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PRODUCT QUALITY MANAGEMENT IN THE PROCUREMENT OF ITALIAN OLIVE OIL

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ABSTRACT

The objective of this thesis was to present practical and useful strategies to control the integrity of the supply chain in the procurement of Italian olive oil. Known quality deviations originate both from inadequate practices during manufacturing, transportation, and storage as well as intentional food fraud.

In order for the thesis to fulfil its intended purpose, it was necessary to first establish the extent of quality control measures that are currently being utilized. This was done by reviewing existing research and literature and interviewing persons who are involved in the procurement of the product. Olive oil producers were also asked for their opinions, because even though their direct control on the quality of their product ends when it is sold and transported from their production facilities, their extensive expertise in the subject matter can and should be utilized to make sure that optimal quality is maintained throughout the supply chain.

The study showed that in response to frequent quality control issues, extensive measures are being taken in different stages of the supply chain to make sure that the quality of the product is sufficient. The wide range of these procedures and the opportunities presented by evolving technological solutions are reviewed providing an extensive overview of contemporary methods of quality control.

Keywords: supply chain management, food safety, food fraud, olive oil

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1 INTRODUCTION

Olive oil has been produced and used as a food product for thousands of years. Efforts to ensure the high quality of the product as it proceeds in the supply chain have an equally long history. In fact, the earliest known historical reference to food fraud and olive oil dates back more than four thousand years to 2300 BC. Clay tablets found in modern-day Syria indicate that inspectors were employed in the city-state of Ebla to supervise olive groves and presses in order to prevent fraud. (Mueller 2012, 23.)

The problem has persisted into modern times as, according to the joint Interpol-Europol project Opson, olive oil remains one of the most alluring targets for criminals in the food fraud field (Europol 2021). The significant price difference between high quality extra virgin olive oil and the cheapest seed oils that can be used to adulterate olive oil create a situation where organized crime groups as well as ordinary olive oil producers may see a chance to make profit while maintaining a fairly low risk level regarding the possibility of getting caught and the severity of the subsequent punishment.

The efforts to maintain optimal quality of olive oil throughout the supply chain from the production facilities to the consumer are not limited to preventing acts of intentional food fraud. Insufficient packaging, as well as exposure to light and extreme temperatures during storage and transportation can have a detrimental effect on the quality of olive oil.

Due to its chemical composition and manufacturing methods, most types of olive oil are not as susceptible to oxidation as other vegetable oils. Regardless of that, olive oil is associated with significant food safety risks. According to research conducted by the Olive Center of UC Davis (Frankel et al. 2010 2, 7), 69 % of examined imported extra virgin olive oils did not reach commonly accepted quality standards as a result of adulteration or oxidation caused by manufacturing defects, exposure to light or high temperatures and prolonged storage time. Although the food safety risks associated with olive oil are not as detrimental to

human health as those of many other foods, the problems in olive oil quality management seem to be astonishingly common.

The notion of quality in itself is largely subjective, but the basic principles of what constitutes a product that can be called, for example, extra virgin olive oil, have been defined by different authorities. The most important definition from the perspective of European consumer markets comes from the European Commission (European Commission Implementing Regulation 29/2012). While an official definition should be beneficial for the entire industry, many producers of high-quality olive oil maintain that the most popular products in the consumer market do not meet those demands, and many of them are now hoping for official institutions to draft a new definition for higher quality olive oils.

Food fraud and other food quality deviations have been the subject of vast amounts of research, but the purpose of this thesis was to find and present information regarding all the relevant aspects of quality control in the supply chain of one specific product from a specific country. Olive oil was chosen as the subject of research because it is a product whose quality is relatively often compromised by different factors, and because the procedures taken to protect the quality of olive oil are virtually always applicable to other products. The decision to focus specifically on Italian products was made because Italian olive oil is very popular in the consumer market and because the writer's prolonged interest in Italian food culture and the Italian language made it possible to access a large amount of literature and other information on the production and quality control of Italian olive oil.

The purpose of the thesis was to create a qualitative compilation of information that is relevant and practical for anyone involved in procuring Italian olive oil. The primary research question is: What measures can be taken in the procurement of Italian olive oil to make sure that the quality of the product is good? The methods used for achieving the objective were reviewing existing literature and executing interviews with industry experts. Two procurement professionals in Finland were interviewed and a larger number of Italian olive oil producers were asked for their

input in a more limited manner. As the problems in ensuring the quality of Italian olive oil have persisted for thousands of years and remain a constant concern within the field, one cannot hope to provide simple solutions that will fix these issues. However, a concise review of contemporary information and the industry's best practices can go a long way in helping organizations and their employees with their quality control efforts.

Throughout the history of olive oil production, in addition to its use in cooking it has been used for other purposes such as lamp oil, lubricant, and cosmetics. The focus of this thesis, however, is on products that are intended for the culinary market.

2 SUPPLY CHAIN INTEGRITY

The integrity of the supply chain is defined by USPNF as follows: *An unbroken chain of custody beginning with sourcing of materials, through manufacture and distribution, ending in the receipt of the product by the intended end-user* (USPNF no date). Even though olive oil is a product that goes through relatively few production phases, its quality can be affected by actions both intended and unintended in any of those phases.

Supply chain integrity and supply chain security have a certain amount of overlap, but the latter deals primarily with the prevention and mitigation of intentional criminal acts, while supply chain integrity may be compromised by a much wider set of events. However, threats to supply chain security are always threats to supply chain integrity as well, and therefore, the two concepts are closely interconnected. (USPNF no date.)

2.1 Risk management

Suominen (2003, 27) defines risk management as a process that is aimed at preventing perils that threaten the company and minimizing the losses caused by those perils. These include risks associated with the entirety of the operating field including crime, accidents, weather, legislation, and marketing failures.

Risk management should not be perceived as a separate function that aims only to recognize threats. Instead, risk management should be a part of strategic planning where both positive and negative changes in the operational environment and their effects on the performance of the company are considered along with the likelihood of those changes taking place. (Ilmonen et al. 2013, 30.) Efficacious implementation of the principles of risk management can improve the company's overall performance (Suominen 2003, 30). Not only can the early recognition of risks help in minimizing the effects on the company, but it can also create an advantage when one company is better prepared than others when a risk materializes.

Risk matrixes (Figure 1) have been used by many industries, including transportation, to assess the effects of different risks based on their likelihood and impact (NZ Transport Agency 2022). The matrix can include as many degrees as desired, and the likelihood may range from highly unlikely to almost certain and the severity from practically inconsequential to catastrophic. The urgency to take preventive measures increases as both metrics increase. The risk matrix can be a helpful tool in classifying events into different categories, particularly when there is a large number of possible events to evaluate.

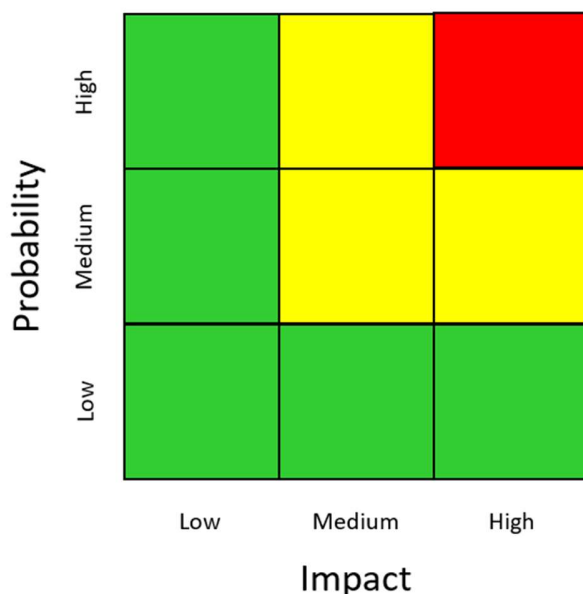


Figure 1. Risk matrix (NZ Transport Agency 2022)

2.2 Security culture

In any company, workplace or other similar operation, the level of security is entirely dependent on security culture. According to Hietanen (2014) security culture is formed by the collaborative actions of the individual, the organization, and the activity between these parties. Therefore, every individual security procedure is part of a larger entity, and at the same time highly dependent on the human element and its individual, social, and organizational aspects.

