known species is *Pleurotus ostreatus* P. Kumm. The context of this work was part of a three-year project, YESP, funded by the Rural Development Project (RDP) of the Veneto Region and its main purpose was to carry out an analysis for the consumption and production of *P. ostreatus.* Organic and conventional farming could lead to changes in the producer and consumer perspective and possibilities. In this trial the quantitative and qualitative characteristics of two different types of mycelia inoculated in organic and conventional substrates were evaluated and two questionnaires were structured to investigate both consumer and producer behavior in the production of *P. ostreatus* P. Kumm. The consumer sample population that has been analyzed in this study was mainly composed by young females from the North of Italy. The results showed a great consumption of *P. ostreatus* P. Kumm and a high willingness to pay for organic mushrooms: the data demonstrated that the consumer would pay more for organic fungi compared to conventional ones. These findings have highlighted a great interest, for both figures investigated, in the organic product: this could lead to potentially new perspective in the production of *P. ostreatus* that should be further analyzed.

1.Introduction

1.1 Pleurotus ostreatus

1.1.1 Biology and physiology

The kingdom of Fungi count at least 100,000 different identified species but research suggest that 5.1 million fungal species exist (Peralta et al., 2017). There are five phyla (Figure 1), among these the sub-kingdom Dikarya is divided in Ascomycota and Basidiomycota, which represent 98% of the currently known species (Bindschedler et al., 2016).

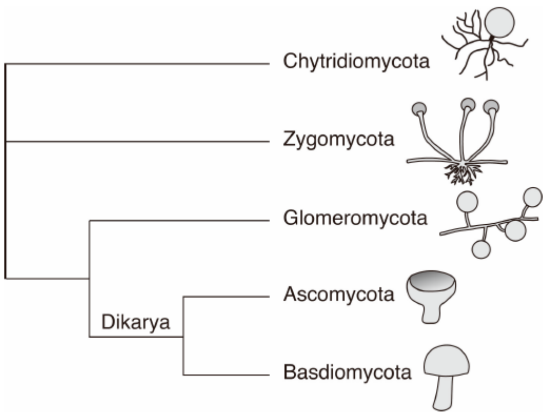

Figure 1 The phyla of Fungi kingdom.

The club-shaped structure basidium at which the spores are attached is responsible for the name basidiomycetes, which comprehend over 30,000 species: edible and medicinal mushrooms, pathogens for plants and animals, symbionts and endophytes in lichens, plant root mycorrhizas, leaves and needles, and saprotrophytes (Peralta et al., 2017). The basidiomycetes are composed of two portions: the aboveground and the underground. The top part consisting of a cap and stalk which forms the edible portion. On the underside of the cap there are numerous, thin, radiating folds or gills which produce and liberate numerous microscopic reproductive bodies or spores. The bottom portion of the mushroom, that grows extensively in the substratum before the above ground edible portion is formed, consists of a white cotton thread like growth called the mycelium (Figure 2). It permeates the organic matter to obtain nutrients like the roots of the higher plant (Oluwafemi et al., 2016).

Figure 2. A mycelium of a mushroom.

The genus *Pleurotus*, defined by Paul Kummer in 1871, is a cosmopolitan group of mushrooms native of China with high nutritional value and therapeutic properties, besides a wide array of biotechnological and environmental applications (Brugnari et al., 2016). They grow widely in tropical and subtropical areas in dead wood and the branches of living trees, especially hornbeam (*Carpinus* sp.), beech (*Fagus* sp.), willow (*Salix* sp.), poplar (*Populus* sp.), birch-tree (*Betula* sp.) (Deepalakshmi and Mirunalini, 2008). These species begun their massive spread worldwide during the first Word War in Germany, when they were introduced to create a new source of food to defeat hunger. The genre comprises about 40 species, commonly known as "oyster mushroom", because they produce different sized, grouped fruiting bodies in forms resembling a colony of oysters (Figure 3). Fruiting bodies are gray to dark brown in color, ranging in a size from 4 to 15 cm. The flesh is white, firm and varies in thickness due to stipe arrangement, the gills of the mushroom are white to cream color and descend on the stalk if present. The stipe is off-center with a lateral attachment to wood and the spore print of the mushroom is white to lilac-grey and best viewed on dark surface (Sher et al., 2011). In the wild, its fruiting bodies generally appear in autumn from October to November; however, they may be encountered during mild winters or in early warm springs (Piska et al., 2017).

Figure 3. Pleurotus ostreatus family.

One of the most known species is *Pleurotus ostreatus* P. Kumm (Royse et al., 2017) that as others of the genre have two phases in its life cycle (Figure 4): a mycelium that is usually hidden and inconspicuous with a longer growth phase followed by short-lived fruiting bodies. In the reproductive phase, after a certain amount of vegetative growth depending on the availability of the compatible strain, the uninucleate mycelium reaches the dikaryotic phase, which in turn leads to the production of fruiting bodies, bearing spores (Rajarathnam and Shashirekha, 2003).

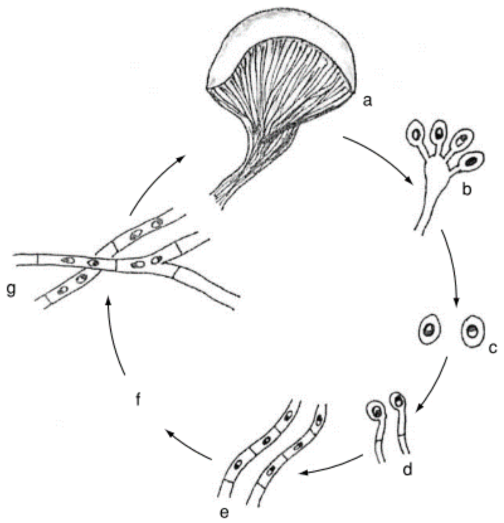

Figure 4. Heterothallic and tetrapolar life cycle in Pleurotus (a) fruiting body; (b) basidium with four genetically different basidiospores; (c) basidiospores; (d) germinating basidiospores; (e) monokaryotic mycelia; (f) dikaryotization; (g) dikaryotic mycelia.

1.1.2 Cultivation methods

Across the globe mushrooms have been considered as an ingredient of gourmet cuisine, since ancient times, especially for their unique flavor. The Egyptians, 4600 years ago, thought that mushrooms were plants of immortality. The Romans thought mushrooms were the food of the gods. In China and Japan mushrooms have been used for medical purposes for thousands of years. They have been judged as a delicacy with high nutritional and functional value, and they are also accepted as nutraceutical foods; they arouse interest because of their organoleptic merit, medicinal properties, and economic significance (Valverde et al., 2017). The consumption of mushrooms' species is different among countries and the technique of obtaining the desired ones has evolved during times: from the collection into the wild, that is still common in some part of Asia, to the cultivation methods. In Europe the first cultivated mushrooms date back to 1650 in France. *Agaricus bisporus* was first observed growing in melon crop compost. This mushroom was cultivated in open fields for 160 years and then moved underground into caves, excavated tunnels or quarries. From there, the diffusion of cultivated mushrooms has touched first England, United States and then the rest of the world (Smith, 1978).

Nowadays the production of edible mushrooms is spread worldwide. Their large-scale commercial production derived from the successful implementation of microbial technology characterized their nutritional, economic, and ecological value and medicinal properties (Sekan et al., 2019). The genus *Pleurotus* accounts for 27% of the global production of cultivated edible fungi (Raman et al., 2020). The beginning of the *Pleurotus* production starts with the need to obtain pure mycelium of the specific mushroom strain. This can be from spores, from a piece of the specific mushroom, or from several germplasms. The inoculation is made from the development of the mycelium on cereal grain such as wheat, rye, or millet which is generally called the "spawn". The purpose of the mycelium-coated grain is to rapidly colonize the specific bulk growing substrate. The fundamental element for the production is the quality of the "spawn", which must be prepared under sterile conditions to diminish contamination of the substrate. The cultivation of *P. ostreatus* is relatively complex and it involves numerous phases: substrate preparation, inoculation, incubation, and production conditions depend on the mushroom species to be cultivated. In the first step substrate is milled to a length of about 2 to 6 cm. Usually the most common substrates used for modern mushrooms is a mixture of cotton- seed hulls and wheat straw that has a higher water holding capacity than cottonseed hulls used alone. Pasteurization is performed at 60 °C for 1 to 2 h and ingredients and water are put into revolving mixers. After this passage there is the inoculation in which the substrate is cooled and spawned with the desired strain (Sánchez, 2010). There are several different types of cultivation methods, however, the indoor ones made on artificial logs with plastic bags filled of nutrient complemented sawdust-based substrates, is usually the most common system (Dulal and Thompson, 2019). In the *Pleurotus* cultivation shelves and bags are the main system. Once the bag is colonized with the mycelium (Figure 5), holes are punched into the plastic to allow the future mushroom fruiting.

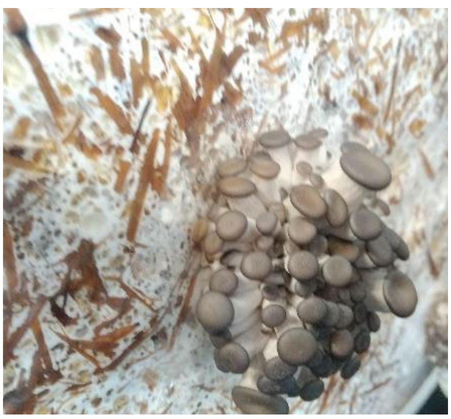

Figure 5. A bag colonized with mycelium of P. ostreatus.

Cultivation of *P. ostreatus* results in about 50% carbon dioxide, 20% water, 10% mushrooms, and 20% residual compost (Grimm and Wösten, 2018). In the phase of incubation, the bags are kept at 25 °C for 12 to 14 days and then transferred to the production room. The formation of the mushrooms starts to form around the edges of the bag perforations. The bags are maintained under optimal temperature, moisture and other conditions for mycelium growth, and the conditions that favor fruiting. The harvest begins with the escape of primordials (Figure 6) and the collection happens when the cap of the largest mushroom in the cluster, begins to be concave (Dulal & Thompson, 2019).

Figure 6. Primordials of Pleurotus ostreatus.

The harvest (Figure 7) usually takes from 3 to 4 weeks after spawning depending on strain, amount of supplement used, and temperature of spawn run (Sánchez, 2010).

Figure 7. Bags of Pleurotus ostreatus ready for the harvest.

1.1.3 Nutritional value

Several are the roles of *Pleurotus*: in cuisine for their unique taste and subtle flavor, but also in the medical field as sources of important nutrients such as dietary fiber, minerals, and vitamins, in particular, vitamin D. Recently, they have become increasingly attractive as functional foods due to their potential beneficial effects on human health (Brugnari et al., 2016).

P. ostreatus is one of the most important cultivated mushroom worldwide (Deepalakshmi and Mirunalini, 2008) and its nutritional composition lead to unique flavor and aromatic properties: the amount of terpenes, lactones, amino acids, carbohydrates, fat and their composition determine a range of precious aromas and flavor characteristics to their fruiting body and mycelial biomass. The qualitative and quantitative chemical properties could change significantly among different strain, origin, extraction process cultivation condition and substrate (Sánchez, 2010).

Studies were carried out concerning the chemical composition of *P. ostreatus* P. Kumm. The flesh is characterized by 85-95% moisture, similar to other fungi and the fruiting body contains approximately 100 different bioactive compounds. The mycelium of *P. ostreatus* has great nutritional value, due to the presence of high contents of amino acids (arginine, alanine, glutamine, glutamic acid). The proteins of these mushrooms begin to be recognized as a promising source of novel proteins, in fact, many of these compounds has shown unique features. The protein fraction occupies 28.85% in the fresh and 17 to 42 g for 100g of dried fruit bodies (Tolera and Abera, 2017); 7 mg of amino acids are present in 100 g of the edible part. Nevertheless, as mentioned above, the content of protein could vary according to different factors. This fraction has a superior quality due to the containment of complete proteins and of essential amino acids, as well as non-essential amino acids. Among these high amounts of c-aminobutyric acid (GABA), that it is required for brain functioning and mental activity has been found. Additionally, the muscle proteins used in the treatment of wasting muscles after illness or postoperative care and ornithine has been detected. Non-protein nitrogen compounds are in the form of amino acids, chitin, and nucleic acids. Among these lectins, lignocellulolytic enzymes and proteases inhibitor can be used for medicinal and biotechnological problems such as microbial drug resistance, low crop yield and demands for renewable energy (Deepalakshmi and Mirunalini, 2008).

The carbohydrates fraction in *P. ostreatus* P. Kumm are primarily involved in the structural composition except for sugar-free components, and they represent about 51 grams on 100 grams of dried mushrooms. Other important compounds, relevant especially for market purpose, are dietary fibers. They are not digestible by humans, but they have important physiological benefits. The composition of this part is built upon chitin, polysaccharide β-glucans and chain β-linked polymer of N-acetyl-glucosa- mannans that are present in their cell walls (Mora et al., 2014). The fiber content is abundant (10.21%) and it gives up to 25% of the dietary fiber recommended. The richness in β-glucans and in phenolic compounds such as protocatechuic acid, gallic acid, homogentisic acid, rutin, myrictin, chrysin, naringin, tocopherol like α-tocopherol and γ- tocopherol, ascorbic acid and β-carotene have an important role for their medical effects. There is an active branched β-glucan, named pleuran, that is as an immunomodulatory agent with potential applications in the treatment of cancer, infections, and immune system disorders.

The higher amount of celluloid substances, including dietary fiber, leads mushrooms as a low-calorie diet with higher therapeutic value for diabetic patients to counteract alimentary ulcers and reduce obesity (Raman et al., 2020).

The lipids content is low (0.1-0.2 grams on 100 grams of fresh mushroom) however, they are excellent sources of fatty acids especially oleic acid (40%), linolenic acid (55%), and other compounds with hypocholesterolemic action. The content of saturated fatty acid is relatively small (≈10%) (Piska et al., 2017). Moreover there is evidence that the accumulation of low-density lipoproteins and very-low-density lipoprotein significantly reduces the total cholesterol (Schneider et al., 2010).

The mineral component is of increasing importance: high contents of mineral salts of potassium, phosphorus, calcium, iron, copper, zinc, magnesium, and selenium were found. The vitamin fraction is opulent, particularly the vitamins of the group B: thamine, riboflavin, pyridoxine, pantotene acid, nicotinic acid, nicotinamid, folic acid and cobalamin as well as other vitamins such as ergosterol, biotin, phytochinon and tocopherols (Deepalakshmi and Mirunalini, 2008). In 100 g of fresh mycelia, the level of vitamin C represents 15% of the recommended daily intake for humans. Besides the richness in protein, carbohydrates, vitamins and minerals are low in calories (Deepalakshmi and Mirunalini, 2008), with an average calorific value of 151 J in 100 g of edible part (Manzi et al., 2004).