Creating security culture in an organization is the responsibility of every employee. The role of management is to organize efforts and make sure that everyone understands their responsibilities. The design, implementation, surveillance, and improvement of security related operations can and should involve all employees, as specialized security experts and managers do not typically have hands on experience in different tasks and may not perceive threats in the same way as the employees themselves. When an organization's security culture is at a good level, there should be no members of the organization who think that security is not their concern. In particular the ability of people to notice deviations should be seen as an asset and this natural inclination supported and encouraged. When recruiting security personnel, it is usually well understood that the work requires a certain type of personality, but the ability and eagerness to maintain a high-level security culture is an important factor in all hiring, particularly in fields of operations where the risks are greater than normal. (Harrison 2010, 71.)

The level of commitment and work satisfaction among employees ties into how well security protocols are followed, but also to how prone an employee is to steal from the organization or hand out critical information in return for money (Hoffer 2010, 49–50). While the immediate effect of an unhappy employee can be as inconsequential as impaired work effort, the overall assessment of risk management must take into consideration the possibility of more serious implications.

The organization's management should make sure that all employees are aware of the risks that are relevant to their field of operations, as well as the ways of preventing and limiting them. Training should be offered to help identify risks, and the employees should be given incentives to improve their commitment to the organization's security procedures. (O'Connell 2010, 210.)

2.3 Cybersecurity

According to the Finnish traffic and communications authority Traficom (2022), cybersecurity is a desirable status where the cyber operational environment can be trusted, and its function is secured. A more detailed definition can be derived from the functions that information technology systems are used for. According to the Cambridge Dictionary (2022) information technology is "the science and activity of using electronic equipment to store and send information". That definition can be extended to cyber threats being incidents that may disrupt those processes, and cybersecurity being procedures that are in place to protect systems from such threats.

The CIA-model (confidentiality, integrity, and availability) in information technology adds to the definition the important consideration that protecting relayed and stored information is not enough. The information must also remain unchanged, and it has to be accessible to those who need it (Chai 2022).

Cyber threats are both intended and unintended events that compromise the processes of storing and sending information. Information technology and cybersecurity are concepts that have become instrumental in supply chain management, and they should be considered both regarding their inherent risks as well as the opportunities they present. Companies involved in the production, transportation, and retail of foods use information technology to control their operations, and they are therefore susceptible to cyber threats. In fact, Enisa, the European Union Agency for Cybersecurity reports that supply chain cyber-attacks have recently increased substantially. (Enisa 2021.)

The motivations behind cyber-attacks can be categorized to those that have a direct financial incentive and those that do not. The non-financially motivated attacks may be performed as an experiment, out of pure malice or as part of a governmental threat actor that aims to damage infrastructure or gain valuable information. The financially motivated attacks will typically consist of stealing information or blocking the use of necessary systems and demanding ransom in return for the attack to stop or to prevent valuable information from being released. (IBM no date) The food supply chain is not a field that should be considered immune to any kind of attack. Even individual computer users are frequently targeted by ransomware-attacks that completely block the use of their computers, which emphasizes the necessity for companies of all sizes to maintain up to date information technology security. In addition to preventive measures such as firewalls and anti-malware software, response and continuity planning are some of the necessary aspects of comprehensive risk management. (Know the types of cyber threats 2022.)

2.3.1 Internet of things

Internet of things (IoT) refers to devices that can transmit online information that they gather about their surroundings or the device's own function. An example is a refrigerator in which the temperature can be adjusted remotely, and the device can alert an employee if there is a problem in its function. While the advantages of the technology include easier supervision and remote usage of devices, the problem is that IoT devices are often built with lacking cybersecurity features. Some of the threats that are relevant to IoT devices must be considered when the devices are being purchased and some during their life cycle. (Langkemper no date)

The problems that relate to the device itself and may not be repairable even by proper security procedures include insufficient access control, which can range from having no access control whatsoever to allowing everyone who has gained access to the same network to control the device. Another example is an overly large attack surface, where the device offers services online that are not necessary for its operation but may be targeted by an attacker. There may also

be differences in how quickly the manufacturer of the device reacts to discovered vulnerabilities by updating their software. (Langkemper no date)

Many of the risks in IoT devices can, however, be mitigated or excluded completely by proper security procedures, such as limiting access to the system based on sufficiently strong passwords and keeping the system software updated. Traditional physical security is also a consideration, as many devices are easier to breach if an attacker gains access to the hardware. (Langkemper no date.) Failsafe systems should also be in place allowing the devices to remain operational offline in case of a security breach or other malfunction.

2.3.2 Blockchain

Blockchain has become best known for its use in the world of cryptocurrencies, but as a layered digital record-keeping system it can also be utilized in supply chain management. The basic principle of blockchain is that every transaction is recorded in its code and can be accessed by the relevant parties, or in some cases by anyone. With cryptocurrencies this means keeping track of the amounts of currency that are transferred between accounts. In the supply chain it should include all possible changes in the status of the goods and its relevant attributes, such as orders, manufacturing, packaging, transportation, refinement, storage, payments. (Gaur & Gaiha 2020.)

The advantages of utilizing blockchain in supply chain management include faster and easier access regarding the status and origin of the goods, as it becomes available to all parties as soon as it is added to the chain. When executed properly the blockchain cannot be tampered with. It can also be used in security surveillance directly by having IoT devices record information about detected deviations directly into the blockchain. An example of such technology is a thermometer that can be used to record the temperatures that transported goods are subjected to. At present, blockchain is utilized by several corporations involved with supply chain management, and based on their experiences, it is to be expected that the technology will become much more prevalent in the near future. (Gaur & Gaiha 2020.)

3 FOOD SAFETY

Because olive oil is a fat, its spoilage typically occurs through the process of oxidative rancidification. There are four major factors that contribute to oils becoming rancid:

1. Having a high polyunsaturated fatty acid composition
2. Being naturally low in antioxidants
3. Being refined or heavily processed
4. Being exposed to prolonged heat, light or oxygen

In comparison to most other vegetable oils, olive oil has less polyunsaturated fatty acids, and it is therefore less susceptible to oxidation. It is also relatively high in antioxidants. These factors indicate that olive oil, at least the kind that is not refined or heavily processed, resists rancidification relatively well. This is an important consideration, not only for the quality of the product relating to its taste, but also the safety of consumers. Results from animal tests indicate that rancid fats should be considered harmful to human health. (Health implications of rancid fats and oils 2020.)

Olive oil can, however, be oxidized if it is adulterated with rancid oil or stored for too long or improperly. Eating oxidized fats is one of the mechanisms that causes oxidative stress within the body. Oxidative stress works as the precursor to oxidative damage, which has been shown to contribute to a variety of chronic disease, such as heart disease, type 2 diabetes, and autoimmune disease. Therefore, avoiding oxidized oils is an essential measure for people who wish to avoid or recover from these kinds of ailments. (Kresser 2018.)

The process of rancidification produces compounds that humans typically perceive as having an unpleasant taste and odor. Oils can, however, be processed in a way that makes rancidification undetectable by taste or smell. Lower quality olive oils as well as other vegetable oils that are used to adulterate olive oil are, as part of their standard manufacturing process, bleached and deodorized rendering them effectively devoid of any taste or smell. The fact that rancidification is a time-consuming phenomenon is also utilized in food fraud by

obfuscating the production date of the oil, making it fresh enough to pass inspection when it enters the market, but clearly rancid well before its expiration date. (Crosby 2018; Loria 2017.)

3.1 Pesticide residues

A European Commission publication (2009) refers to a Greek study, in which samples taken from olive oil presses and retail stores were tested for pesticide residues. 60 % of organic oils in the study were found to be free of any residue, but for non-organic products the corresponding number was only 10 %. While the immediate health effects of pesticide poisoning are usually limited to farmworkers who are in direct contact with the substances, even residual amounts can accumulate and be present in consumers in detectable amounts (Health risks of pesticides in food 2013). The direct causation between these chemicals and people becoming ill are difficult if not impossible to prove conclusively, but the risk of people becoming ill from extended exposure to smaller concentrations of toxic substances should not be taken lightly.

According to a more recent large analysis by the European Food Safety Authority (2020) pesticide residue does not currently appear to present a significant risk for consumers. Out of 3167 samples of olive oil, 19 were found to exceed the maximum residue level permitted, and only one of those originated in Italy. These tests are conducted every three years, with the research material from the 2020 publication originating from 2018. From 2015 to 2018, the percentage of contaminated samples went down from 0.9 % to 0.6 %.