The impact on human health of this species could be explained by different activities such as anticancer, antihypercholesterolemic, antihypertensive, antidiabetic, antiobesity, hepatoprotective, antiaging, antimicrobial, and antioxidant. Also, there are compounds important for medical purposes. The lovastatin is a market drug used in the treatment of dyslipidemia, found in the lamella of mature mushrooms, that acts as an inhibitor of HMG-CoA reductase (Chen et al., 2012) Ergothioneine is a compound which is accumulated in animal cells and tissues exposed to oxidative stress; however, it is not synthetized and due to its role not only as an antioxidant, but also as an antimutagenic, chemo- and radioprotective agent; it is suitable in adjuvant treatment of strokes, neurodegeneration, and cardio-vascular diseases (Cheah and Halliwell, 2012).

1.2 Economic insights: the Italian and foreign market

There are 300 edible mushroom species, but only 30 have been domesticated and 10 grown commercially (Sánchez, 2010). There are five main genera that constitute around 85% of the world's mushroom supply: *Lentinula* is the major one, contributing about 22% of the world's cultivated mushrooms. *Pleurotus* is a close second, with five or six cultivated species, constituting about 19% of the world's output while *Auricularia* contributes around 17%. The other two genera, *Agaricus* and *Flammulina*, are responsible for 15 and 11% of the volume, respectively (Royse et al., 2017). All these species require shorter growth time when compared to other edible mushrooms, they demand few environmental controls, and they can be cultivated in a simple and cheap way (Reis et al., 2017). Nowadays the production of edible mushrooms is spread worldwide due the successful implementation of technology linked with their nutritional, economic, and ecological value and medicinal properties (Sekan et al., 2019).

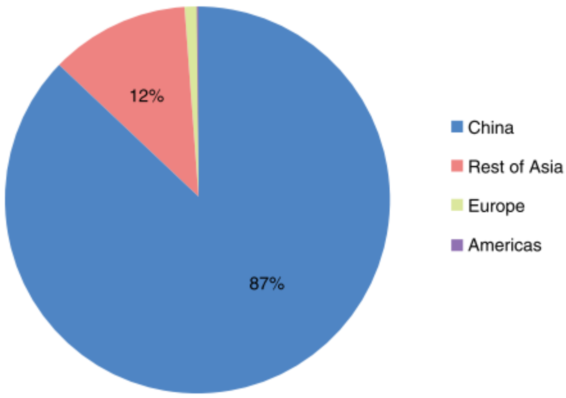

Figure 8. Percentage of total world Pleurotus spp.

China is the main producer of cultivated edible mushrooms, about 87% of total production. Europe, Americas, and other countries have a production of 3.1 billion kg, while aside from China, the rest of Asia produces around 1.3 billion kg. According to the Food and Agriculture Organization (FAO), the five main producers of mushrooms and truffles in 2014 were China (7.63 million metric tons), Italy (600 thousand metric tons), United States (423 thousand metric tons), Netherlands (310 thousand metric tons), and Poland (254 thousand metric tons). Portugal was the 44th producing country in 2014, with an overall production of 1443 metric tons (Boin and Nunes, 2018). The mushroom market in the United States has a gross production index number of 89.93 million, while the European one has 109.11 million (FAOSTAT, 2019). The USA mushroom production has a value of 63 billion dollars, where the leading component is formed by cultivated and edible mushrooms that account for

54% so $34 billion. Medicinal mushrooms make up 38% or $24 billion and wild mushrooms account for 8% of the total so $5 billion (Figure 9).

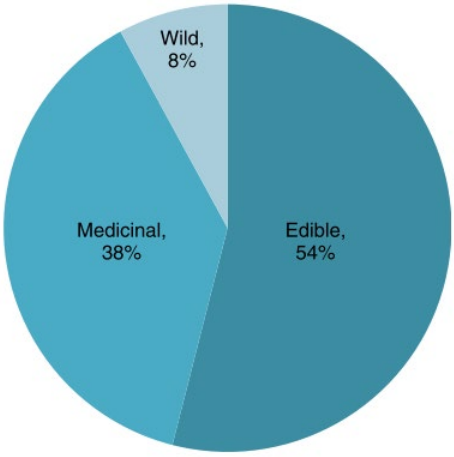

Figure 9. The repartition of USA mushrooms production.

As mentioned before cultivated edible mushrooms have an important impact on human health and nowadays at global level the consumption has reached 4.7 kg annually (Royse et al., 2017). *Pleurotus* species are cultivated on a large scale using a wide range of agro-substances with simple and low-cost techniques. Furthermore, these mushrooms could use agro-wastes, which amount around 998 million tons per year, as substrates for their growth, and thus, the cultivation of them helps in recycling agro-wastes and alleviates the nutritional gap mainly prevalent among the population of China, India, and Africa. The spent substrates are used as fertilizer, animal feed, and biogas production. The possibility to be used for different purposes lead *Pleurotus* species to increase their market value. Also, beside the edible cultivated market, the ability of *Pleurotus* species to absorb heavy metals from the environment can be helpful in recovery strategies, such as mycoremediation (Raman et al., 2020). In Italy the production of mushrooms is around 62000 tons: 54000 of which is devoted to the fresh market and just 8000 to the industry. The country is at the 7th spot among the EU ranking for the production of mushrooms, however, the value of the consumption is well over the 75000 tons that are equal to a pro-capital value of 1,2 kg per year. In Italy the data for the production of cultivated fungi shows the following trend: 78% *Agaricus bisporus,* 8% *P. ostreatus* and 14% from other fungi: *Cyclocybe aegerita*, *Lentinula edodes* and *Pleurotus eryngii* (AIF, 2018). At world level *P. ostreatus* is cultivated on large scale, however, their demand due to a low shelf life is still low in global market (Raman et al., 2020).

The production chain is composed of spawn developers, growers that may be large or small, retailers (fresh market but also supermarket) restaurants, mushroom consumers, and its value involves the entire production process. It is important for the producers to understand which are the activities that create added value and eliminate the ones that are not profitable. The value chain is made up of multiple interdependent activities. By rebalancing and arranging the organizational structures, activities are optimized to achieve the competitive advantage. At the same time working to achieve effectiveness and efficiency by reducing production costs, differentiating the product, and reducing logistics, distribution and use costs of the product itself. The decisions regarding the configuration of the chain must consider the satisfaction of the customers, which therefore influences the relationships and the organizational form of the activities. The value chain in this production comprehends primary and support activities. Primary activities involved in the development and management of the mushrooms, involve mycelium logistics and harvest, and the marketing and sales activities. The support activities, that are those of procurement, technological development, human resource management and infrastructural activities give transversal support to the primary activities (Goncharuk, 2017).

The industry of cultivated mushrooms is a highly perishable commodity, and as such their marketing is invariably associated with high costs. This condition has led to require rapid and refrigerated transportation to consumption centers or immediate processing into less perishable forms. This limits the period during which mushrooms can be marketed as a fresh commodity or used as raw material in processing. Such conditions normally subject producers to limited marketing flexibility as they often find themselves in an unfavorable bargaining position, particularly against buyers who have alternative sources of supply (Ortmann and Lecturer, 2013).

1.3 Consumer behavior in mushrooms consumption

The consumer behavior and the factors influencing it represent a great opportunity to build better marketing strategies and targets, beside the improvement of user-oriented products. Although the above-mentioned topics are important for the producers in economic terms, research on them is still at the beginning. The categorization of the consumer through demographic factors such as age, income, gender, and occupation separate them from other behavioral factors which leads to a gap in which aspects drive food choices.

The work of Boin and Nunes of 2018 on Portuguese population about the mushroom consumption is one of the few European studies on the topic. It is used, in this case, to draw similarities with Italy, due to similar per capita income among the two countries (EUROSTAT, 2018), similar legislation and similar diet (Philippou et al., 2020). Italy is one of the first European countries for the daily consumption of vegetables (Organic F & V Monitor, 2020) and because mushrooms are usually considered as vegetables, there is the possibility to include mushrooms in daily meals. According to a recent market research, mushroom consumption may even rise due to current consumer preference for value-added products, health benefits, and the increasing awareness among consumers about these benefits.

The amount of different species of mushrooms consumed vary according to the country, nevertheless, the types are quite similar worldwide: Italy, (AIF, 2022), United States (Lucier et al., 2003) and Mexico (Mayett et al., 2006) consumes in majority the *Agaricus*, whereas, in China *Lentinula* is the most widely grown mushroom accounting for over 7 billion kg (Royse et al., 2017). Moreover, the frequency of the mushroom's consumption is different. In China the utilization is not regular: the consumption is low, with a 51,6% of consumers that use them once or twice a week, while, 43% once in a while and the remaining part, three times per week or more (Wen et al., 2016). In Portugal the use of mushrooms is increasing, but their consumption is represented by 41% of consumers that purchase them once a week and 23.7% that uses them at least once in a month (Boin & Nunes, 2018). In the case of Mexico the frequency of mushroom consumption varies from one to four times per week (49.4%), one-two times per month (41.6%), daily (5.3%) and occasionally (3.7%) (Bringye & Fekete-farkas, 2021).

The current trend for vegetarian and vegan diet (Leitzmann, 2003) has led to an increase in the consumption of mushrooms due to the fact that they have been widely used as sources of meat substitutes.

Among the many factors that can influence the behavior there is the color of the mushroom, as reported by the Indian study of Shirur in 2014. It was found that the shade was the major influencing factor of the respondents' opinion in purchasing the mushrooms. The next factor influencing the purchase was the shape and then the size whereas price was the least influential aspect of their purchase. Hence, price is a secondary matter for consumers (Shirur et al., 2014).

The most common types of mushrooms that sell in the market are canned and fresh. The market of frozen and dried mushroom is small and sparse; however, companies are trying to develop techniques to increase shelf life of mushrooms which may lead to a change of this behavior in the future. The studies available have not showed differences between countries based on the type of mushrooms consumed: canned and fresh are the most common ones. In the United States, canned mushroom consumption gradually declined (Lucier et al., 2003) after 1990 and in Mexico, it was reported that consumers ate two times more fresh mushrooms than canned mushrooms (Mayett et al., 2006). In the case of Portugal both canned and fresh mushrooms presented high consumption frequencies, the difference between the number of factors that influenced consumption of each type reveals that canned mushrooms are seen as established products in the supermarkets. Thus, they are consumed regardless of the socio-demographic profile (except for gender), in contrast to fresh mushrooms, whose consumption is influenced by many socio-demographic aspects. The gender and household size influenced frequency of fresh mushroom consumption negatively, whereas age, education, and income influenced positively. Therefore, women were also more likely to consume fresh mushrooms with higher frequency, as well as people that lived in smaller households. Moreover, the price of the products also may influence purchase and consumption decisions because fresh mushrooms are more expensive than canned mushrooms (Boin & Nunes, 2018). This is also true for the US case, however, it is important to consider that if a member of the household dislikes the product it will not be purchased, since the dishes are made for the entire household. Likewise, for mushroom eating habits, the overall frequency of consumption, for fresh and dried, the education level was a positive influencing factor, which reinforces the discussion on a development of consumer education and awareness on mushroom benefits and gastronomic options as a method to promote mushrooms. Household size, education level, and gender were the factors that influenced most variables, and age was positively associated with mushroom consumption behavior, and income was the least influencing factor on mushroom consumption behavior (Lucier et al., 2003). Nevertheless, a study carried out in Shanghai (China) in 2016 by Wen reported that gender, education level, and household size had no significant effect on the frequency of mushroom purchase.

Outside of varietal preference, no study has examined the role of marketing strategies, such as labeling (e.g., locally grown, and organic) on consumer preference for mushrooms. It could be important for producers and retailers to identify their consumer base to make critical production and marketing decisions. The American study by Chakbrabarti in 2019 on the consumer willingness to pay for various labels (organic local and non-GMO) could be used to understand the importance of the tags. Based on the results of this study, stakeholders in the mushroom industry can adapt their marketing strategies to capture heterogeneous consumers at farmers' markets, restaurants, gourmet groceries, and other specialized outlets. Consumers have shown an indirect preference for local products in terms of not being willing to pay a higher price for imported products or mushrooms grown outside the state. Overall, results showed that if mushrooms were appropriately labeled either "locally grown" or "organic," producers and retailers could increase their mark-up for a select group of consumers. Notably, mushroom producers and retailers that are targeting our label-oriented class should focus on promoting their mushrooms as locally grown given the preference for local mushrooms (Chakrabarti et al., 2019).

1.4 Organic farming and labelling: the Italian case study

The Green Revolution technologies, which started at the end of the 1950s (Pimentel, 1996), supported by policies, and fueled by agrochemicals, machinery and irrigation, are known to have enhanced agricultural production and productivity. The use of fertilizers and pesticides, the two major inputs of the green revolution, need fossil fuels or expensive energy, and are associated with serious environmental and health problems. The situation over the last decades has started to become highly critical: modern agricultural farming practices, along with improper use of chemical inputs have resulted in a loss of natural habitat balance and soil health and has also caused many hazards like soil erosion, decreased groundwater level, soil salinization, pollution due to fertilizers and pesticides, genetic erosion, ill effects on environment, reduced food quality and increased the cost of cultivation, rendering the farmer poorer year by year. In this context, alternative farming techniques and strategies have become widespread, among these organic farming is the most widely used nowadays. It was defined by the FAO in 1999 as '*a holistic production management system which promotes and enhances agroecosystem health, including biodiversity, biological cycles, and soil biological activity. It emphasizes the use of management practices in preference to the use of off-farm inputs, taking into account that regional conditions require locally adapted systems. This is accomplished by using wherever possible, agronomic, biological and mechanical methods, as opposed to using synthetic materials, to fulfill any specific function within the system*'. The term conventional farming refers to a production system which employs a full range of pre and post plant tillage practices, synthetic fertilizers, pesticides and a high degree of crop specialization (Economics & Library, n.d.).

The organic farming origin dates back to the 1920s in Germany with Rudolf Steiner's course on *Social Scientific Basis of Agricultural Development*. However, the research and practice of organic agriculture has begun to expand worldwide just after the 1960s and a new stage of growth has started in 1990s. During these years its enforcement has been made through the foundation of trade organizations for organic products, the implementation of organic farming regulations and the promotion by both governmental and non-governmental organizations. The organic food production during these years has been managed with the introduction of regulations: the government of the United States published the regulation for organic food products in 1990, the European Commission adopted EU regulation 2091 on organic agriculture in 1991 that became a law in 1993 (IFOAM and FAO, 2002). Organic farming had rapidly developed worldwide during this stage and the main drivers for a steady market and production growth were the commitment of many retail chains as well as favorable policy conditions. Together these had created conditions favoring a harmonious increase in supply and demand. The state support for organic farming research and legal framework was increasingly gaining importance since the end of the 1990s (Shi-mingl & Sauerborn, 2006). Nowadays the organic legislations throughout the world are different.