In 2020, the European Union implemented a set of policies called the European Green Deal. This plan includes a 50 % reduction in the use of pesticides and increasing the amount of farmland used for organic farming to 25 % by 2030. One of the aims of this set of policies is to gradually decrease the amount of pesticide residue and ban some pesticides completely. (Entering the European market for olive oil 2022.)

3.2 Hexane residues

Hexane is a chemical solvent used in the production of many vegetable oils, including some low-quality olive oils. Hexane is toxic, but animal tests indicate its toxicity level when ingested is low and it does not cause an acute danger in residual amounts. (Hexane 2016.)

It has been estimated that one kilogram of refined vegetable oil contains approximately 0.8 mg of hexane. Food oils, along with other possible food sources, will typically account for less than 2 % of a person's daily intake of hexane, the majority of which comes from inhaling gasoline fumes. (Crosby 2018.) While research indicates that there is little concern regarding the health effects of trace amounts of hexane in vegetable oils, the long-term effects remain unknown as, for example, hexane has not been tested for its ability to cause cancer in animals (New Jersey department of health 2014).

4 OLIVE OIL PRODUCTION

The process of making olive oil includes several phases, and different risks are associated with each one of them (Figure 2).

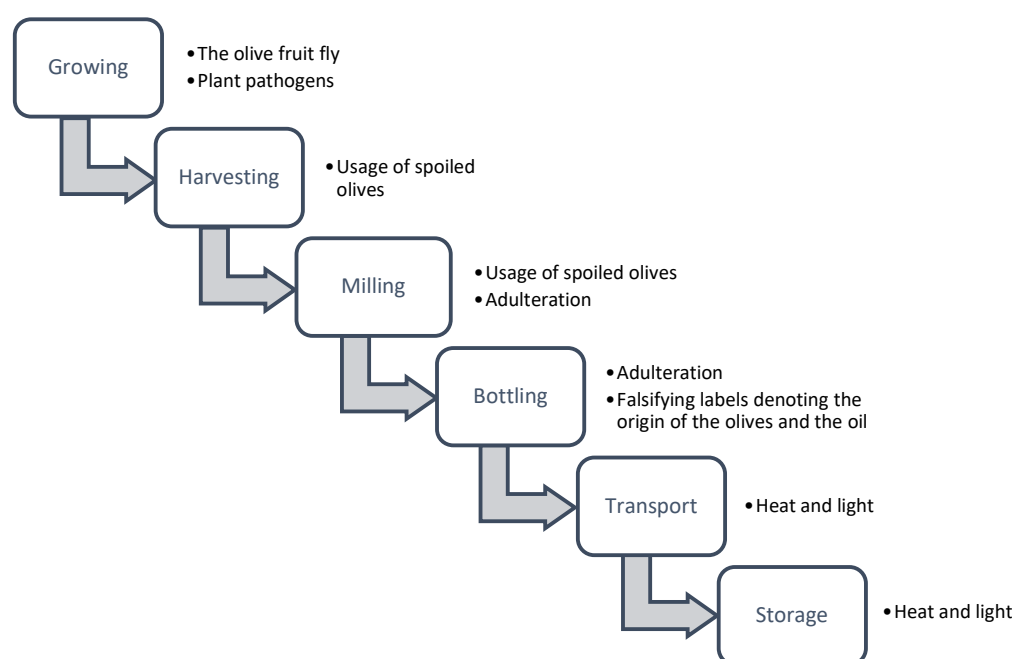


Figure 2. Production phases and risks (Alfei et al. 2021, 45–338)

While the olive tree originates in the Mediterranean region, olives are now produced around the world in places with similar climates. It should be noted that not all olives used for Italian olive oils are grown in Italy. Since Italy is simultaneously the biggest consumer and biggest exporter of olive oil, olive importation from other countries, such as Spain, remains necessary to meet market demand. (di Schino et al. 2016, 67–68.) In the final product packaging this is typically declared by presenting the olive oil as made in Italy while also stating that the olives originate from within the EU.

4.1 History

The olive tree, *Oliva europaea*, is originally native to the Mediterranean region. The plant's drupe has been used as food by humans for thousands of years, and archeological findings indicating production of olive oil date back as far as eight thousand years. (di Schino et al. 2016, 10.)

Historical sources describe the profound effect of olive in Mediterranean cultures. The most significant crop plants of the Roman Empire were wheat, olive, and grapevine. The hill of Monte Testaccio stands to this day in the city of Rome as a testament to these crops, as it is made up of broken and discarded vases that had been used in the transportation of wine and olive oil. (di Schino et al. 2016, 13.) It should be noted, however, that a large portion of olive oil produced at that time was used as lamp oil, as food use alone could hardly have been comparable with wine in terms of consumed volume.

The proper ways of storing food products will have been learned through trial and error, and advice to store olive oil in a dark and cool place date back to the renaissance. (di Schino et al. 2016, 28). This may not have been common knowledge in the Roman period, as fewer options existed regarding storage temperature, and glass vessels were not as widely available.

4.2 Cultivation

In the commercial market olives are often categorized as black and green olives. That division is not, however a true distinction of variety, as all olives are green as they grow, and they become darker as they mature. The color of edible olives is thus determined by the time at which they are harvested. That difference is also associated with olive varieties, as some of them are considered to be at their best when they are harvested before full maturity. That distinction is also relevant in olive oil production. While the vast majority of olive oils are made from mature dark olives, certain green olives are used for oil production as well. (Alfei et al. 2021, 399.) It should also be noted that in Italy only 2 % of olives are produced for use as edible olives (Alfei et al. 2021, 389), and essentially all the rest are used for olive oil production.

4.2.1 Plant varieties

Globally more than one thousand varieties of olives are recognized. More than five hundred of those are grown in Italy. However, the ten most popular varieties account for 58 % of total production in terms of utilized farmland. Many rare varieties are only grown in specific regions. The more common varieties tend to also be regional to a certain degree, as the variety that is planted is often chosen based on the characteristics of the soil and climate in the area. (Alfei et al. 2021, 89–90.) Different varieties of olives produce very different taste profiles, and as many high-quality extra virgin oils are sold as single variety products (*monovarietale*), being aware of the taste profiles is one aspect of confirming that the product is unadulterated and unspoiled.

4.2.2 Plant characteristics

The olive tree starts producing olives 2–3 years after it is planted, and it usually reaches the best phase for production at around 12–13 years. (Alfei et al. 2021, 70). Planting olive trees is, therefore, a time-consuming investment. While the olive tree can survive and produce olives for more than a thousand years, that does not necessarily balance out the cost of the initial investment, since the older trees are so large that it becomes difficult to use mechanical harvesters, which

are the most financially effective option for harvesting the crop. Many producers of high-quality olive oils have, however, kept harvesting manually from their ancient trees instead of planting new ones. One obvious reason for this is the widely held opinion that the best olives grow on hills due to their microclimate and harvesting machines would not be able to traverse on the steeper slopes anyway. (Alfei et al. 2021, 4.)

It is recommended that the trees are pruned annually, and the undergrowth be kept low so that the nutrients and the water of the soil would remain as accessible to the trees as possible (Alfei et al. 2021, 169). Maintaining some undergrowth is, however, important in many places to prevent erosion and preserve moisture in the soil. One possible solution is to grow the younger trees in a field-like fertilized environment and allow the desired undergrowth to take over later on as production is stabilized. (Alfei et al. 2021, 175–176.)

The olive tree has relatively small leaves and a large root system, and as a result of these characteristics it does not usually require irrigation even in the hottest environments (Alfei et al. 2021, 14). The tree sustains damage when the temperature drops below freezing. Growing olives in colder climates is therefore a substantial financial risk for olive production. It is also one of the reasons why olive production is often centered close to the coast, as the vicinity sea moderates extreme temperatures. (Alfei et al. 2021, 3–4, 19–20.)

4.2.3 Common risks associated with the quality of olives during cultivation

During the growing period the olives are subjected to certain risks, whose effects can have an impact on the final product. The most common pest associated with olives is the olive fruit fly (*Bactrocera oleae*). It is an insect native to the Mediterranean region, that has also recently spread to the olive groves of North America. The fly lays its eggs inside the olives, where the larva lives for approximately three weeks while consuming the olive. The olive fruit fly damages crop both in terms of quality and quantity, because the larva living in the olive flesh causes a fermentation process and makes the fat of the olive oxidize faster.

In addition, the punctures made by the flies when laying their eggs make the olives more susceptible to the growth of mold. (Alfei et al. 2021, 274–275).

Other pathogens, such as bacteria and fungi can cause damage both to the tree and its crop. A wide variety of biological and chemical methods are utilized to minimize these risks. (Alfei et al. 2021, 278–295.) Those methods are, unfortunately, not without risks themselves.

4.3 Harvesting

In the Mediterranean region the harvesting period of olive begins in late September and continues to the end of the year. Different varieties ripen at different times, but the desired level of maturity is also a factor in when the olives are harvested. (Alfei et al. 2021, 246–251.) The harvesting period will typically begin when the olives have matured to the point where they are ready to fall from the tree (di Schino et al. 2016, 43).

There are two primary methods of harvesting the olives. The more traditional method is to set up a tarp or a net under the tree and shake the tree or its branches, allowing the olives to fall on the collection device. The advantage of this method is that only the olives that are ripe enough to fall are collected and the olive itself is handled as little as possible, which helps in avoiding bruising the olive or breaking its surface, which could lead to accelerated spoilage. The practical aspect is that shaking the tree can be done in any terrain, where heavy machinery cannot be utilized. That said, machines are also used for this method of harvesting, as specially made devices that attach to the trunk of the tree can be used to vibrate larger trees. (Alfei et al. 2021, 253, 258–260.)

Another way of getting the olives to separate from the tree is to use special rake-like tools (Alfei et al. 2021, 257). That can be done manually, but large harvesters that can drive over the trees can also be used in settings where the trees are relatively low and planted in straight rows. These machines have collection devices on both sides, and they provide by far the fastest method of collecting the olives. (Oxbo International 2010.)

4.4 Risks associated with harvesting

The optimal harvesting season varies slightly depending on the harvesting method. Because mechanical harvesters tend to harvest all the olives, including the immature ones, the taste profile of the resulting oil can change as well (Alfei et al. 2021, 253).

The quality of the olives begins to deteriorate immediately after harvesting, and it is therefore recommended that oil production begins as quickly as possible. Care should also be taken to transport the olives in such a way that they do not spoil. Perforated boxes are recommended, while the somewhat common practice of using bags or sacs should be avoided. (Alfei et al. 2021, 318–319.) These precautions have practical implications, as the olive oil production facilities should not be very far from the growing area. Therefore, it should be taken into consideration that the oils that are made in Italy from imported olives may not be made with quality as the primary goal. For example, if the olives are grown in Spain, the oil could just as well be made there, and its quality would likely be better. The only reason to transport them to Italy is to gain the more prestigious status held by Italian olive oils.

Regarding the precautions to avoid using spoiled olives it must be noted that the olives may have been compromised during the growing phase, or due to inappropriate handling or prolonged storage after the harvest. The use of spoiled olives that results in an inferior product may be caused by involuntary negligence, and as such, it is a standard quality control issue. However, if the use of inadequate raw material is intentional, it clearly constitutes food fraud.

4.5 The manufacturing of olive oil

The contemporary production methods can for the most part be categorized in the traditional and the continuous method (Figure 3). The primary difference between the two is that while the traditional method is used to make one batch at

a time, the continuous method allows an ongoing process which is better suited for processing large amounts of olives.

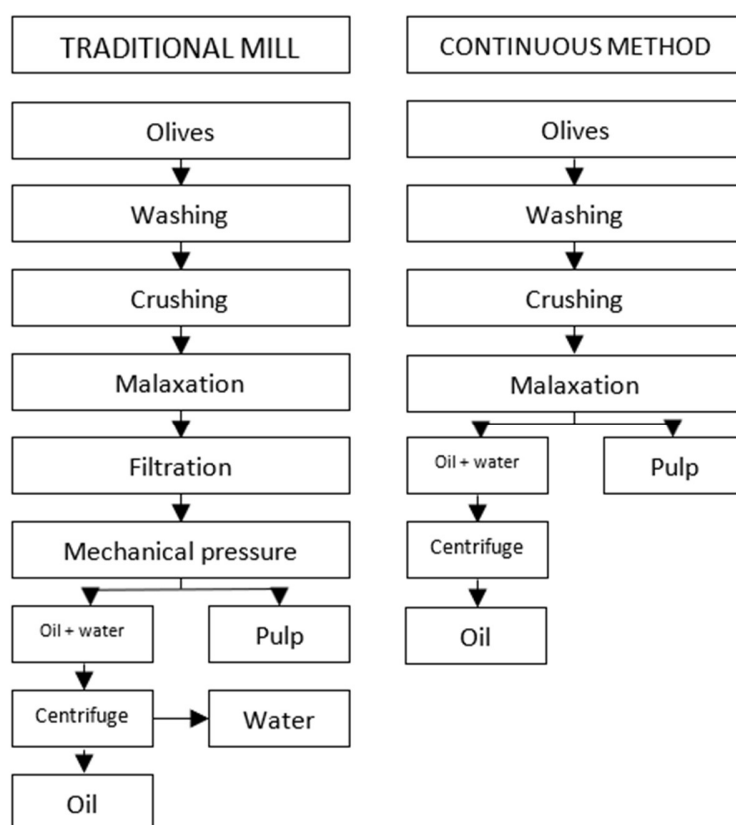


Figure 3. Olive oil pressing (di Schino et al. 2016, 46)

Different types of olive oils are produced in different ways, and the resulting products are very diverse between the categories and within them. There are ca. 5000 olive oil presses that produce extra virgin olive oil in Italy (Elenco dei frantoi in Italia 2022). That number does not include some of the smallest operations where individual farmers and co-operatives can make oil for extremely limited distribution. Some of the smallest pressing machines can fit within a couple of square meters of floor space (Alfei et al. 2021, 332). In addition, there are processing plants where lower quality oils are made from the olive pulp that is left over from making extra virgin oil. The differences in production methods are noteworthy not only because of the differences in the character of the product, but also regarding the various food safety risks that they are associated with.

4.6 Official categories of olive oil

Olive oil is divided into separate categories based on the means of production and the properties of the oil. The definitions laid out here are those of the European Commission. These definitions are the most relevant because they form the basis of legislation within the European Union, which, according to the Commission, produces 67 % of the olive oil in the world. The Commission recognizes eight different types of olive oil (Olive oil no date):

1. *Extra virgin olive oil is the category with the highest quality. From an organoleptic point of view, it has no defects and is fruity. Its acidity level must not exceed 0.8%*
2. *Virgin olive oil may have some sensory defects but at very low level. Its acidity must not exceed 2%.*
3. *Lampante olive oil is a lower quality virgin olive oil with an acidity of more than 2%, with no fruity characteristics and substantial sensory defects, which can result from the olives being damaged by poor processing, weather incidents or olive fruit flies. Lampante olive oil is not intended to be marketed at retail stage. It is refined or used for industrial purposes.*
4. *Refined olive oil is the product obtained after the refining of a defective virgin olive oil (lampante olive oil for instance). It is not intended to be marketed at retail stage. It has a degree of acidity up to 0.3%. The refining process leaves the oil without much taste or aroma, and if it is to be sold to consumers, it is often mixed with extra virgin or virgin olive oil, which results in the fifth category.*
5. *Olive oil composed of refined olive oil and virgin olive oils is an oil resulting from the blending of refined olive oil with extra virgin and/or virgin olive oils. It has a degree of acidity up to 1%.*
6. *Crude olive-pomace oil: the olive-pomace is the residual paste obtained after the oil is extracted from the olives. The oil obtained from that paste is called crude olive-pomace oil.*
7. *Refined olive-pomace oil: crude olive-pomace oil can be refined and blended with virgin olive oils. The result of that blend is called refined olive-pomace oil. Its degree of acidity can be up to 1%*
8. *Olive-pomace oil: results of the mixture of refined olive-pomace oil with extra virgin and/or virgin olive oil. Acidity degree must be below 1 %.*

Many of these categories are hardly recognizable for a European consumer. In fact, in retail stores the selection is usually limited to extra virgin olive oils and “olive oils”, whose production methods and even the origin of the olives are not specified.