In the European Union, since the 1st of January 2022, Reg 2018/848 of the European Parliament and of the Council of 30th May 2018 is the applicable legislative act, also known as the basic act, laying down the rules on organic production and labelling of organic products, repealing and replacing Council Regulation (EC) No 834/2007 of 28 June 2007. The aim of the regulation on organic farming is to provide a clear structure for the production of organic goods across the whole EU. There is the need to satisfy consumer demand for trustworthy organic products whilst providing a fair marketplace for producers, distributors, and marketers. The farmers benefit from organic farming methods, however, the consumers need to trust that the rules on organic production are being followed. Therefore, the EU maintains the following strict system of control and enforcement to guarantee that organic rules and regulations are being followed properly. Each member country establishes control bodies to inspect operators in the organic food chain. Producers, distributors, and marketers of organic products must register with their local control body before they are allowed to market their food as organic. After they have been inspected and checked, they receive a confirmation that their products meet organic standards through a certificate. All operators are checked at least once a year to make sure that they are continuing to follow the rules. Furthermore, imported organic food is also subject to control procedures to guarantee that they have also been produced and shipped in accordance with organic principles (European Parliament and Council, 2018). The new legislation of 2022 includes a strengthening of the control system, to build further consumer confidence in the EU organics system, an easier conversion to organic farming for producers, new rules on imported products to ensure they follow the EU standard and a greater range of products that can be marketed as organic. Policy support for organic farming has gradually been strengthened by the evolution of the Common Agricultural Policy (CAP) towards greater allocation of the EU budget. The European Commission has put also a lot of effort into monitoring the results of the CAP, as European funds represent the main source of subsidies to agriculture in most European countries (Cisilino et al., 2019). The political context in which polices are applied and implemented is important: rural areas showed significant challenges compared to the urban ones and this has led to an increased focus of policies for those areas. The cross-sectorial approach of governments around the world has the tools to improve equity, stewardship of rural resources and competitiveness of rural areas (OECD, 2006)

In the EU the economic performance of both organic and conventional farming is strongly influenced by rural development policies. Since the year 2000 there has been a growing attention and sharp redirection of public support from intensive and polluting agriculture towards sustainable practices encouraging positive externalities by generating a change of approach towards a greener farm management. To meet this challenge, working advisory and institutional mechanisms were needed, as well as legal measures to correct negative externalities. In this context the role played by regional Rural development programs was very important. The increasing spread of organic farming in Europe during the last decades has stimulated the interest of many economists in terms of both economic and environmental performance. The aim of comparing organic and conventional farms was to evaluate the estimate of the impact of the policy on the environmental and economic effects of organic farming as subsidies under the Rural Development Policy. In recent decades, RDPs under the CAP have been the most important tool for fostering organic farming in Italy's regions (Cisilino et al., 2019) . The Rural development program (RDP) 2014-2020 has introduced some novelties among which a multi-level governance approach and a strategy into six priorities and sub-divided in 18 focus areas (European Commision, 2020). Furthermore, at the Italian level there are other strategies implemented for the integration of rural areas: rural district, territorial pacts, and integrated territorial projects.

The data of the organic environment, made available by IFOAM in 2020, shows that over 74.9 million hectares are organic agricultural land, including in-conversion areas. The regions (Figure 10) with the largest organic agricultural land areas are Oceania (35.9 million hectares – almost half the world's organic agricultural land) and Europe (17.1 million hectares, 23%). Latin America had 9.9 million hectares (13.3%), followed by Asia (6.1 million hectares, 8.2%), Northern America (3.7 million hectares, 5.0%) and Africa (2.1 million hectares, 2.8%).

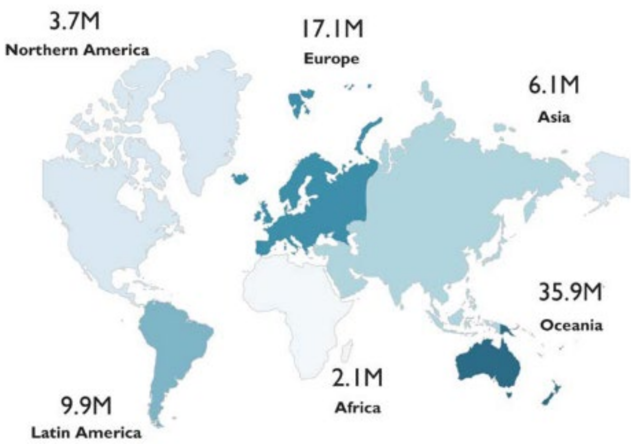

Figure 10. Organic agricultural land in hectares.

In the EU, France with almost 2.5 million hectares, is the number one in terms of farmland under organic management, followed by Spain (2.4 million hectares), Italy (2.1 million hectares) and Germany (1.7 million hectares). In 2020, there were almost 350000 organic producers and 78000 organic processors in the European Union: Italy is the country with the largest number of producers (more than 70000) and of processors (22689).

The organic market in the United States had the lead with 40.9% of global retail sales of organic products followed by the European Union with the 37.1%. The latter has grown around 15%, doubling its size in ten years. More in depth, the highest per capita consumption (Figure 11) of organic food was in Switzerland (418 euros) and Denmark (384 euros).

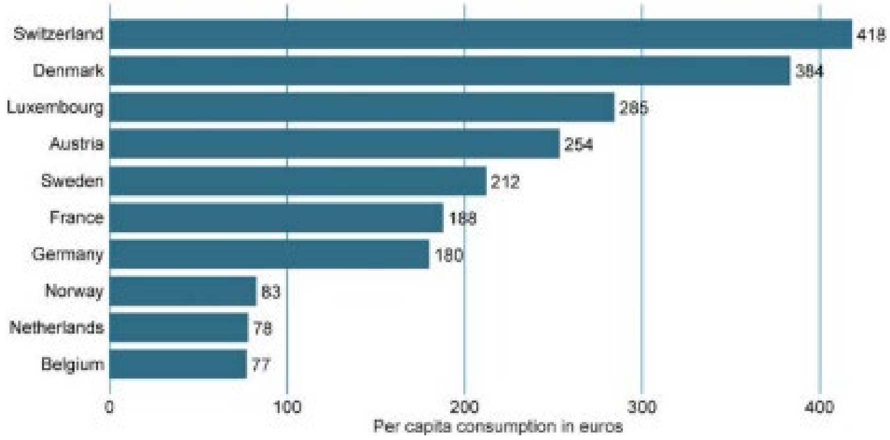

Figure 11. The countries with the highest per capita consumption in 2020.

The continual growth in consumer interest is documented by the development of per capita consumption that rose to 101.8 euros in the European Union. The framework for detailed retail sales data is scarce for some countries and it is not regularly updated: the Czech Republic and Estonia are the only countries with a permanent collection system. Generally, organic fruit and vegetables continue to be a highly popular purchases among European organic consumers. In organic agriculture the marketing channels are particularly important, and they vary from country to country. In the past, countries with strong involvement by general retailers showed steady organic market growth (e.g., Austria, Denmark, Sweden, Switzerland, and the United Kingdom). France and Italy are good examples of countries with strong market growth, where specialized retailers play a significant role, even though their importance is decreasing.

The organic logo (Figure 11) gives a coherent visual identity to EU produced organic products that are sold in the EU.

Figure 12. Organic EU logo.

This makes it easier for EU consumers to identify organic products and helps farmers to market them across all EU countries. The organic logo can only be used on products that have been certified as organic by the authorized control body (European Parliament and Council, 2018).

Many sensorial analysis studies, based on trained descriptive panelists and consumer panels, were tested for the differences among organic and nonorganic products (i.e., fruits, vegetable, yogurts), however, they have not detected major sensory differences (Apaolaza et al., 2017). Nevertheless, the organic label could be a factor that influences consumer behavior. Although the scarcity of the references on this topic is wide, Poelman in 2008 has carried out a study about the consumer perception of pineapple based on the information on organic production. The subjects, separated into subgroups with similar positive or negative attitudes towards organic information, have showed that the same cognitive information evoked opposite affective reactions in different subjects. Organic information is generally assumed to have a positive effect on consumers' evaluations (Spence and Townsend, 2006): subjects with a positive attitude towards organic production perceived products to have a stronger sensory impact in the presence of such information than in its absence. Similarly, subjects with a negative attitude towards organic products perceived products to have a weaker sensory impact in the presence of such information than in its absence. Thus, the appropriate label leads to a more favorable perception in subjects with a positive attitude towards products labelled as such. These could be caused by the ‘‘halo” effect: a perceptual bias in which one salient attribute determines the overall impression of a person or an object, affecting the perception of other conceptually distinct and independent attributes. In product perception, the halo effect occurs when the evaluation of one specific quality of a product attribute strongly impacts or biases the perception of other characteristics of the same product. Also a study on the perception of organic label on wine showed that organic labeling increases hedonic evaluation and purchase intention: it increases sensory ratings and perceived healthiness, providing a process explanation for this effect (Apaolaza et al., 2017).

There is no research on the organic labelling of mushroom and on its effect on consumer behavior. This absence, however, could act as a catalyst: consumers could not only associate health benefits with organic mushrooms, but also there could be expectancy beliefs involved that in addition to increasing hedonic ratings, induce a more intense experience of sensory properties. This could have significant implications for marketers of organic mushrooms and consumer policy aimed at promoting consumption of organic produce.

2. Aim

Nowadays consumer attitude towards food is complex to understand: internal psychological and external influence factors have to be considered. The global trend for organic food is increasing, however, the knowledge about the impact of this certification on different categories of products are just at their beginning.

P. ostreatus cultivation occupies an important market share in the sale and production of edible mushrooms. Nevertheless, there is a general unawareness of organic labelling on mushroom farming and an absence of references related to its impact both on producers' revenue and on the consumers' behavior. The context of the experiment is part of a three-year project, YESP, funded by the Rural Development Project (RDP) of the Veneto Region, aimed at improving and stabilizing the production system of *P. ostreatus*. The main goals of it are the identification of new growing facilities useful to improve oyster mushroom production, the efficient combination of organic matrix for the suitable cultivation substrates of *Pleurotus* without pathogens and innovative growing techniques and post-harvest tools to increase the oyster mushroom shelf-life. In this trial the quantitative and qualitative characteristics of two different types of mycelia inoculated in organic and conventional substrates were evaluated. The main purpose of this work is to carry out an analysis for the consumption and production of *P. ostreatus:* organic and conventional farming could lead to changes in the producer and consumer prospective and possibilities.

3. Materials and Methods

3.1 Cultivation and experimental setting

The study was conducted inside a mushroom farm located at the "Lucio Toniolo" experimental farm of the University of Padova. The structure was 25 m long, 8 m wide and appears to be an effective commercial module, on a small scale, for mushroom production so its construction characteristics are the same as those of facilities for large-scale production. The climate control equipment technologies are similar to the ones that could be found in production facilities: the refreshment is provided by an irrigation system using micro sprinklers and cooling system. The heating is managed with a diesel-fueled hot air generator equipped with a fanjet. The ventilation system aims to expel carbon dioxide and ensure proper air exchange. Moreover, the appropriate air recirculation and homogeneity of environmental conditions in the greenhouse are implemented with an additional fan, installed in the middle of the structure. The microclimate inside the mushroom farm (Figure 13) was carried out with automatic system.

Figure 13. Part of the cultivation of Pleurotus ostreatus inside "Lucio Toniolo" farm of the University of Padova.

Nine fixed sensors (three sensors for each of one of the three production blocks) were installed at a height of about 50 cm from the floor, to continuously measure relative humidity, air temperature, and brightness. The monitored data was sent to a control unit with reference parameters which automatically activates a system to correct and restore the values close to the desired ones. The sensor for monitoring CO_2 concentration was unique and it was located on the north wall of the mushroom farm. In addition to the sensors, the mushroom farm is also equipped with 3 mobile sensors (one sensor per growing block) that were used to measure the temperature of the growing medium inside the bags.

Part of the experiment, as reported earlier, evaluated the effect of mycelia on substrate on *P. ostreatus* production to identify any differences among treatments. The substrates provided by an important Italian producer, were two: one organic and one conventional. They were identified through the respective abbreviations B and C. Their inoculation was done with 2 different types of mycelia, P80 denominated as M1 and P73 named as M2. Overall, the trial considered 192 bags of substrates inoculated with *P. ostreatus* divided into four different treatments (Table 1) within 3 blocks with north-south orientation.

Table 1. Average weight, number of bags and holes divided per type of substrate and mycelium.

Mecelyum	Substrate	NUMBER OF BAGS	AVERAGE WEIGHT FOR BAG (G)	NUMBER OF HOLES
M1	**B**	48	29,10	22
M1	**C**	48	26,95	22
M2	**B**	48	27,29	22
M2	**C**	48	26,98	22
Total		192	27,58	/

Each block had the four combinations of mycelia and substrates. Their arrangement was done through an experimental design of randomized blocks. Each block was then divided into 4 smaller grids with 16 bags. These 16 bags were then arranged in pairs each having a different treatment (Figure 14).

BLOCK	TREATMENTS			
3	M1B	M1C	M2B	M2C
2	M2C	M2B	M1B	M1C
1	M1B	M1C	M2B	M2C

Figure 14. The blocks are three and per each four treatments were assessed

3.2 Cultivation phases

The trial began with the arrival of the bags of inoculated substrate at the farm and their placement inside the mushroom house on the 5th of January 2022. Once the bags of substrate were placed, a sufficiently representative number of samples were taken in order to perform the chemical and physical characterization of the four types of treatments. This analysis was applied in the laboratory with the measurements of: dry matter, relative humidity, content of Carbon (total, inorganic, organic), Nitrogen (N), Phosphorus (P), Potassium (K) and heavy metals (Cr, Cd, Cu, Zn, and Pb). Throughout the cultivation phase, the bags were randomly monitored to assess the average temperature of the substrate, an important indicator for assessing the biological activity of the mycelium; in addition, a periodic assessment of the condition of mycelium emergence and health was carried out. The following environmental parameters were measured during the test: environmental and substrate temperature (°C), relative air humidity and environmental light intensity.

3.2.1. Incubation phase

The incubation phase began simultaneously with the bag placement with an average temperature of 18 °C. This stage lasted until the emergence of the primordia, during which, thermal bag temperature measurements were taken. This allowed the distribution of heat loss from the substrate to be assessed, allowing the zones of maximum mycelium growth to be evaluated.

3.2.2. Emergence phase of primordia

The end of incubation has coincided with the emergence of primordia, which are in the form of small clusters resembling many match heads that emerged from the holes in the bag. The time between the outing of the primordia and the first sprint is relatively short as the mycelium after the incubation period expresses itself to the maximum and with a certain uniformity. During this phase, the primordia developed on each bag were measured almost daily.

3.2.3. Maturation stage and appearance of fruiting bodies

The beginning of this phase starts when the differentiation of the primordia, with an obvious reduction in the number of fruiting bodies, has occurred. Development both in terms of size and volume of fruiting bodies at this stage is very rapid, with evident growth within the same day. If environmental conditions are optimal, the rates of ripening and therefore harvesting vary from 1 to 3 days. During this stage, especially during the first sprint, harvesting operations were carried out on average every 2 to 3 days depending on the stage of maturity of the fruiting body. One of the most important aspects considered during the harvest were the individual families' fruiting bodies: wide, expanded caps with the edge slightly downward. Collection of the mushroom families was done manually by detaching the fruiting bodies directly from the substrate (Figure 15).

Figure 15. Families ready to be harvested.

3.3. Morphological and yield analysis

After the harvest, the production obtained was subjected to different measurements. The first was the weight of the whole production harvested from each bag to quantify the yield individually. Then, three of the most representative families of daily production for each bag were chosen: on these the evaluation of the weight, number of fruiting bodies for each family, width, thickness of the fruiting bodies and colorimetric analysis were carried out. Three measurements were made both for the width (cm), from one end to another of the cap and for the thickness (mm) with a pre-calibrated electronic caliber. The colorimetric analysis for the three was made by Minolta CR200 tristimulus colorimeter by detecting the coordinates L*, a*, b* (Figure 16).