The first three categories are virgin olive oils, which means that neither elevated temperatures nor solvent chemicals are used in their production (Olive oil no date). Extra virgin olive oil is considered the highest grade, and it is the most esteemed and most valuable olive oil. The basic manufacturing method involves washing the olives and separating other plant material as they arrive at the press facility, crushing the olives and applying pressure to extract the oil, and separating the oil from the water the olives naturally contain by using a centrifuge. There are many different kinds of machines that can be used and a variety of production details that can affect production capacity and the quality of the oil. (di Schino et al. 2016, 45–46.) Modern mills will extract the oil while the olives are exposed to nitrogen in order to prevent oxidation in this critical phase of the manufacturing process (Parkkinen 2022). The production methods are relatively simple and contain few inherent risks, which means that the food safety of virgin olive oil is quite good at least all the way up to the production phase.

Olive-pomace oil is made from the pulp that is left over from making virgin olive oil. Cold pressing cannot extract all the oil from the olives, and the pomace can be treated with hexane to reduce the viscosity of the oil. After that the mixture of oil and hexane is heated to evaporate the hexane, and the remaining oil is purified for alimentary use. Typically, olive pomace oil is not sold to customers unless some virgin olive oil is added to the oil, because pomace oil in itself is practically tasteless after the treatment necessary to make it. The final product is considered to be safe for food use, but some of these oils have been found to contain carcinogens as well as other toxins. (Mueller 2012, 137–138.)

The manufacture of pomace oil is similar to the way other vegetable oils are made. Cold pressing is not used extensively with other plants, because the oil would be too difficult to extract, or it would have an unpleasantly strong taste. (Saarela et al. 2005, 162.)

4.7 Bottling and packaging

While the beginning of the production process of olive oil is very time-sensitive because it is necessary to harvest the olives at the right time and move them to

the press as quickly as possible, the requirement for urgency decreases once the oil is made. During storage the essential factors that alter the molecular structure of olive oil are light, temperature, oxygen, and time. That is why, once the oil is made it is usually preserved in large stainless-steel containers, which work quite well in preserving the oil before it is bottled. (Alfei et al. 2021, 336.) The bottling can therefore occur in a different facility. The most popular retail container is a colored glass bottle. According to a 2018 study (Sanmartin et al.) green bottles seem to work well by limiting the oil's exposure to harmful wavelengths of light. The research also verified the commonly held belief that the oil will oxidize slower if it is stored in a cool place.

In addition to standard food safety risk related to hygiene and proper packaging, the risks related to the packaging phase are primarily instances of food fraud. This is the case when the labels on the packaging do not match the actual product. (Koistinen 2020, 13.)

5 FOOD FRAUD

In the United States, claims have been made that up to 80 % of imported Italian olive oil is fraudulent (Rodriguez 2016). There are, however, several ways of committing food fraud, and their health implications vary from non-existent to life threatening.

A typical manner of committing food fraud is by conveying fraudulent information about the product, which can be done by selling a product that is advertised as coming from a designated area, when in reality the olives are from a different province, different country or even a different continent. In addition to the area of origin, the production date of the oil or the time when the olives were harvested may be altered. (Koistinen 2020, 13, 64–65.)

A more aggravated method is to adulterate the oil by adding cheaper vegetable oils, also known as seed oils, such as rapeseed, corn, soy, or sunflower oil. In these cases, the food fraud probably does not cause a direct threat to consumers' health, but that possibility cannot be excluded. (Tuomaala 2017.)

While adulteration with another kind of oil is the most egregious type of food fraud, even a large, recognized brand name on the bottle does not guarantee that the oil has not been adulterated. (Kirchgaessner 2015). When the supply chain is long and complicated, it can become harder to find out whether the company is the perpetrator of the crime or if they were themselves cheated into buying adulterated oil.

It is important to note that food fraud can happen at any stage during the production of olive oil, and in order to efficiently detect food fraud, all aspects of the oil's production should be monitored.

5.1 Health effects of food fraud

Many official dietary guidelines, like those of the United States (USDA 2020), recommend rapeseed oil – known as canola oil in the USA and Canada – and other so-called seed oils as healthy sources of fat. The arguments are that these so-called soft fats are more heart-healthy and have a fatty acid composition that is well suited for human nutrition. The characterization of soft fats comes from the fact that the vegetable oils that contain more polyunsaturated fat will not turn solid even in the refrigerator. Olive oil, which has more saturated fat, may turn partially solid when it is cold, depending on the individual product. Despite that, it is generally considered a soft fat. (Pusa 2020.)

There are, however, contrary opinions among experts regarding the health effects of seed oils. Common points of criticism are that they are heavily processed and oxidized, and therefore cause oxidative stress and inflammation, and that their fatty acid composition is not as optimal for human consumption as animal fats, which have been a part of our ancestors' diet through millions of years of evolution. (Berry 2018.) Regarding rapeseed oil specifically, even though many experts have labelled it the healthiest fat, studies have linked its ingestion with heart disease, inflammation, and oxidative stress. (All about canola oil 2021.) Many studies have also shown that people who eat more seed oils are more likely to contract cancer (Teicholz & Hyman 2019). For these reasons many consumers have stopped eating seed oils altogether, and therefore adulterating

olive oil with a seed oil could be seen as harmful to health. While that effect might not seem substantial considering the fact that many people eat vast amounts of seed oils for decades without becoming noticeably ill, it should not be neglected either because of the serious nature of many of the diseases associated with seed oils and the frequent occurrence of food fraud regarding olive oils.

5.2 The toxic oil incident

In the 1980s in Spain, an event known as the toxic oil syndrome contributed to the death of more than a thousand people and over 25 000 serious injuries. According to the investigation conducted at the time, people had bought cheap olive oil from street vendors. The alleged olive oil, stored in large plastic containers, had been adulterated with rapeseed oil. At the time, importation of rapeseed oil to Spain was only allowed for industrial purposes, and the oil had to be denatured with aniline to prevent alimentary use. This measure was in place to protect Spain's olive oil industry. The investigators came to the conclusion that people were getting sick from aniline poisoning. Oil samples from the street vendors were studied, and while none turned out to be pure olive oil, they did not all contain aniline, either. According to research aniline seems to only be toxic to humans in doses too large to have come from oil consumption, and the true reason for the poisonings may have been pesticide residues from the country's vegetable industry. (Woffinden 2001.)

Even if the most famous and destructive adulteration scandal in history turns out to have been caused by a different phenomenon, it should not be viewed as an indication that food fraud does not have potential for severe outcomes. After all, all of the tested oils had been adulterated, and many of them contained a toxic chemical. If the pesticide residues in vegetables were indeed the true cause of the poisonings, it also goes to show that even accidental issues in the supply chain of foods can cause horrible results.

6 QUALITY CONTROL TESTING

Informal tasting of the olive oil is used in different phases of the supply chain in order to verify its quality, but more elaborate methods exist as well. Laboratory tests can be utilized to make sure that the product does not contain undesired residues or oils from different plants, and they are also used to measure the acidity of the oil. (Koistinen 2020, 62, 65.)

Sensory testing through the use of trained panels is a very reliable and frequently utilized way of making sure that the taste profile of the product is good, and this method can detect defects that cannot be found in laboratory testing alone (Alfei et al. 2021, 347).

6.1 Sensory testing

The panel used for testing olive oil usually consists of 10–15 individuals who are trained in detecting specific characteristics in the taste, smell, and appearance of the oil. The taste characteristics, such as sweetness, bitterness, and acidity are rated numerically, giving different oils an easily comparable profile. (Amelio 2019, 1–2.)

Consumer panels are also utilized, but they serve a somewhat different purpose. Consumer test panel members are given some training in the topic to help control the applicability of the results, but the scope of the testing is more general, focusing on whether the panel enjoyed the product or not. These tests can help in determining the market potential of the product. These panels tend to be larger, between 20 and 25 persons, because the lower level of expertise can lead to greater variability in the results. (Amelio 2019, 1, 7, 10.)

While professional panels will focus only on the taste of the oil, consumer panels have a more practical approach and may therefore pair the oil with different foods. Professional panel members should only drink water or eat a slice of apple between samples to cleanse the palate, and they should not eat anything for at least one hour before the tasting. (Amelio 2019, 7–8, 45; Alfei et al. 2021, 350.)

The appearance of olive oil, which consists of its color and degree of opacity, does not, in any of its manifestations, show a direct correlation with the oil's taste. While consumers may find certain colors more desirable, a professional panel will typically smell and taste the oil from colored glasses in order to prevent the appearance from creating false expectations regarding the taste. (Amelio 2019, 12.)

The accuracy of panel tests is very good when the tests are conducted in a professional manner. Repeatability and reproducibility are basic requirements of the process, and when subjecting the same oils to testing by different panels, the results have been shown to be very similar. (Amelio 2019, 30–31.)

6.2 Laboratory testing

Testing the chemical compounds of olive oil can be used to definitively reveal signs of adulteration and other deviations from quality standards. Some of the interesting factors include the amount of triglycerides, fatty acids, free acidity, amount of peroxides, oxidative changes, and wax content. (Alfei et al. 2021, 345.)

The free acidity increases when fatty acids are released from triglycerides. An increase in free acidity is a defect in the oil that cannot be tasted, which is why laboratory testing is necessary to detect it. (Alfei et al. 2021, 343.)

Peroxide is formed in the oil when it is in contact with air. Low peroxide content is therefore one of the indications of high-quality oil. It is measured in milliequivalents of oxygen per kg, and a good value is below 12. (Alfei et al. 2021, 343.)

Wax content is a natural and benign phenomenon for olive oils, as the wax originates from the surface of the olive. However, wax content is typically higher in olive-pomace oils as a result of their manufacturing process involving the use of solvents. In an extra virgin olive oil wax content should be below 250 mg/kg. A

number higher than that can be indicative of adulteration with lower quality oil. (Alfei et al. 2021, 344.)

As scientific methods evolve, and more elaborate techniques become widely available, completely new strategies can be found to aid in the authentication of product origins. An excellent example of that is the DNA traceability project regarding the Taggiasca olives from Liguria. When batches of these rare olives are produced, their DNA is verified, and the batch number is made public so that retailers and consumers can verify the authenticity of the product. (DNA controllato 2022.)

7 RESEARCH METHODS AND DATA

In this thesis, qualitative research methods were applied. The aim of qualitative research is to understand the observed phenomenon. It is a type of research that is particularly applicable when the phenomenon is not well known, or previous research does not provide a sufficient amount of information to understand the phenomenon. (Kananen 2008, 32–33.) While information about food fraud in general is widely available, and publications typically mention olive oil as one of the most commonly adulterated food products, general publications will often dedicate only a very limited number of pages to olive oil specifically. The most important consideration regarding the importance of this thesis is that, as explained earlier, quality control issues in the supply chain of olive oil that are unrelated to food fraud are also quite common and need to be addressed.

The primary research methods of qualitative research are making observations, studying documented sources, and conducting interviews. Choosing the right methods depends on the availability of information, as well as the objective of the research. (Kananen 2008, 48.) Due to the fact that the topic has a substantial amount of global reach, literary sources of excellent quality were relatively easy to find.

Sources can be divided into two categories, where secondary sources consist of existing literature and primary sources are ones that are acquired directly by the

researchers. (Kananen 2008, 82–83.) The specific methods used for this thesis were one semi-structured interview which was conducted via e-mail, one semi-structured telephone interview which consisted of mostly the same questions with certain points being explored further, and an e-mail survey that was sent to 77 olive oil producers. The survey had only one question and fifteen replies were received. While the number of respondents was higher than expected, it is still far from enough for the responses to have any quantitative value.

In order to maintain full independence regarding the content and of the thesis, the author chose to work without an employer or subscriber. Regardless of this, this thesis has many elements that are associated with a functional development study, which is normally conducted in collaboration with an organization that hopes to benefit from the work. Functional research is practical and applicable to the organization's processes. (Airaksinen & Vilkkä 2004, 9–10.) While this thesis is not intended to be a manual for any specific organization, it can be very useful in that role since the research question is directly related to the interests of many companies.

As a subcategory of qualitative research, this thesis can be considered a case study. According to Eriksson and Koistinen (2014, 4–5) case studies can be conducted on a wide variety of topics and in many ways, with the defining characteristic being that a case study studies one or several cases, whose definition and analysis, as well as developing possible solutions to the case are the main focus of the study. This definition should also be applied when pertinent sources of information are chosen.

7.1 Overview of the information gathering

For the purpose of expanding the reach of this research beyond existing literature, information requests were sent out to 77 different Italian olive oil producers. The subjects were chosen using two pieces of criteria: the producers are involved with the entire supply chain from growing the olives to marketing the oil, and their oils are sold outside of Italy.

The question presented to the producers was the primary research question of this thesis: what measures can be taken in the procurement of Italian olive oil to make sure that the quality of the product is good. The request for information was restricted to a single question to encourage more oil producers to provide at least a brief response, and it also gave them the opportunity to focus on the issues that they found most important without being led to specific topics by the questions. The request was made, and the responses were received in Italian.

Geographic variety was addressed by attempting to get responses from different parts of the country. The recipients of the request were located in seventeen out of the twenty regions of Italy.

It is very important to recognize that Italian extra virgin olive oil is sold as two very different kinds of products. The category with the greater volume includes mass produced oils, a large proportion of which do not really meet the requirements of extra virgin olive oil as defined by the EU regarding their quality and taste profile. The corporations that make these oils buy their olives from outside suppliers, and unfortunately, most of the large companies in the industry have hardly exhibited an exemplary attitude towards quality control in the past (Kirchgaessner 2015). The other category consists of higher quality oils that are often made by small companies who grow their own olives. The same quality control measures that can be used when buying oil from these smaller producers are not always applicable with mass produced oils.

Olive oil producers who have been associated with food fraud in the past were not included in the dissemination of the request for information.

In addition, both large grocery retailers in Finland were contacted and a list of questions was sent to them. Unfortunately, despite an initial promise from both of them to participate, only one of them eventually responded. Fortunately, the answers were expansive and provided a large amount of insight into the retailer's perspective. As opposed to the single-question approach with the oil producers, the retailers were sent several questions (appendix 1) to get a better

understanding of their current quality control measures. As a large part of procurement is made through international co-operative establishments that procure products for several retail companies internationally, these results can be considered universally applicable for the most part. The interview was conducted by email, as the answers required feedback from different levels in the corporate structure.

The retailer's point of view was an extremely important consideration, and therefore a specialty store in Helsinki was also contacted. The store sells Italian foodstuff with a primary focus on olive oil. This company turned out to be an extremely valuable source of information, since the entrepreneur herself takes care of most of the business processes, including sourcing the oils in Italy. This interview was conducted over the phone with the same questions that were presented to the other retailers and expanding upon many of them. The duration of the interview was approximately thirty minutes. The specific quality control measures appropriated by this individual retailer can be considered applicable to other smaller businesses that wish to purchase olive oils directly from manufacturers. In addition to retailers, that category includes restaurants and catering services.

7.2 Olive oil producers' perspective

In total, fifteen responses were received from the olive oil producers. All of the answers were received within two weeks. One problem associated with this part of the information gathering was that the e-mails were sent in August, which is the most popular holiday season in Italy. However, that could not be avoided because of the timetable of the writing. The writer would have been prepared to accept replies for at least two months, and no deadline was specified in the request.

Some of the answers were concise, offering only a single measure of quality control, while others were longer and more detailed. Many of the respondents had university degrees in agrology, and several responses recognized the importance of the subject. The answers were categorized according to the

principal themes, but the details of each were taken into consideration. The suggested quality control measures are detailed below.

7.2.1 Co-operation with the producer

The most frequently addressed measure for quality control was to co-operate and get to know the company that produces the oil. This can be done by asking about the company's reputation from other actors in the business or looking into open-source information.

Many respondents raised the argument that smaller companies are safer to work with for a variety of reasons: their acquisition of the olives and their growing areas and conditions are easier to examine, the small companies work in a highly competitive market and cannot afford to lose their reputation, and it is possible to get to know the proprietors personally and develop a good rapport with them. It was also suggested that direct supervision can easily be applied, as it is in the best interest of the companies to be open about all their business practices. This supervision could be conducted by a third party if necessary.

7.2.2 Changing the official definitions

A common concern among producers is that the current definition of extra virgin olive oil has become futile because many companies are selling sub-par oil that is categorized as extra virgin even though it does not even meet the official requirements. One possible solution to this issue could be more stringent adherence to the official requirements. However, many producers feel that the reputation of extra virgin olive oil has already been irreversibly damaged by the current situation, and it is therefore necessary to create a completely new official category, such as *high-quality extra virgin olive oil* or *superior extra virgin olive oil*.