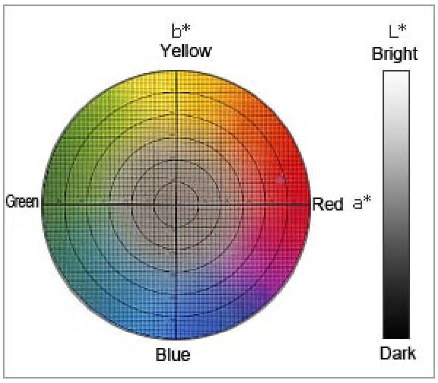

Figure 16. Rating scale use for colorimetric analysis.

L*: measures the color intensity from black to gray

a*: measures the color band from green to red

b*: measures the color range from blue to yellow

The following process was the preparation of the three samples for qualitative analysis. One sample was placed in a ventilated oven at 65°C to obtain the dry matter percentage, while the remaining two were frozen to be later used for qualitative analysis and determination of total antioxidants and polyphenols.

3.4. Qualitative analyses

The qualitative analyses aimed to characterize the product according to several parameters, including dry matter, soluble solids content, pH, electrical conductivity, and titratable acidity. To determine the amount of the dry matter of the fruiting bodies, portions of *P. ostreatus* were weighed and then placed in an oven at 65°C for 48 hours. At the end of it, the sample was weighed again to obtain the amount of water evaporated and thus, through the difference among them, obtain the level of dry matter. One of the two previously frozen samples was thawed to obtain the cell juice contained within the fruiting bodies; this juice was used for the analysis described below. An aliquot of the juice was also used for the determination of soluble solids content (°Brix), which was carried out by HI 96801 Hanna Instruments digital portable refractometer; an instrument that uses refractive index measurement to determine sugar content. Part of the juice was also taken to perform pH and electrical conductivity (EC) analysis using portable pH meter-conductivity meter, model H19811. Titratable acidity was determined according to the standard ISO 750:1998 (E) method using the Titrex Act automatic titrator (Steroglass). The volume of soda ash required to reach the inflection point (pH 8.2) was used in the following formula:

$$Z = \left[\frac{(V \cdot N \cdot mEq)}{Y}\right] \cdot 100$$

Figure 17. Volume of soda required.

Z= g of acid per 100 g of sample

V= volume in mL of NaOH used for titration

N= normality of NaOH

mEq= milliequivalents of acid (0.064 citric acid)

Y= volume in mL of sample

3.5 Determination of antioxidants and total polyphenols

The determination of antioxidant activity and total phenolics involved the use of the methods given by Kang et al. (2002), with appropriate adjustments to adapt the methods to the matrix analyzed. Before proceeding with the analysis, one of the two previously frozen samples was taken and placed in freeze-dry by freeze-dryer. The obtained sample was finely ground, and a powder has been obtained. For the determination of antioxidant activity and total phenols 0.5 g of ground sample was weighted, to it 20 mL of methanol (for HPLC) was added then the sample was filtered with filter paper (589 Schleicher diameter 125 mm). Antioxidant activity was determined by the FRAP (Ferric Reducing Ability of Plasma) method. FRAP reagent (1 mM solution of 2,4,6-tripyridyl-2-triazine [TPTZ], 2 mM ferric chloride and 250 mM sodium acetate pH 3.6) was prepared daily from stock solutions of 300 mM acetate buffer, 12 mM TPTZ (in 48 mM hydrochloric acid) and 24 mM ferric chloride in a 10:1:1 ratio. To 100 µL of extract, 1900 µL of FRAP reagent was added and homogenized using a vortex; after 4' at 20 °C, absorbance was read at 593 nm (Shimadzu UV-1800). The reading was compared with a calibration curve consisting of ferrous ammonium sulfate solutions with concentration from 0 to 1200 µg mL-1 of ferrous ion. Antioxidant activity was then subsequently expressed as mg Fe2+ equivalents (Fe2+E) per kg of dry or fresh sample.
For phenol determination 200 µL of the extract was taken, 1000 µL of Folin-Ciocalteau reagent and 800 µL of 7.5% anhydrous sodium carbonate were added. This was followed by 15" shaking and subsequent resting for 30' at room temperature before reading in the spectrophotometer at a wavelength of 765 nm (Shimadzu UV-1800). The absorbance was compared with the one read for solutions of known concentration of gallic acid (0 to 300 µg mL-1) that underwent the same procedure as the samples. Total phenol content was expressed as mg gallic acid equivalents (GAE) per kg of fresh or dry sample.

3.6. N, P and K content.

In the comparisons of the elements N, P and K, sample ash was suspended in concentrated HCl by dissolving the ash of 1 g dry matter in 5 mL of HCl. After half an hour had elapsed, the solution was diluted with distilled water to a volume of 50 mL. Next, the solution was carefully filtered to be used in the elemental content reading. The instrument used in this analytical step was the ICP-AES (Inductively Coupled Plasma - Atomic Emission Spectroscopy) SPECTRO CIROS (from Spettro Italia S.r.l.) emission spectrophotometer.

3.7. Anion and cation analysis

For the determination of anion and cation content, ion chromatography (IC) was employed using a gradient chromatographic system (Dionex ICS-900), consisting of a binary pump and conductivity detector (Dionex DS5) with anion suppressor (AMMS 300, 4mm) for anion analysis and cation suppressor (CMMS 300, 4mm) for cation analysis. The Ion Pac AS23 column with dimensions 4x250 mm was used for anion analysis while the Ion Pac CS12A column with dimensions 4x250 mm was used for cation analysis. Both are preceded by a pre-column. Data provided by this system was collected and processed using Chromeleon software for LC systems. 200 mg of dry ground sample was extracted in 50 mL of water for 20 min on a rotating plate at 150 rpm. The sample was then filtered first with 589 Schleicher filter paper and then with 0.20 µm cellulose acetate syringe filters. The injections were made using a valve injector (Rheodyne) with a 50-µL loop. Multi standard of anions (Dionex), multi standard of cations (Dionex), concentrated eluent AS23 (Dionex), concentrated eluent CS12A (Dionex) were used. The eluent used is 100% sodium carbonate 4.5 mM, sodium bicarbonate 0.8 mM for anion analysis and 100% methane sulfonic acid 20 mM for cation analysis. The flow rate used is 1 mL/min and the column is kept at room temperature.

3.8 Questionnaire

Two questionnaires were structured to investigate both the consumer and the producer behavior in the production of *P. ostreatus*. The first was applied to a sample of Italian and international population (n = 327) through an online questionnaire regarding mushroom consumption behavior and socio-demographic data, from March 2022 to August 2022. The questionnaire was written in Italian and English language and available through a link, which was spread on social media. The survey subjected to consumers was composed by thirteen close ended questions, among which: three where about the gender, the origin and the age, the others were related to mushrooms consumption. The latter comprehended: the overall frequency of consumption, the type of consumption by species, the form in which the consumption was made, the marketing channel used, the classification of the most important aspects considered, the knowledge of the distinction among organic and conventional farming, the willingness to pay for organic mushrooms and for those that have a higher content of vitamins (Table 2). The overall frequency of consumption regarding periodicity of mushroom consumption were: “Once a week,”, “Once a month,” “More than once a month” and “Two-Three times a year”. Five cultivated species and the general classification “wild mushrooms” were considered. Cultivated mushrooms included: champignon (*A. bisporus*), shiitake mushroom (*L. edodes*), oyster mushroom (*P. ostreatus*), king oyster mushroom (*P. eryngii*) and poplar mushrooms (*C. aegerita*).

Table 2. Consumer questionnaire on mushrooms consumption.

Question	Answers
In which form do you purchase cultivated mushrooms?	- Fresh in bulk - Fresh in tubs - Frozen - Pre-cooked
What trade channel do you use when purchasing cultivated mushrooms?	- Local market - Supermarket - Direct sale from producer - Other
What are the aspect you most consider when purchasing cultivated mushrooms (in order of importance) in a scale from 1-5	- Price - Size - Color - Taste - Practicality of use
If cultivated mushrooms were sold without the basal part of the stem, would you find it easier to buy them?	- Yes - No
Do you know the difference between a certified organic and conventional product?	- Yes - No
Would you prefer to buy an organic mushroom over a conventional one?	- Yes - No
If in the previous question you answered yes, how much would you be willing to pay to purchase a certified organic mushroom?	- The same price as the conventional product - +0.50 cents/kg - +1.00 euro/kg - +2.00 euro/kg
How much would you be willing to pay to purchase a mushroom grown with a higher vitamin content?	- The same price as the conventional product - +0.50 cents/kg - +1.00 euro/kg - +2.00 euro/kg

The producer survey was made in Italian, and it was made available both online through a link on social media and both on papers distributed at the conferences from March 2022 to June 2022. The questionnaire regarding mushroom production comprehends eight close questions: the geographical area of production and the age which represent the socio-demographic profile and then the others concerned the production. These examined different aspects of the production and the willingness to produce organic mushrooms (Table 3): in few of them, due to the wide differences among small producers, the option “other” was added to give the possibility of writing the answer.

Table 3. Producer questionnaire: production and willingness to buy

Question	Answers
Which are the typologies of mushrooms that you produced?	- Champignon (*Agaricus bisporus*) - Oyster mushroom (*Pleurotus ostreatus*) - Poplar mushrooms (*Cyclocybe aegerita*) - Other
Which is your marketing channel?	- GDO - Local market - Restaurants - Others
Which is your level of interest in the production of organic mushrooms?	- High - Low - Not interested at all
Do you think that the production of organic mushrooms for your factory could be interesting?	- Yes - No - I don’t know
Which are the main difficulties in the production of organic mushrooms?	- Substrate finding - Cultivation technique - Structure of the factory - Other
Do you think that the consumer is aware of the difference among organic and conventional product?	- Yes - No
If the consumer would be willing to buy organic mushrooms, would you produce them?	- Yes - No

3.9 Statistical analysis

The data obtained from the quantitative and qualitative measurements was statistically processed by two-way ANOVA analysis of variance, and the means were separated by Tukey's HSD test with $p \leq 0.05$. Statgraphics 19 centurion software (Statgraphics Technologies, Inc.) was used for statistical processing.

4. Results

4.1 Environmental parameters

The data collected has been analyzed just for the first flush to the 55th DAI (day after incubation), due to the impossibility of making significant measurements on the mushrooms of the other two pickings. The trends illustrated in figures17 and 18 show the temperature of the different treatments up to the first flush: the two substrate, organic and conventional, and the two mycelia, M1 and M2. In both cases no relevant difference has been detected and the performance of the temperature was quite similar for all four: two peaks were detected around 30°C and then, at the beginning of the first harvest, then there was a decrease and a stabilization of the temperature around the 15°C.

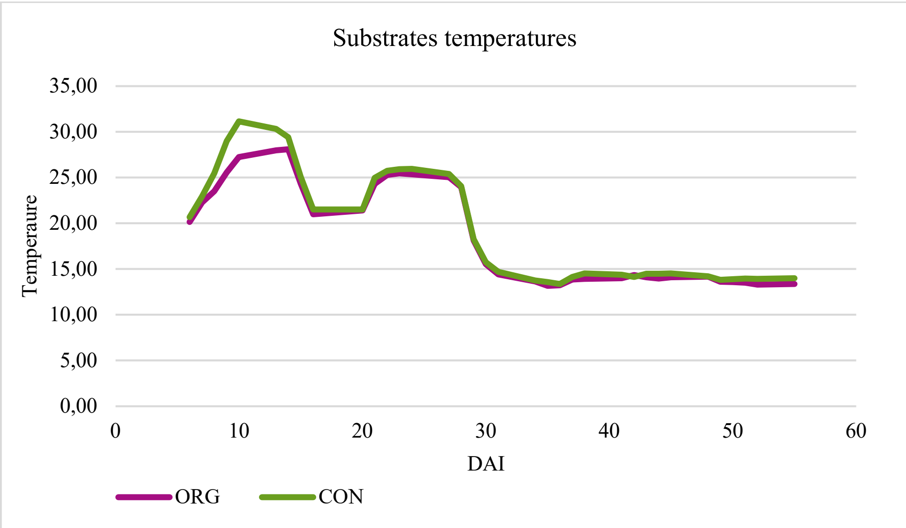

Figure 17. Temperature of substrate during the production cycle expressed in days after incubation in the organic and conventional substrates.

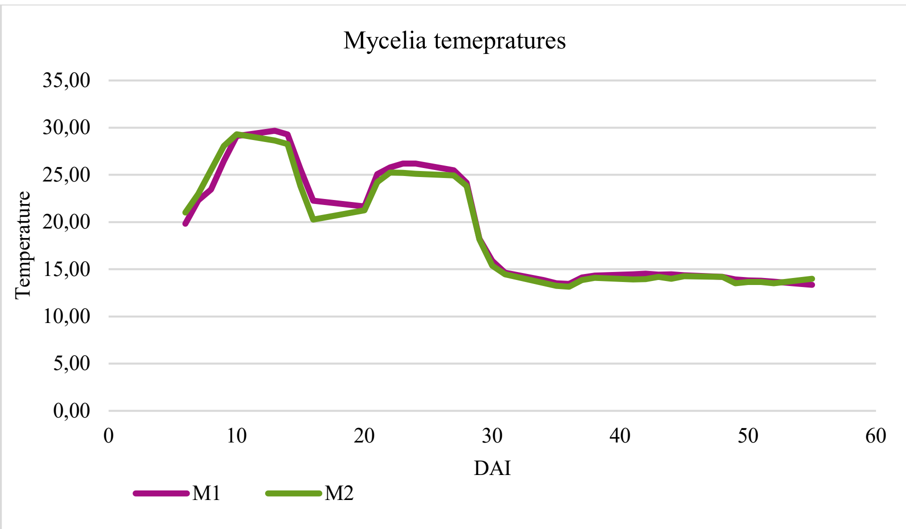

Figure 28. Temperatures of substrate during the production cycle expressed in days after incubation in mycelia M1 and M2.

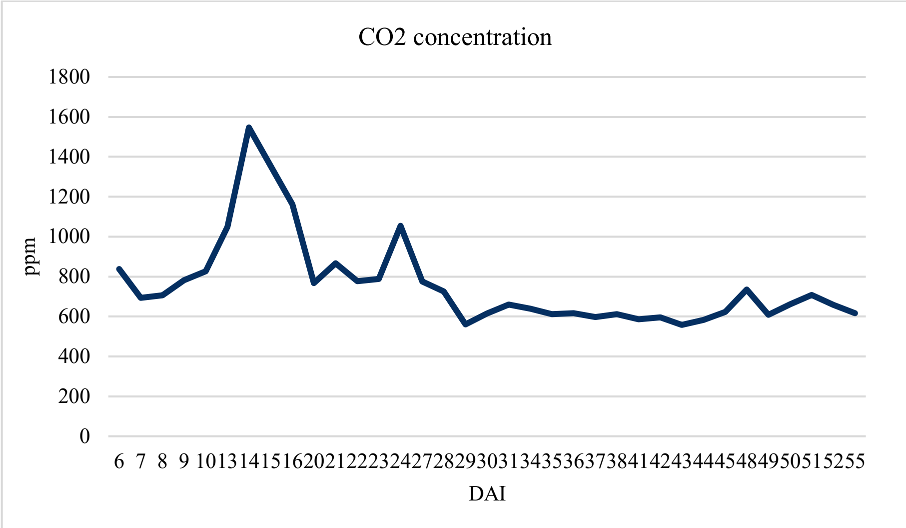

Figure 19. Concentration of carbon dioxide (CO2) present inside the mushroom house during the first harvest expressed in DAI (days after incubation).