It was also noted that the chemical definition of this proposed new category should be more specific than those of the existing categories, taking into

consideration characteristics such as the acidity and the amount of peroxides, polyphenols, and oleic acid within the oil.

The current quality standards in place in the EU concerning protected designation of origin (PDO), which can often be found on Italian products in Italian as DOP (*denominazione di origine protetta*), was mentioned in several answers as a good indicator of quality, since being able to use the designation requires quality control measures regarding the sourcing and manufacturing methods, and, to an extent, it is indicative of continued and established production.

Creating a new category would involve legislative work in the EU, and the process could be initiated by demands from within the industry. The change could be seen as an opportunity for retailers to be able to better cater to their customers' needs by providing them with a clearer understanding of what they are buying. While some olive oil producers might not see the change as a positive prospect, a clarification of the currently somewhat dubious situation could help in elevating the reputation of all olive oils.

7.2.3 Testing samples

The applicability and limitations of testing samples both through laboratory testing and sensory panel tests were mentioned in several responses. With these practices it is important to note that the samples used in the sale and promotion of the product may differ from the mass quantity that will be delivered to the buyers. It is therefore equally important to test samples from various deliveries making sure that the quality remains consistent.

7.2.4 Price considerations

A frequent concern among olive oil producers is that oils can be found in retail stores that are labelled as Italian extra virgin olive oil, but their price is so low that it is not economically feasible that they could have been made in Italy adhering to industry standards. Products like this can alter the consumers' perception of what is a reasonable price to pay for olive oil and what an extra virgin olive oil is

supposed to taste like. Retailers could consider the total cost of producing olive oil in Italy and assess what the minimum price for such a product can be in order for all of the participants of the production chain to make profit. Selling products that are cheaper than that estimate could be refrained from on the basis that it is fundamentally dishonest towards the consumer, and it is damaging to the entire line of business from the oil producers to the retailers.

7.3 The retailer's point of view

The retail chain whose representative was interviewed (Interview 1, 2022) currently has a market share of 46 % of the grocery retail business in Finland (Päivittäistavara-kauppa ry. 2021). Olive oils are purchased by this chain directly from oil manufacturers as well as through the sourcing company Coop Trading, which operates in the Nordic countries. Choosing producers from whom oil is purchased involves verifying that the producers adhere to quality certificates and that they are able to provide a product that meets the required quality standards and has an appropriate price. Quality and sustainability policies in the company apply to all purchasing. The company also strives to send its representatives to periodically visit olive oil producers from whom they purchase goods directly. The products that are purchased through Coop Trading go through a stringent quality control and risk assessment process provided by the purchasing company. Direct purchases are evaluated by the retailer through sensory assessment, laboratory testing, and accredited panel testing.

Olive oils are also purchased from importing companies, but that does not directly affect the quality control process. All of those products are subject to the same quality control plan as direct purchases.

Whether the purchasing is made directly, through Coop Trading, or from a separate importer, the traceability of the olive oils is taken into consideration in the contracts. Upon request from the purchaser, the sourcing company must be able to provide information regarding the production facilities and origin of the olives. The companies are also responsible for making sure that all of their subcontractors adhere to the same quality and sustainability requirements.

The expiration date of the olive oil is determined by the company that makes or bottles the oil, depending on the circumstances. The date is typically set at twelve to eighteen months from the production date. Therefore, even if the production date is not provided with the product, it can be roughly determined because of the fixed production seasons. If needed, the exact production date can also be inquired from the vendor.

Regarding the olive oil producers' demand for the creation of a new category of high-quality olive oils, the retailers experience has been that high quality olive oils are currently not in high demand in Finland, even though they have been made available in certain locations. The higher price of these products seems to be a deterrent for many consumers.

7.4 Specialty trade

A telephone interview was conducted with the proprietor of an olive oil retail store located in Helsinki (Interview 2, 2022). The store specializes in Italian olive oil and other specialty food items.

The selection process of products chosen for distribution differs significantly when sales volumes are much lower than those of major retailers. Building business relationships with olive oil producers with desirable products can be difficult, and it is made much easier through personal contacts to people in the business who can make important introductions. Smaller retailers can also buy products through importers.

Quality control measures are limited to careful evaluation of the quality standards exhibited by the manufacturer and tasting the products before purchasing them and after they are delivered. The limited scope of these measures emphasizes the requirement to perform them with elevated scrutiny. These measures are equally important regardless of whether the purchasing is made through an importer or directly.

The respondent has found that the size of the producer is an important consideration for the type of high-quality olive oil sales they are engaged in. If the manufacturer is too small, they may not be able to adhere to sufficient quality control measures, but larger companies lean towards mass production, which often has a deteriorating effect on quality and traceability.

In this retailer's opinion, the expiration time for a high-quality olive oil is approximately one year. Availability of fresh oils around the year is guaranteed by bringing the first new harvest oils to the market in November, as the ones made from olives harvested later on may be produced as late in the season as February.

The respondent agreed with the olive oil producers' complaint that the market situation is very confusing for consumers, because products that do not meet the quality standards of extra virgin olive oil are sold under that classification. Therefore, creating a new category seems warranted, but it is also noteworthy that customer awareness of quality issues seems to be increasing and many consumers are more inclined to find information on how to find high-quality products, including olive oil.

8 CONCLUSIONS

If the general situation regarding sufficient quality of olive oils that are available in the retail market is observed adhering strictly to the official definitions, it would appear that problems in quality control are quite common (see Frankel et al. 2010 2 & 7). However, third party testing of products in stores appears to be rare, and they do not necessarily offer much insight into what caused the problem in the first place. If, for example, an olive oil bottle picked up from a supermarket shelf turns out to be oxidized, the test results are highly unlikely to answer the question of what went wrong in the supply chain; were damaged olives used, were they stored too long before milling, was the oil subjected to light or heat and when did that happen etc. Releasing such research results is also problematic because they can tarnish the reputation of the oil manufacturer even if the quality compromising mistake was made by someone else. While the most notorious

problem of food adulteration is a high priority in the supply chain management of olive oil, care must also be taken to make sure that transportation and storage conditions are periodically reviewed.

One of the fundamental problems with testing olive oils is that when the tests are done by companies involved in the supply chain, they are likely not released, and even if they are, they can hardly be considered objective. Even separate entities conducting research, such as universities, can be perceived as being partial if they receive funding from the food industry. Food and health authorities, on the other hand, are mainly concerned with quality control issues that have direct health implications. This situation creates a paradox, where the entire industry would certainly benefit from the increase in quality brought on by increased testing, but if problems were to surface, it is certainly not in the industry's immediate best interest in to publish the issues. Based on the interviews conducted for this research, the situation in Finland at the moment is actually quite good regarding the testing and other quality control measures, but this does not help consumer confidence if the consumers are not aware of these measures.

The scope of laboratory tests available is wide, and new opportunities for testing are incrementally becoming available as technology evolves (see Alfei et al. 2021, 345; DNA controllato 2022). Research has also demonstrated that sensory panel testing reaches a high level of confidence. These methods provide a good basis for quality control, so long as the limitations of the methods are understood. It is understandable that many companies such as small retailers and restaurants that purchase olive oil cannot afford to use official tests, which is a significant limitation to their quality control efforts if they choose to buy directly from producers. In those cases, particular care should be taken in researching the reputation and other available information about the producer.

8.1 Variations within the industry

Olive oil is a food product with very high variability in its quality, and that effects quality control measures in many ways. It also means that the most demanding

consumers have demands that are very difficult for most retailers to meet. For example, some connoisseurs maintain that the quality of any olive oil will have deteriorated substantially within six months of manufacturing, and they insist upon using European and North American olive oils during the winter and spring and shifting over to oils made in the southern hemisphere, primarily in South America and Australia as their harvest season begins in June (Mueller 2012, 219). While answering to these demands may be economically unfeasible for retailers of any size, it should not signify that the higher-end olive oil market must be completely ceded to online retailers. The more demanding customers are often knowledgeable of the availability of different products in the market and will gladly buy from local stores if good products are available. The requirement for this to happen, however, is that information about the product is sufficiently available, including what varieties of olives were used, and the critical information of when the oil was made. Production dates or seasons can currently typically be found only on the packaging of higher quality oils. One of the reasons why manufacturers might be reluctant to present this information is that if they believe their oil maintains its quality for as long as eighteen months, as the manufacturing time becomes more distant, consumers are less likely to purchase the product. However, manufacturing dates are typically only a high priority for the more demanding consumers, who will simply not buy an oil if the production time is not available. Therefore, increased openness regarding manufacturing dates would seem to offer more advantages than disadvantages. If the growing areas of the olives and the production date of the oil are indeed traceable to the retailers, printing them on the bottles would seem to be much more of an advantage than a disadvantage.

The market situation for olive oils from the consumers' point of view is somewhat confusing. While there are eight official categories of olive oil, the only ones widely available in stores are extra virgin olive oil and refined olive oil, which is simply labeled as 'olive oil'. Therefore, the category of extra virgin olive oil includes such a large variety of different types of products that the notion of the classification having lost its meaning is well founded. It seems as though the extra virgin olive oil market is divided into at least two completely different

categories, where most of the sales are achieved with products that experts consider to be hardly worthy of the classification. The demand for a new higher quality olive oil classification is undoubtedly not seen as a positive prospect by the large companies in the business, as it can be perceived as a measure that decreases the marketing value of their products. For retailers it could be seen as a marketing opportunity and a step towards offering customers a clearer image of what they are buying. At the moment high-quality extra virgin olive oils account for a very small portion of supermarket sales, which seems to be the case because higher quality products are more expensive, and consumers are not sufficiently aware of the differences between products. Consumer awareness can be raised through marketing, and the higher price of premium products is balanced to some extent by lower consumption, as many households use such small amounts of cooking oils that they do not have to purchase these products often. If the customer is confident that they are buying a high-quality item, they are more likely to be willing to spend more money on it.

The quality control measures and demands for these products are also somewhat different, as the large companies producing mass quantities will buy olives from different regions and different countries as needed depending on the market situation. The large size of the business operation, which is further obscured by the use of sub-contractors, provides a very different operating environment for quality control in comparison to small companies that grow, mill, bottle and sell their own olives. Both scenarios and all of the variations in between demand different considerations which have to be evaluated individually.

8.2 Food fraud and health

Media outlets periodically publish articles and news stories about food fraud, and these stories will usually feature olive oil as one of the prime targets of this activity. When consumers read about the topic, their trust in the product can become compromised. In response to this, increasing the openness of the entire supply chain in co-operation with the different actors involved, could go a long way in restoring that trust. Many consumers are interested in the products that

they purchase, and a traceability system based on blockchain, for example, would give them the opportunity to trace their product all the way to the groves in which the olives were grown. Releasing the basic information of where the product comes from and what it consists of has tremendous potential in building consumer confidence in the product and expanding marketing opportunities.

Regarding the health considerations of adulterated olive oil, it is difficult to make definitive statements. Nutrition science is an extremely complicated field of research, as it is virtually impossible for researchers to control everything that their research subjects eat, particularly over an extended period of time (Research study types 2022). The situation is further complicated by the fact that different individuals have different responses to different foods, as can be deduced from the existence of allergies. It can also be argued that a research project can lose at least some of its credibility if it is funded by corporations that produce the particular foods that are being researched (Teicholz & Hyman 2019). Health authorities have also been very slow to change existing recommendations as new evidence emerges. For example, it took decades of accumulating evidence from research before dietary guidelines were changed to reflect the fact that consumed cholesterol from eggs does not seem to have a health threatening effect on blood cholesterol (Brown 2020). These confounding factors can make it extremely difficult for even the most observant consumers to find the healthiest food products. Despite the somewhat conflicting evidence, there are many consumers who choose to buy olive oil specifically because they believe it is the healthiest fat, and that conviction should be held in high regard by the individuals and companies who are responsible for sourcing olive oil. Substituting olive oil with cheaper oils is not harmless to health in the same way as adulterating wine with water, and the efforts to provide customers with the exact product that they are paying for should reflect that.

9 DISCUSSION

In the planning phase of this thesis, it was clear that literary sources would be easy to find. However, the willingness of industry professionals to participate was impossible to predict. Therefore, receiving answers from fifteen different olive oil

producers, and many of those answers reflecting similar concerns, is a very satisfactory result for that part of the information gathering. The perspective of retailers was also crucial, and fortunately a large amount of information was extracted from those sources as well.

The reported quality control measures that are in place in the retail market turned out to be a positive surprise, taking into consideration that large retailers have thousands of product categories in their catalogues. When one of those categories, particularly one as narrow as Italian olive oil, receives so much attention, it goes to show that expansive quality control that goes beyond the scope of what customers expect or are even aware of, is a standard procedure at least for some retailers.

9.1 Answer to the research question

Co-operation with various types of olive oil producers can differ substantially, but as there clearly is market demand for many different kinds of products, these differences have to be accepted and handled appropriately. Individual assessments are required for different producers and different products in order to apply quality control measures that are sufficient and relevant regarding the predicted risks of the specific product. With the phases of production and their inherent risks, an overview of food fraud, and the means to mitigate these risks presented, the scope of the research is comprehensive.

The quality control measures and proposed improvements presented in this thesis are pertinent and useful in the writer's opinion. Many of the quality control measures are of course industry standards, but emerging technologies and personal insights from reviewing a large amount of information are also presented. That being the case, the objective of the thesis has been met as intended.

In terms of the author's personal learning process, the information gathered has helped tremendously in shaping a realistic perception of how olive oil is produced and distributed, and what risks are associated with those functions. Typical

problems associated with conducting this type of research, such as conflicting information in certain sources as well as the difficulty of finding information about certain niche subjects were encountered, and resolving these issues was an important part of the learning process. This result should indicate that readers of this thesis can reach similar insights.

9.2 Reliability and validity of the results

The assessment of reliability in qualitative research can be initiated by addressing biases that may be present in the way that the researchers choose sources of data and how that data is interpreted. In handling research data, it is important to maintain its integrity when it is presented. The language of the presentation must also be sufficiently clear to avoid misunderstandings. Different perspectives to divisive issues should be taken into consideration, and every source of information has to be vetted for reliability. (Noble & Smith 2015.)

In this study the writer had no substantial biases relating to the subject, and the lack of any existing bias or its effect on the results is evident in the fact that many of the writer's expectations were challenged by the data and with sufficient evidence led to changes of opinions.

A comparison to previous research shows that there are no major discrepancies, and the propositions presented by the writer are not at odds with pertinent literature. The amount of sources utilized was large, and in any of the major topics the sources did not contradict each other.

9.3 Further research suggestions

While one of the goals of this thesis was to present aspects of quality maintenance in food supply chains that are applicable to other food products as well, there is no doubt that individual food groups have such distinct characteristics that similar research would be helpful in proliferating information about those products.

Olive oil specifically is a product that is subject to frequent professional research. Particularly the applicability of new laboratory tests in confirming the origin and consistency of the oil are subjects that will no doubt continue to be addressed in the future. Regarding research where the supply chain and its integrity are emphasized, emerging technologies such as automated transportation, electronic surveillance, and blockchain have plenty of potential, and their practical applications would provide important points of consideration.

The learning opportunity offered by taking a focused look at the supply chain should not be neglected. Even though the subject matter of this thesis focused on a relatively narrow section of the transportation industry, researching this topic, and developing an understanding of the entire supply chain of a single line of products was a very good way of summarizing the entirety of the studies that led up to the thesis phase. This provided the writer with a good understanding of the practical applications of theoretical concepts and a much better faculty for applying this knowledge to other aspects of supply chain management.

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APPENDIX

Questions presented to the retailers:

1. In direct procurement, how are the suppliers chosen, and in what way is quality control performed? For example, are tastings organized periodically?
2. In non-direct procurement, what are the quality control measures utilized by the intermediaries, does your company perform additional measures, and are you able to follow the supply chain all the way to the growing location of the olives?
3. Has your company come across recognized instances of food fraud with Italian olive oil?
4. Who determines the expiration date of the olive oil?
5. In bulk retail the production date is usually not disclosed in the package, does the retailer nevertheless have access to the date?
6. Many Italian olive oil producers think that the EU-defined category of extra virgin olive oil has lost its meaning, and hope that a new category is created for high-quality products. What is your impression regarding the market potential of such a product in retail sales in Finland, if the prices start at 15–20 € for a 0.5-liter bottle?