The concentration of carbon dioxide varied during the period considered. This value increased during the first fifteen days of incubation reaching values close to 1500 ppm, due to the rapid growth of the mycelium, that consequently increased cellular respiration. Afterwards, as showed in Figure 19, there has been a rapid decrease up to the 24^{th} day, the beginning of the primordia development and during this a low peak was detected, reaching the 1000 ppm. Following with the harvest the mycelium activity has dropped further and then has been stable with values around the 700 ppm.

4.2 Substrate composition

In order to measure the composition of different treatments, samples were taken at the beginning of the cycle, as shown in Table 4. However, significant differences where not detected among the two conventional and organic substrates.

Table 4 - Initial chemical characterization on the nutrient and heavy metal content of the two substrates compared.

	ORG	CONV
Organic carbon (%)	41,32529	41,39632
Inorganic carbon (%)	0,365294	0,368421
Total carbon (%)	41,69059	41,76474
Nitrogen TKN (%)	0,700274	0,752298
K (mg/kg)	14500,53	15616,26
P (mg/kg)	624,72	809,20
C/N	59,53468	55,51624
Cd (mg/kg)	<0,7	<0,7
C (mg/kg)	6,549626	5,178332
Cu (mg/kg)	5,245964	4,938545
Fe (mg/kg)	1463,599	1034,635
Pb (mg/kg)	<0,7	<0,7

4.3 Primordia

The cumulative production of the primordia has been normalized according to the number of holes. The mycelia trend has demonstrated a statistical difference among M1 and M2, as showed in Figure 20. The two mycelia have begun the flush together, the 26th DAI, but immediately after from the 27th, M1 has increased rapidly and kept a dominant and steady trend on M2, that has a less uniform and productive performance. The M1 has reached in few days the 40% of primordia, differently, M2 lead the same results in 15 days. Furthermore, also the final percentage of production was around the 90% for M1 and about 75% for M2.

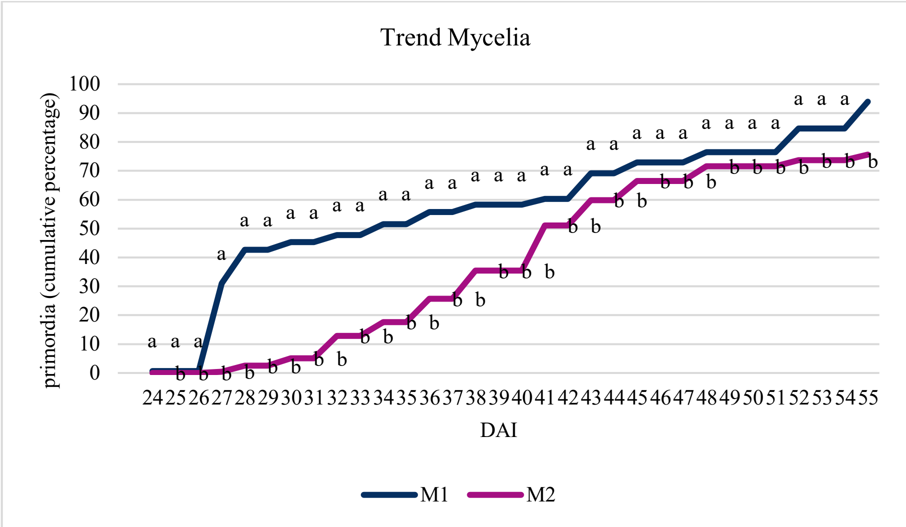

Figure 20. Effect of mycelium on the production of primordia by mycelium of P. ostreatus: M1 and M2. Different letters indicate significant differences between averages (p-value<0.05) according to the HSD Test.

The trend of the substrates, conventional and organic, has been also compared. As illustrated in the Figure 21 on the 27th DAI, the percentage of pinhead of the organic grew slowly but steadily, trend that has been kept during the fifteen days after. The conventional, instead, had a lower performance up to the 42nd DAI where this treatment began to develop and exceed the organic. the first flush reaching in few days the 40%, differently from M2 that lead the same results in 15 days. Furthermore, this performance has been maintained up to the 52nd DAI, while, at the end of the experimental trial the two substrates had a similar production without any significant difference. The final percentage of production was for both around the 90%.

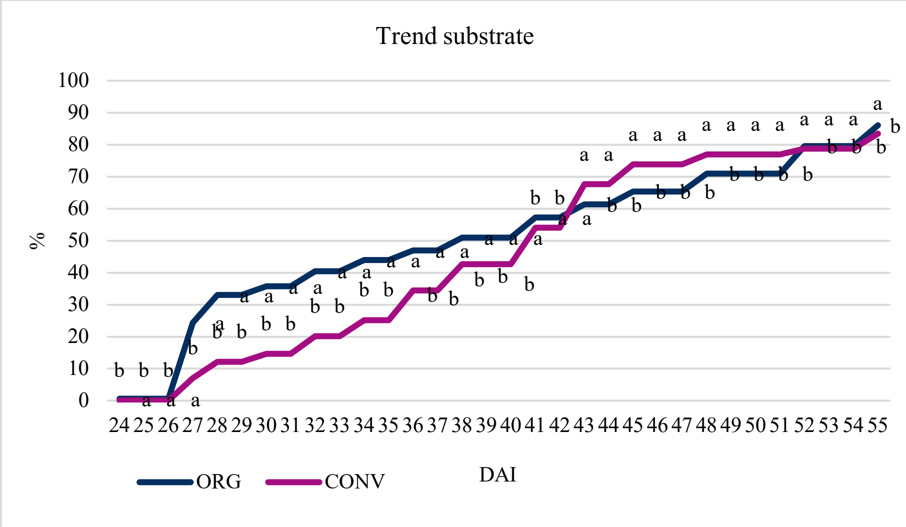

Figure 21. Effect of the substrate, organic and conventional, on the production of primordia of P. ostreatus. Different letters indicate significant differences between averages (p-value<0.05) according to the HSD Test.

4.4 Production parameters

4.4.1 The production capacity

Production capacity in terms of weight of fruiting bodies was normalized to kg of substrate (Figure 22).

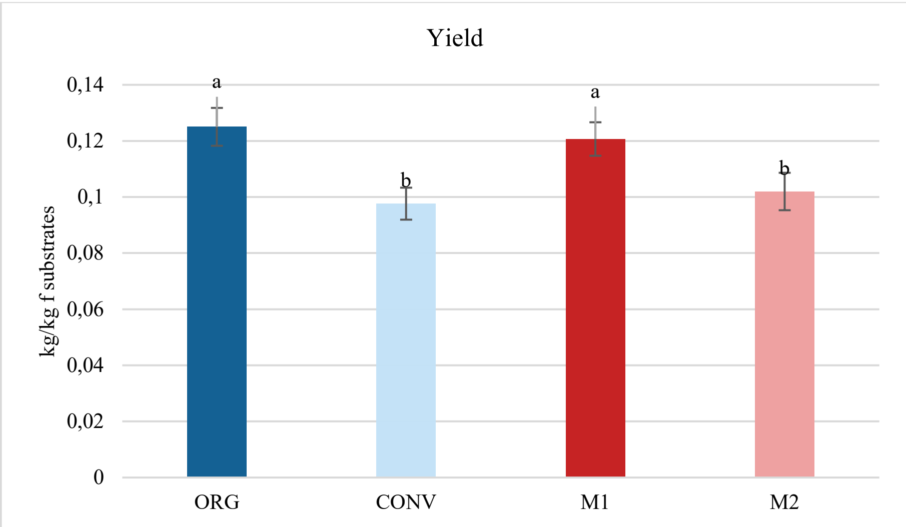

Figure 22. Effect of mycelium and substrates on P. ostreatus production. Different letters indicate significant differences between the averages (p-value<0.05) according to the HSD Test. The error bar represents the standard error.

The highest production has been reached by the organic substrate with 0,125 kg/kg of substrate, however, also mycelia M1 had high levels with 0,121 kg/kg of substrate, while M2 and conventional treatments respectively 0,110 and 0,09 kg/kg of substrate have showed lower productions. The two substrates had a bigger difference in terms of performance if compared to the two mycelia that had a lower gap.

4.4.2 Diameter, thickness, and color

The width (Figure 23) has showed significant differences among the different treatments. The mycelia M2 and the organic substrate had lower performance compared to the conventional and M1 treatment that had higher value. Nevertheless, the gap among the conventional and the organic was significant but not wide equal to 0,03 cm, while M1 and M2 had of 0,09 cm.

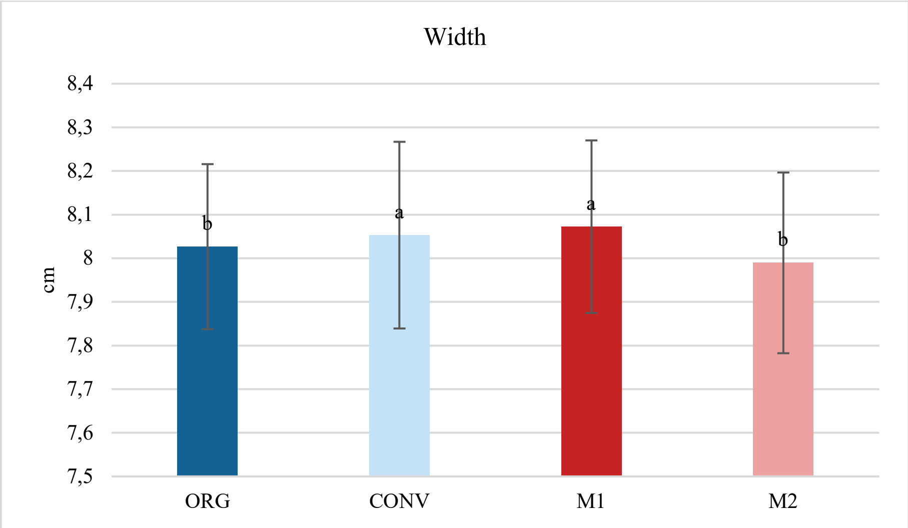

Figure 23. Effect of mycelium and substrates on average diameter of fruiting bodies of P. ostreatus. Different letters indicate significant differences between the averages (p-value<0.05) according to the HSD Test. The error bar represents the standard error.

The thickness (Figure 24) was also compared: the biggest values were detected in M2 mycelia, followed by the conventional substrate that had respectively 7,90 cm and 7,00 cm. The organic and M1 had lower performance. The difference among M1 and M2 was of 2,3 cm and was of 0,9 cm for the two substrates.

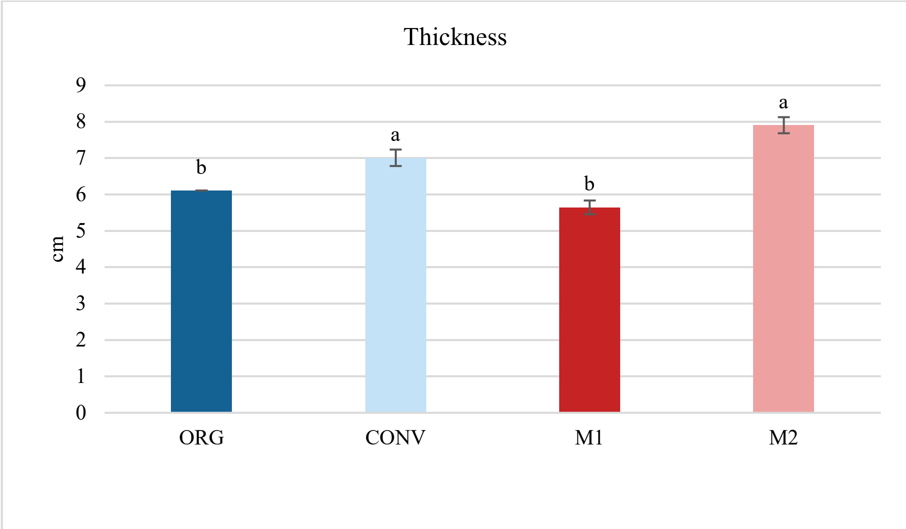

Figure 24. Effect of mycelium and substrates on average thickness of fruiting bodies divided by of P. ostreatus. Different letters indicate significant differences between the averages (p-value<0.05) according to the HSD Test. The error bar represents the standard error.

The color, as the results mentioned above, have showed a difference for the L* parameter that is represented by the Figure 25. The mycelia M2 was the best, followed by the organic substrate, while the conventional substrate and M1 had the lowest performance. These last three treatments had a net lower value rather than M2.

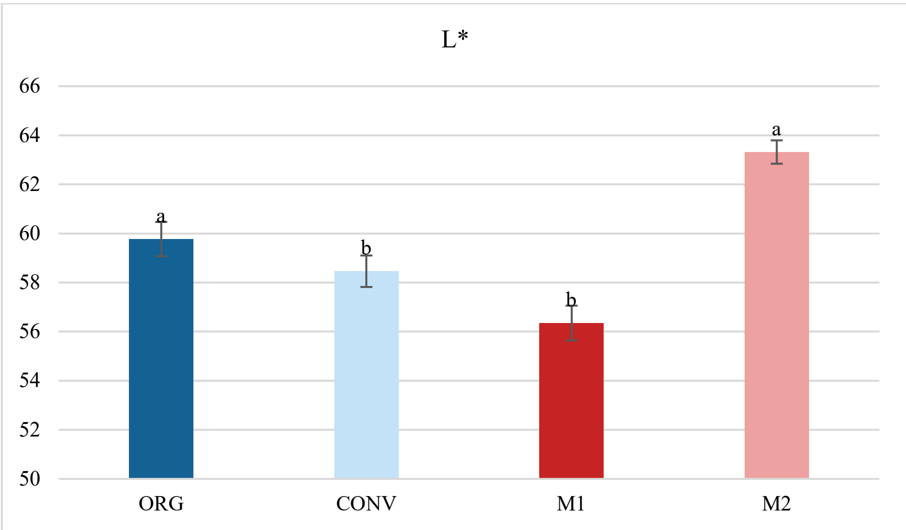

Figure 25. Effect of mycelium and substrate on the L value of P. ostreatus. Different letters indicate significant differences between the averages (p-value<0.05) according to the HSD Test. The error bar represents the standard error.*

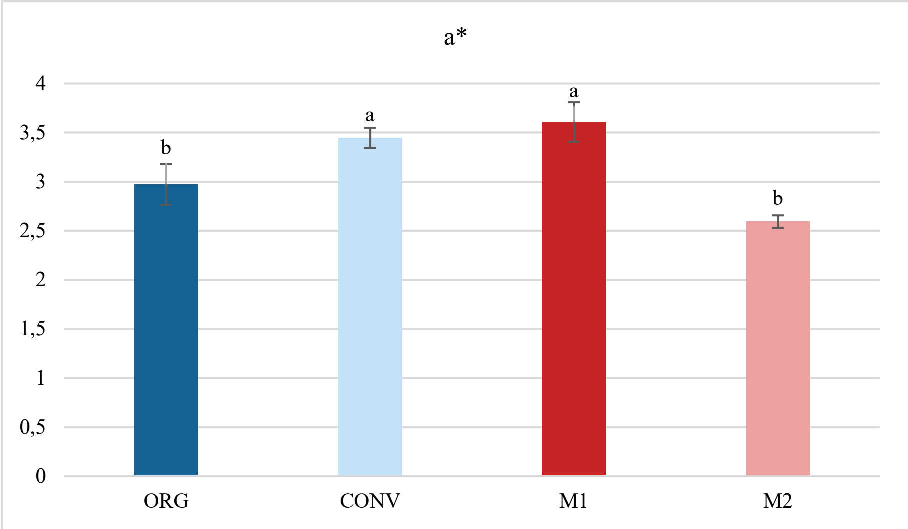

Figure 26. Effect of mycelium and substrate on the a value of P. ostreatus. Different letters indicate significant differences between the averages (p-value<0.05) according to the HSD Test. The error bar represents the standard error.*

The effect of the different treatment on a* value has been illustrated in Figure 26. The highest values were reached by M1 and conventional, whereas organic and M2 had the lowest value. The difference among the two mycelia is wide amounting to 1,01, while the two substrates had different performance but with a lower discrepancy than the other two equal to 0,48.

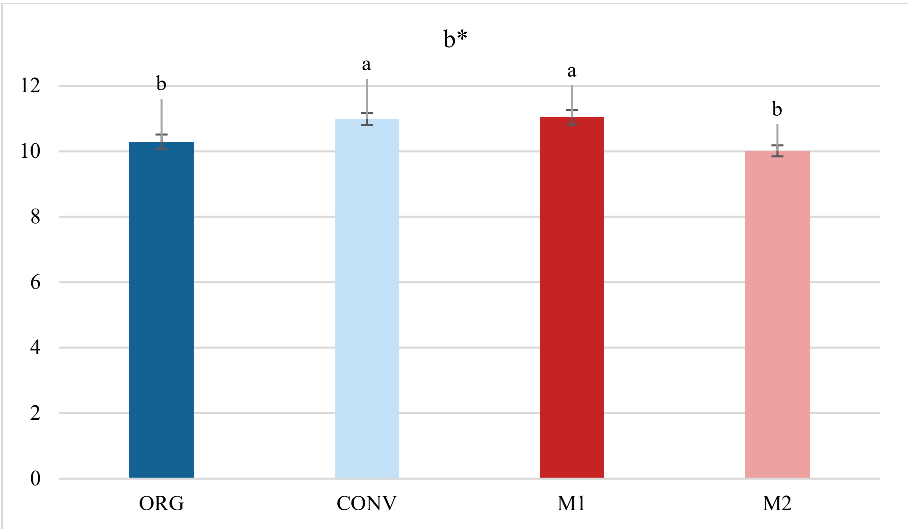

Figure 27. Effect of mycelium and growing medium on the b value of P. ostreatus. Different letters indicate significant differences between the averages (p-value<0.05) according to the HSD Test. The error bar represents the standard error.*

The b* value trend had seen the overcoming of the M1 mycelia and the conventional substrate, respectively with 3,60 and 3,41 compared to M2 and the organic. The last ones had the lowest trend, with the mycelia having the lowest value equal to 2,59 and the organic substrate with 2,97.

4.5 Qualitative analysis

The results on the qualitative analysis (Table 5) have showed statistical differences just in the case of the two mycelia: ph, electrical conductivity and dry matter had higher value in the M1, while, the Brix° parameters were higher in M2.

Table 5- Effect of mycelium and substrates on quality parameters (soluble solids, pH, electrical conductivity, dry matter and titratable acidity) of P. ostreatus. Different letters indicate significant differences between the averages (p-value<0.05) according to the HSD Test.

	Soluble solids (Brix°)	**pH**	**Electrical conductivity** (mS/cm)	**Dry matter (%)**	**Titratable acidity** (mg ac. Citric/100 ml)
ORG	4,667	6,655	4,230	8,565	0,044
CONV	4,450	6,603	4,292	8,703	0,039
M1	4,0167 **b**	6,81 **a**	4,918 **a**	9,051 **a**	0,031
M2	5,1 **a**	6,448 **b**	3,603 **b**	8,217 **b**	0,051

4.6 Total phenols and antioxidant activity

The antioxidant and phenols activity illustrated in figures 28 and 29 did not show a significant difference. However, in both cases the biologic and M1 treatment had highest values, while M2 and conventional are the lowest.

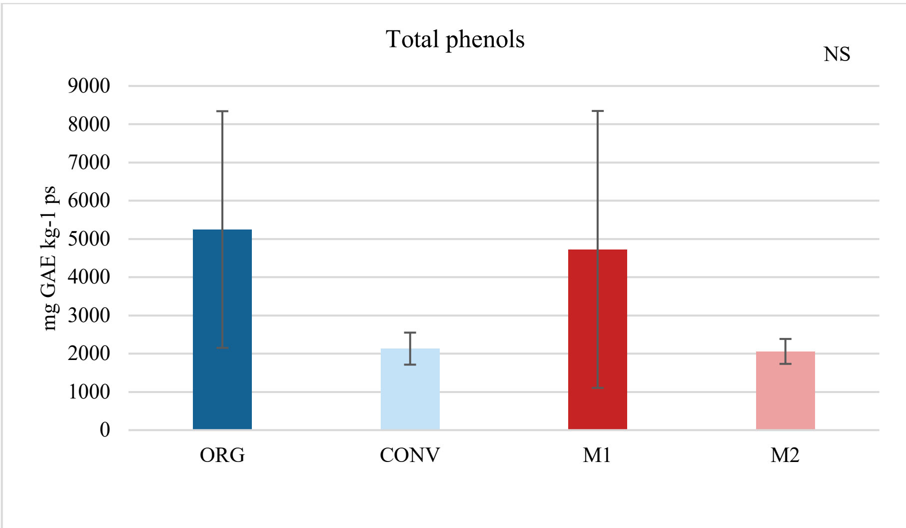

Figure 28. Effect of mycelium and substrates on total phenols of P. ostreatus. Different letters indicate significant differences between the averages (p-value<0.05) according to the HSD Test. The error bar represents the standard error.

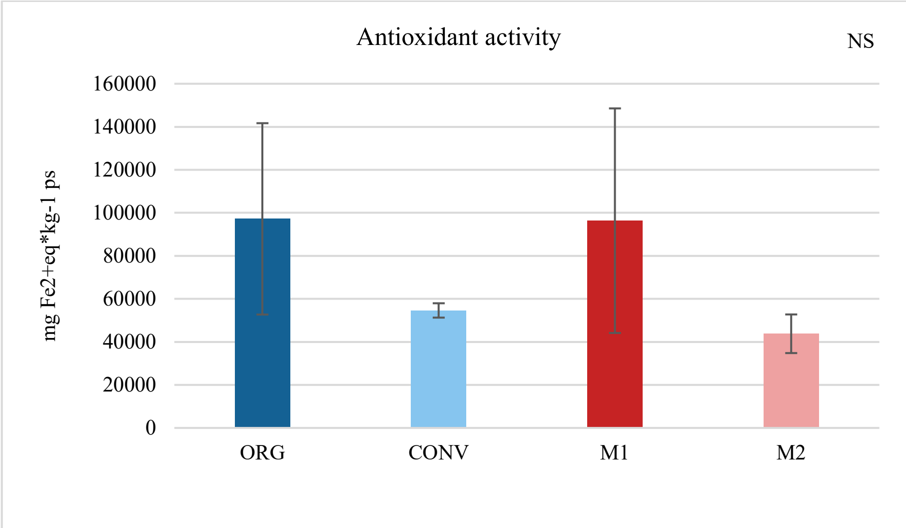

Figure 29. Effect of mycelium and substrate on total antioxidant activity of P. ostreatus. Different letters indicate significant differences between the averages (p-value<0.05) according to the HSD Test. The error bar represents the standard error.

4.7 Questionnaire

The questionnaire has collected 327 answers among Italian and international sample population (Figure 30). Among these, 238 were from north Italy, 37 and 28 respectively from center and south Italy, while 13 came from different countries outside the European Union and 11 from EU. The average age was 41 years old, however, the 61,3% that has answered was among the 20-30 years old.

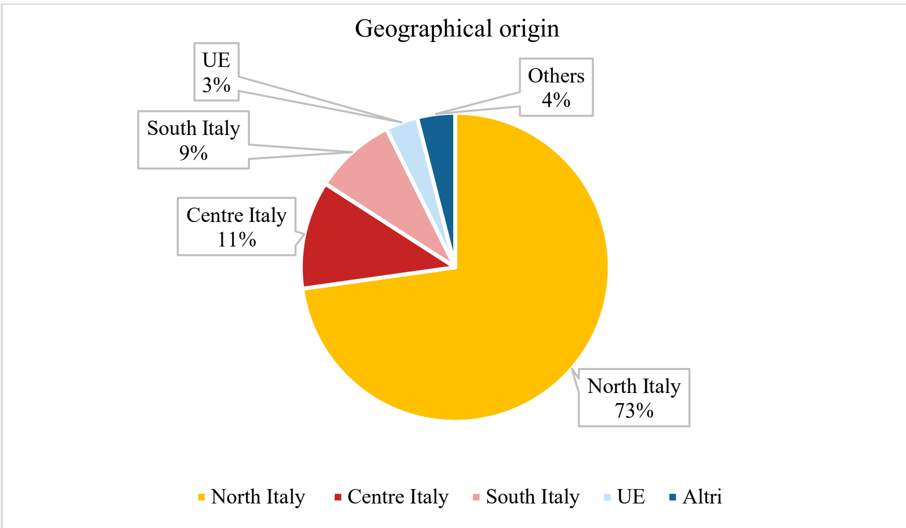

Figure 30. The graph illustrates the origin of the people that has answered to the questionnaire.

The type of mushrooms consumed received 427 answers (Figure 31). The one that reached the highest values were the champignon (241) followed by poplar (103) and *P. ostreatus* (83).

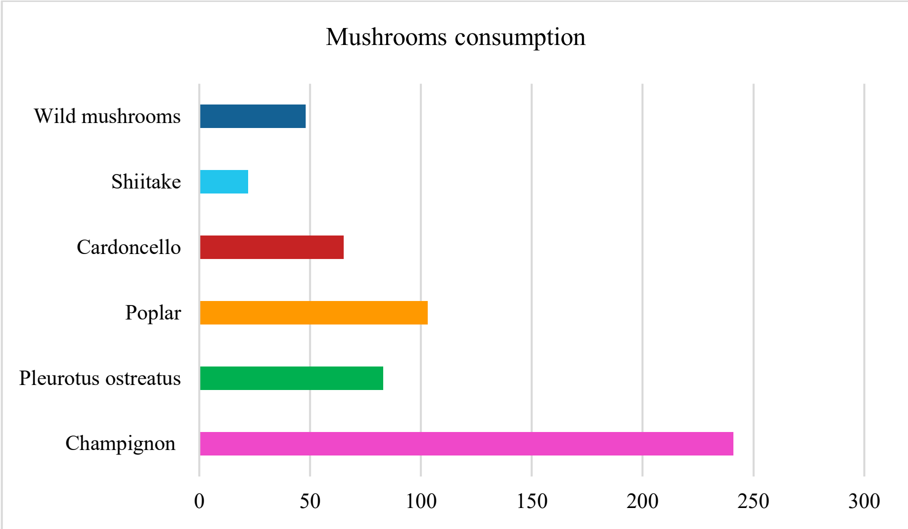

Figure 31. The graph illustrates the consumption of mushrooms.

The frequency of the consumption showed that the 35% of the population considered consumed mushrooms *once a month*, the 34% *2-3 times a year,* while the option *more than once a month* has the 24% and the 7% used fungi *once a year*.

The most important aspects that are considered by the sample were collected in a scale of preference from 1 to 5. The figure 32 illustrate the results: the taste has the biggest influence, followed by the price, the color, while the dimension and the easy of practice where the last two.

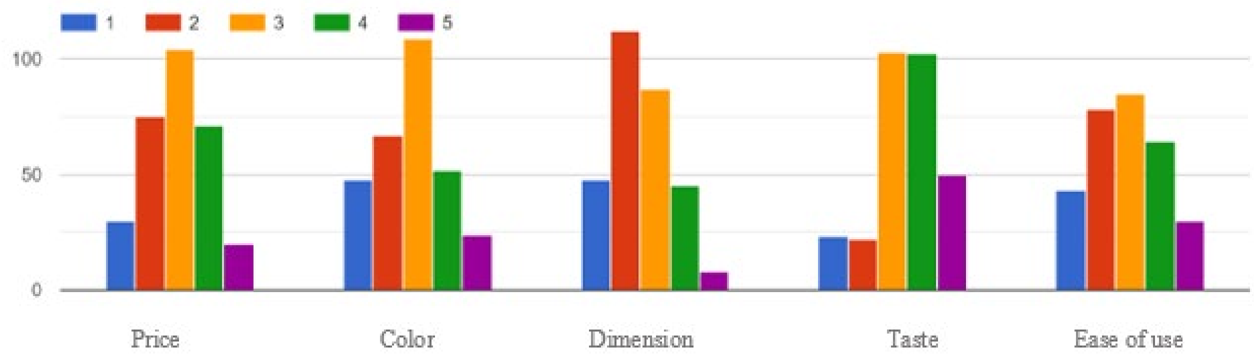

Figure 32. The graph illustrates the aspects considered in a scale from 1-5. In this case (from the left to the right) are reported: price, color, dimension, taste and ease of use.

The typology of consumption most used was *fresh in tubs* (51%) and the other were respectively *fresh in bulk* (25%), *frozen* (12%) and *pre-cooked* (12%). The channel of distribution demonstrated a clear preference for the supermarket which has reached the 74%. The local market, the direct sales from producers and the others represent together just the 26%. Furthermore, the question on the difference among organic and conventional (Figure 33) showed that the 68% of the people has affirmed that they are aware of the difference among the two, while the 32% admitted the lack of knowledge on the topic.

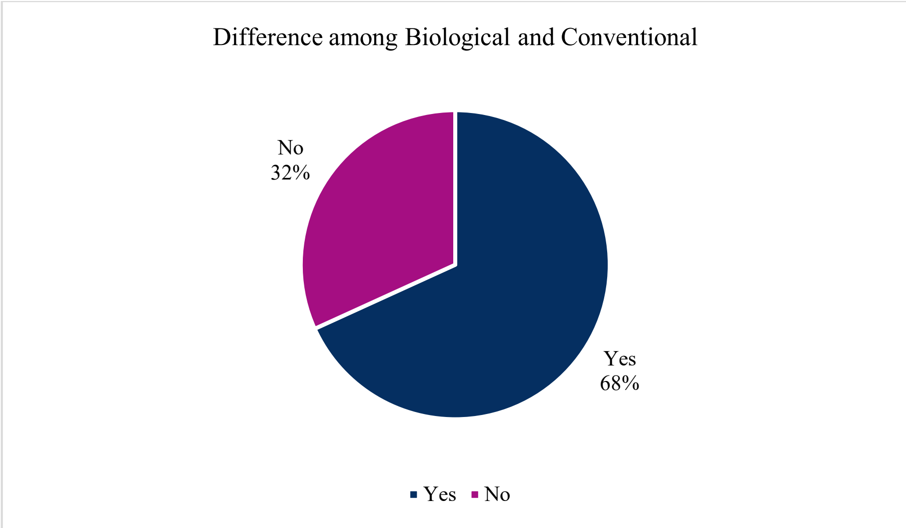

Figure 33 The graph illustrates the difference among organic and convention of the sample population

The same percentage was reached for the preference of buying organic rather than conventional: the 69% would prefer to buy organic product differently from the 31% that is not disposed to make this purchase. The willingness to pay for an organic product, as illustrated in the Figure 34, has an equal distribution of the answers: the 40% would buy the product if the cost is +1 euro/kg, the 32% +0,50 cents/kg, the 16% would buy a product organic with the same price of conventional, while the 12% would purchase +2 euro/kg.

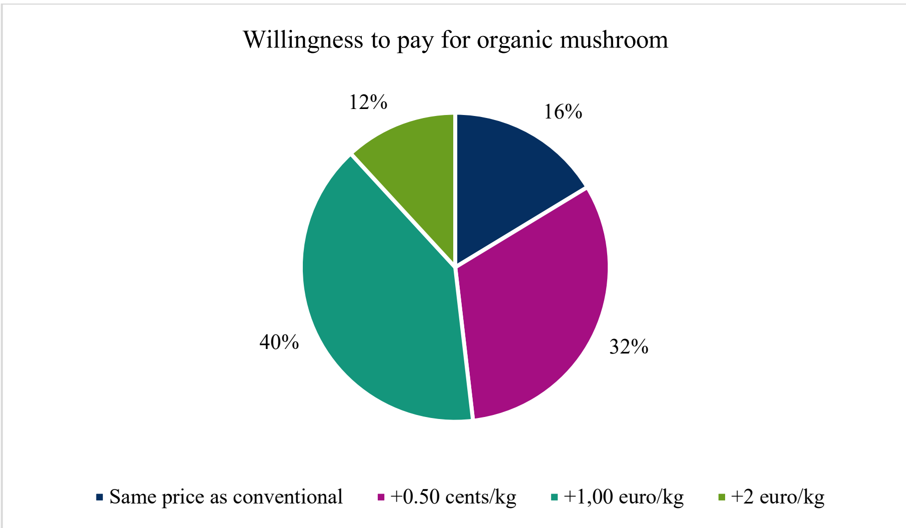

Figure 34. The graph illustrates the willingness to pay for organic products.

The questionnaire for the producer had 9 answers and it was only diffused in the Italian language. Their geographical origin of production was mainly in North Italy, followed by an equal repartition among the central and south of the same country (Figure 35)

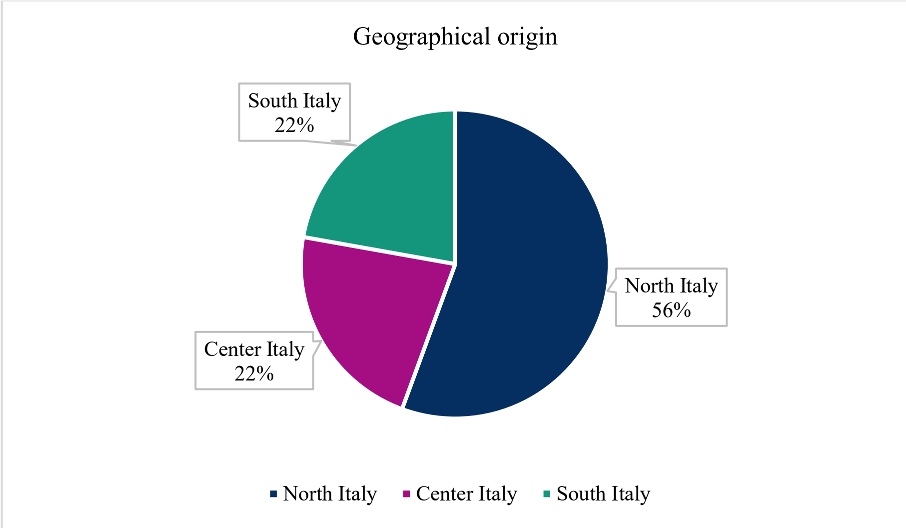

Figure 35. The graph illustrates the geographical origin of the producer.

The production species was tested on the same mushrooms asked to the consumers (shitake, champignon, poplar, wild mushrooms and *Pleurotus ostreatus*). Among these: 8 producers cultivated Pleurotus ostreatus, 3 poplar and just 1 shitake. The distribution channel considered by the producers, as showed in figure 36, were represented by the 37,5% by the local market, the 25% by the HO.RE.CA, and the other in an equal percentage 12,5% were divided in: GDO (ready to eat), do not sell and private.

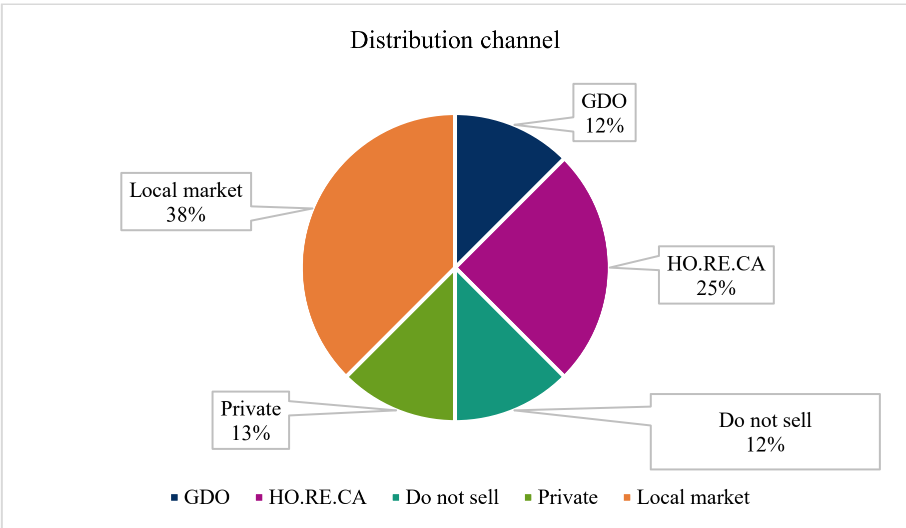

Figure 36. The graph illustrates the channel distribution for mushrooms.

The willingness to obtain the organic certification was tested and the 66,7% of producers answered that they would have a high level of interest, the 22,2% declared a low level of interest and the 11,1% were not interested at all. The question regarding the affordability of organic mushroom production showed that 44.4% think they would be positively impacted by it, the 44.4% do not think it is affordable, and 11.2% do not know.

The figure 37 illustrate what the producers thinks about the consumer knowledge on the organic production. The most part of the producers did not think that the consumers know the difference among an organic and a conventional product.

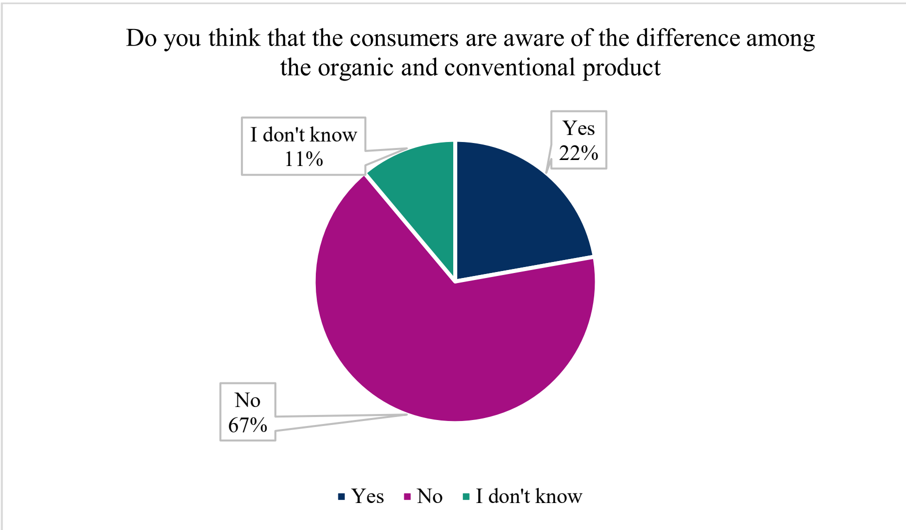

Figure 37. The graph answered to the question: Do you think that the consumers are aware of the difference among the organic and conventional production?

The 100% of the producers that has answered at the questionnaire would produce organic mushroom if the consumers had a willingness to buy them.

5. Discussion

5.1 Agronomic parameters

5.1.1 Environmental factors

There are many environmental factors that influence the growth and performance of *P. ostreatus* P. Kumm, one of the most important is temperature. The growth of the mycelium occurs in a wide range of temperatures that are reported to have an optimum between 25 °C and 30 °C. Three different categories could be detected based on the use of different strains of *P. ostreatus*: the high temperature strain (25°C-30°C), medium temperature strain (16 °C-22 °C) and low temperature strain (12 °C-15 °C) (Fletcher et al., 2019). In this research, during the incubation, the temperature that both mycelia M1 and M2 reached, suggested that they are a high temperature strain. During the harvest the temperature should be between 13 and 16°C (Hoa and Wang, 2015) and this is confirmed by the data collected on this study that were between 14-16°C. Nevertheless, if for the mycelia, the scientific literature reports many examples on how their growth can be influenced by temperature, for the two substrates, organic ad conventional, no reference has been detected. In this case, the only noticeable behavior was that both had similar trends in terms of highest peaks reached and developed in time, also alike with the ones of M1 and M2.

The optimum concentration of carbon dioxide for mushroom cultivation and for obtaining good fruiting body morphology is 3000 ppm (Jang et al., 2003) which is considerably higher than those measured in this experiment: after an initial peak phase, which had reached 1500 ppm and was positive for the development of the primordia, the concentration decreased, stabilizing during the harvest at 600 ppm. The concentration trend can be attributed to mycelium growth since in the first incubation phase growth, and with-it respiration, was disruptive. Thereafter, however, the values tend to drop until they settle and remain stable throughout cultivation. It can be argued that a lower concentration is due to greater aeration of the mushroom house, despite this, no problems were found in the production and morphology of the fruiting bodies.

5.1.2 Primordia

The primordia emergence and percentage of production had important discrepancies among mycelia and substrates. The performance of M1 was clearly better than M2: with higher and faster development. The appearance of primordia in the first sprint occurred at 27th DAI for M1 and M2: these values are similar to the range reported in the technical sheet of both, where the pinheads are expected to emerge respectively from 24-26 DAI and 25-30 DAI (ITALSPAWN, 2016). Furthermore, the same data was found in different studies: Muswati et al. (2021) reported that the emergence of

primordia occurred at 30 GDI, while, in Shah et al. (2004) the emergence of primordia occurred at 24 GDI. This difference may be attributed mainly to the different temperatures maintained in the structure, which affected the emergence of the primordia.
In the case of the substrate the primordia trend had begun at the 27^{th} DAI, but for the organic treatment it had increased rapidly since the beginning. In this case the percentage of pinheads during the first fifteen days grew slowly but steadily reaching 60%, while the conventional had a better performance starting from the 42th DAI where the two trends had a reverse performance. The effect of the type of substrate on the *P. ostreatus* P. Kumm primordia production has not been studied yet. However, the organic substrate probably shows a faster pinhead emergence due to a reduced use of fungicides. In the mushroom cultivation the use of control methods against fungal diseases usually involves the application of fungicides and strict hygiene practices. The main problems of their applications are related both to the limitations of the directive 91/414/ECC about the fungicides within the mushroom industry and to the fact that both the pathogen and the crop are fungi. Nevertheless, even if study on the toxicity of several fungicides used during mushroom production has been taken (Savoie, 2011) no research has been produced on the effect of these on primordia production.

5.1.3 Production parameters

The production capacity, as a function of the mycelium, cannot be compared with other papers in the bibliography since the data was recovered using Petri dishes. However, it can be noticed that the trend of M1 for primordia, was maintained also in yield where it had a higher production compared to M2. The organic and conventional substrates had a statistical difference in the weight of fruiting bodies: differently from what was reported by Jawad et al. in 2013 where the general trend for the organic crops have been suggested to be 20% less than the conventional.
It is established that the diameter of the fruiting bodies changes depending on the season in which the harvest occurs since temperatures have a direct action in it; in fact, as temperatures increase, the diameter of fruiting bodies increases (Yildiz et al., 2002). In the case of mycelia, there is no comparable data in the literature, that is representative of a real cultivation condition, because studies were carried out in agar solutions on Petri dishes. Therefore, analyzing the data of the present study, it is possible to state that that the type of mycelium influenced the diameter of the fruiting bodies: M1 had the highest values, with an average diameter of 8,07 cm.
The type of substrate that had a statistical effect on the diameter of the fruiting bodies: the organic demonstrated a shorter width compared to the conventional. However, these results compared with other studied crops such as apples (Ján and Davide, 2018) are in accordance, while, they are clashing with tomatoes, in which no noticeable difference has been detected (Györe-Kis et al., 2012).

Nonetheless they could be influenced mainly by the environmental condition. Due to the lack of reference on this topic and due to the presence of only one set of data to compare, it cannot be stated that the organic substrates produce bodies of *P. ostreatus* P. Kumm that have a shorter diameter if compared to the conventional.
Relative to the average thickness of fruiting bodies the mycelia had a reverse trend compared to the other production parameters mentioned before: M1 had a significantly lower performance than the M2. The explanation of this phenomenon is quite simple: higher is the weight and bigger is the diameter lower is the thickness, as it happens in M1. The two substrates, where the conventional had smaller values, in respect to the above-mentioned principle: the yield of the organic is higher, but it has a lower diameter while the thickness is steeper than the conventional.
As reported by Marino et al. (2003) temperature and brightness affect the coloration of fruiting bodies. The L* value in the present study changed according to the type of mycelia and substrates used, visible on the clarity of the fruiting body. This is confirmed by the fact that both obtained statistically different results for this parameter. The a* value varied significantly with an opposite trend compared to L*. The M1 and conventional had higher values: therefore, it can be hypothesized that the type of substrate and mycelia influenced this parameter although unfortunately, there are no studies that can motivate this change. According to the data collected, the average value of b* was 10,55, and there was a significant difference among the four treatments that followed the a* trend. It is possible to state that the b* value was directly related to the type of mycelium and substrates used and therefore depending on these the pigmentation may vary.
In conclusion it is possible to suggest that the type of treatments directly influenced the coloration of the fruiting bodies, so depending on the mycelium and substrates used, the coloration of the fungus may change. The organic and conventional substrates may influence the coloration, but further research should be carried out due to a lack of research on the topic.

5.1.4 Qualitative analysis

The pH values had an average of 6,63 that is slightly superior with the ones found in the literature (Villaescusa and Gil, 2003). It does not appear to change as a function of substrate but had a significant difference among mycelia: M1 had the highest level of pH, while the M2 had the lowest. This trend was maintained valid also for the electrical conductivity and the percentage of dry matter, while the organic and conventional substrates did not show any statistical difference where the average was respectively 4,21 mS/cm and 8,63%. The average electrical conductivity observed from the present study appears to be similar to other papers, such as Ikay Koca in 2011.

Soluble solids, for which the average found was 4,5 °Brix, were not affected by the type of substrate but were influenced by the mycelium. The mean value was lower than the one reported by Villaescusa et al. (2003) of 5.1°Brix, and higher than the average value of 1.5° Brix found by Kortei et al. (2017). Titratable acidity did not appear to vary as a function of mycelium and substrate, these results agreed with those found in the literature (Villaescusa and Gil, 2003).

5.1.5 Polyphenols and antioxidant analysis

The content of total antioxidant in this study reported slightly lower values if compared to other studies such as Keles (2011), but they are confirmed with others such as Gonzalez-Palma (2016). From the results obtained, we can state that mycelium and substrate had no effect on antioxidant production, this can be inferred since there was no difference between the different treatments. Phenol content generally depends on a multitude of factors such as genetic and environmental factors: mushroom strain, substrate composition, harvest time, and substrate management and preparation techniques (Yıldız et al., 2017). The results obtained are lower than those presented by Vieira et al. (2013), as these are always higher than 3000 mg GAE kg^{-1}. However, the mycelium and substrate had no effect on antioxidant production: no difference has been inferred.

5.2 Questionnaire

The population sample that has been analyzed in this study was mainly distributed in North Italy. For this reason, the data collected painted a picture of the wealthier parts of the country, that were identified through the analysis of the GDP, per capita income of regions (ISTAT 2018) (Figure 38). The GDP is the one considered in this study due to its widespread use, but to address in a complete way the differences among areas, a multidisciplinary approach should be adopted (Andreoli & Zoli, 2020). The average age was 41 and the females represented the 60,7% and the males the 39,9%. This data are a known trend that are found also in other research papers about the food consumption and in which they suggested that higher is the women percentage, higher is the expenditure of vegetables (Leclercq et al., 2009). Due to the fact that in consumption analysis the mushrooms are usually considered inside the vegetables category, there could be the hypothesis that greater are the levels of females the higher are the mushrooms purchases. Nonetheless, in a USA study of Lucier in 2003 the per capita consumption of all mushrooms was tested, and the results were different from the ones of this research: consumption was the same for women and men, with the greater consumers between the ages of 20 and 39. In order to confirm the above-mentioned assumptions further studies on the relationship among gender and mushroom utilization should be carried out.

Figure 38. The gross domestic product (GDP) of Italians regions. The northern part are the ones where the highest percentage of the data has been collected. The darker colors indicate higher levels of GDP.

The rates of fungi consumption obtained by this thesis could prove the supposition for which Italian inhabitants are mycophillic, that is a typical characteristic of Romanic speaking people (Peintner et al., 2013). The Italian National Health Survey of 2020 indicated that 49.9% of the Italian population eats vegetables daily (ISTAT 2020), and because mushrooms are usually considered as such, it is possible to infer that fungi may be one of the vegetables included in the Italian daily meals. Nevertheless, the data obtained by the consumer questionnaire recorded a frequency of mushroom consumption that was mainly monthly, in agreement with the one obtained by the Mexican study, (Mayett et al., 2006) while they differ from the Portuguese population data where the highest rates of utilization were daily use (Boin & Nunes, 2018). However, according to a recent market research, mushroom consumption may rise due to the current consumer preference for value-added products, health benefits from mushrooms, and the increasing awareness among consumers about these benefits (Boin & Nunes, 2018). This is also demonstrated by the trend from 2013 to 2018 that was characterized by a conspicuous increase of fruits and vegetables (+8.5%) (CREA, 2020).

The most consumed species were 73,2% champignon, 32,8% poplar and 26,4% *P. ostreatus* P. Kumm. These results were expected for the *A. bisporus* J.E Lange: in many studies it is the most widely used mushroom, however, the difference among countries changes in the following position. The poplar is not mentioned in other studies and the *P. ostreatus* in Portugal had a high percentage of people who *did not know it* reaching the 73,3% (Boin and Nunes, 2018), while in Mexico it occupied the second position among the highly use mushroom. Differently from what presumed, even if Italy and Portugal have been presented at the beginning of this study as comparison factors, the highest level of similarity was detected with a non-EU country: Mexico. Furthermore, the world production trend in 2013 placed *shitake* at the first spot (Royse et al., 2017) but only the 7% of answers in the present answers where devoted to it. This could be caused by the area in which the questionnaire was spread: the north part of Italy is the biggest area for the production of *champignon*, *poplar* and *P. ostreatus* (AIF- Associazione italiana fungicoltori, 2020).

Among the most important consumer behavior questions there was the ranking of the five principal characteristics that the responders evaluate for the mushroom purchase. The results place the taste as the most considered factor: many studies have found that sensory factors are among the most influential in determining eating behavior. In a pan-European survey that aimed at the consumer attitudes to food, nutrition, and health, when consumers were asked about their influences on food choice, quality, was the most mentioned and taste was within the first three mentioned. When looking at ‘satisfaction’ beliefs, ‘good’ taste was an essential prerequisite for the consumption of fruits and vegetables (Pollard et al., 2002). The price was the second most important factor. The average purchasing power in Italy, in 2022 had a decrease of 0,6% compared to the pre-Covid period but it is also among the lowest in Europe and the average monthly expenditure is 2940.0 euro/year for those who work full time. As it can be seen in Figure 39, the 24,6% of the monthly expenditures is devoted to vegetables, with an average value for the grocery shopping of a family to be estimated at 93,72 euros.

In the specific case of edible mushrooms, among which there is the *P. ostreatus*, no research has been already produced on the Italian expenditure even if the consumption is expected to increase worldwide as illustrated in Figure 40.

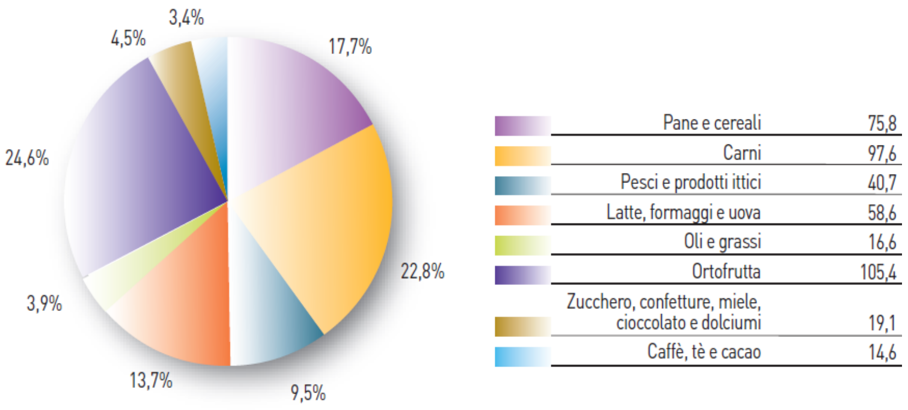

Figure 39. Monthly expenditure repartition in Italian population (CREA, 2020)

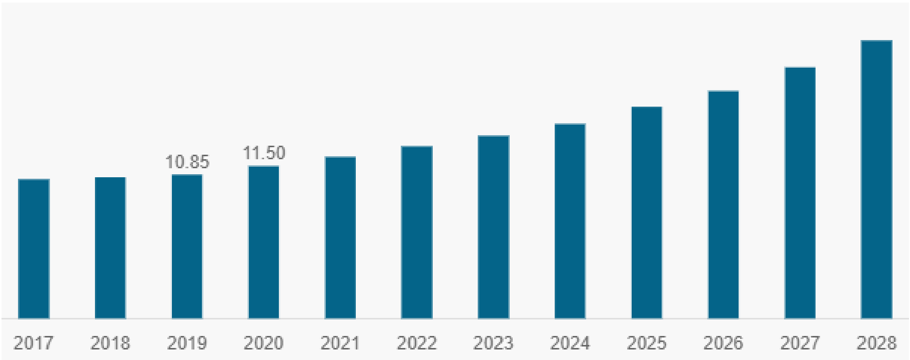

Figure 40. The Asian Pacific mushroom market size 2017-2028 (Odekon, 2015).

The global mushroom market size was valued at USD 50.3 billion in 2021 and is expected to expand at a compound annual growth rate (CAGR) of 9.7% from 2022 to 2030. As already mentioned, mushrooms could be used for a variety of different reasons: the increasing vegan population demanding a protein-rich diet around the globe, the nutritional value, and the natural umami flavor.

The type of consumption that was obtained from this study followed the general trend in which the *fresh* mushrooms are the commercial form most consumed (Figure 41) and the *fresh in tubs* are the most purchased ones.

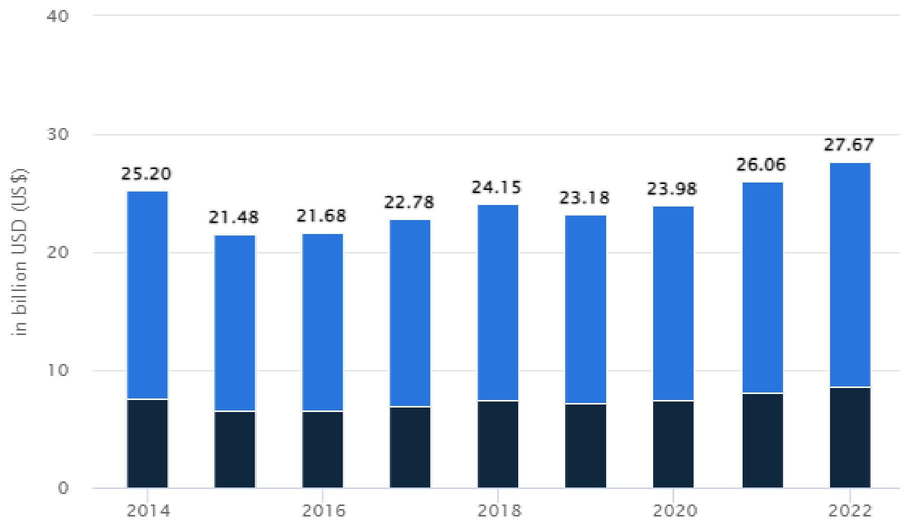

Figure 41. The Italian market for fresh vegetables (light blue) and frozen/prepared (dark blue) (Statista, 2022).

The main distribution channels are the supermarkets that are used by most of the producers (AIF-Associazione Italiana Fungicoltori).

The consumer knowledge of organic food has been tested and their percentage (68%) was lower than the average reached in Serbia or Croatia (Vlahovi et al., 2011). It can be noticed that the same respondents that knew the meaning of *organic* were also the same that would not prefer to buy a conventional product: the correlation suggests that higher is the level of consumer awareness higher is the possibility for him to buy an organic product. Consumers tend to perceive organic food as healthy, safe, and environmentally sustainable however, it depends on the category of food: organic fruits and vegetables are perceived differently from other products. The buyers exhibit a low unwillingness to pay more for them and a substantial percentages of willingness to pay more compared to other foods (Krystallis and Chryssohoidis, 2005). In this case study more than the 80% of the population would pay a higher price for the organic mushroom: this is an important information for the producers. The utilization of specific labels contributes to increase the perception of organic food as healthy, safe, and environmentally sustainable. The more detailed the information on labels the more influential are the attributes for the consumers; the higher the detail, the higher the feeling and the lower the uncertainty of consumers related to the perception of organic food (Lamonaca et al., 2022) but, the purchasing is a phenomenon guided by many factor (Vindigni and Janssen, 2001) that should be investigated better to confirm the above mentioned hypothesis.

The producers that answered to the questionnaire had a similar repartition with the respondents of the consumer survey: the north Italy had the higher percentage which could be connected to the high concentration of mushroom producers in this part of Italy. The most part of them produced *Pleurotus ostreatus* that, as mentioned above, have great level of consumption. However, the data collected by the consumers are in dissonance with the producers that sold mainly to the local market, while GDO (supermarket) were not widely used. Nevertheless, producers were unanimous in the possibility, whenever the consumer requires it, of producing organic mushrooms. The data above mentioned should be used by marketers and producers: information is most valued by customers. Producers may consider strategies to improve the image of their organic production by including and communicating messages of healthiness via detailed information on labels or health claims, absence of harmful ingredients through quality and organic labels, and sustainability by means of environmental labels. Understanding consumer perceptions enables marketers to propose tailor-made strategies to successfully communicate benefits of organic food. This is of particular relevance in a framework where producers have to choose among several labels which potentially affect consumers' decision-making process (Lamonaca et al., 2022).

6. Conclusion

This thesis' aim was to point out the potential effect of organic substrate on *P. ostreatus* P. Kumm both from the consumer and producer point of view. These two investigated figures demonstrate a high level of interest for the organic production.

Nowadays it is well known that the consumers buy organic food products because they believe in their high quality and the legislation of the European Union has moved in the same direction: the legal regulatory framework for organic food and farming Reg. (EU) n. 2018/848 defines high quality of the products as an important goal of production (Kahl et al., 2012). Furthermore, Italy is among the countries where there is a high level of trust to organic products due to a long tradition. The National Organic Food Organization highlights that high levels of trust in the organic farmers has led to a great rank of credence also in organic food. Previous research has shown that confidence in producers is the most important predictor of consumer assurance in the safety of food products. As safety is not a salient issue in organic food, this trust could be transferred to the certifying organizations and to the labeling of the products. In addition to the framing effect (Levin et al., n.d.) the trust in organic certification has been shown as a fundamental part in consumers purchase intention and the general profitability of organic produce. Improving awareness of the processes undertaken by organic farmers to grow organic products, and the extensive procedures in place to regularly check farms and test products to ensure the "organicness" of the produce, are key areas that can increase awareness and organic sales. Italian consumers preferred EU-level certification (Murphy et al., 2022) so the possibility of *P. ostreatus* P. Kumm to be produced as an organic product could increase its market and the consumer preference. Nevertheless, there are no studies that investigate the organic mushroom consumption so farther research is suggested. Also regarding producers, the bibliography that aimed at knowing their level of interest is poor and the few results underline different reasons for the conversion in the making of organic products. A review of the literature suggests profit as the main driver, but the study of Cranfield in 2010 in Canada suggested that health and safety and environmental motivations were more important factors in a farmer's decision to convert to organic. The research on the motives of the conversion to organic from producers could be beneficial also to the prospective of the consumer: further studies on this topic and on a bigger sample of producers should be carried out. This study took into evaluation a small population sample that was mainly young and from the wealthier part of Italy so the results obtained could be influenced by this factor: younger people tend to be more aware of the organic certification and the willingness to pay could be higher if compared to less wealthy areas of the country.

The potential of the organic label on *P. ostreatus* could be great. Mushrooms offer an excellent food source to alleviate malnutrition in developing countries and their cultivation also represents an effective opportunity for the improvement of rural areas in developed states. Rural areas, that suffer from poor economic performances especially where they overlap with long-term negative effects of climate change, could use organic fungi cultivation for a novel branch of eco-tourism, such as mycotourism, that could help stabilize social and political structures (Buntgen et al., 2017). However, before the application of the tendencies pointed out in this study, further research should be carried out.

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