



WildFood

WildFood Project

Eating the wild: Improving the value-chain of Mediterranean Wild Food Products (WFP)

Report on comparative analysis on specific wild food chains

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Executive summary

Wild food supply chains transfer products from forest to the end users, which pay back the entire chain till the producers. The report analyzes the structure and overall performance of different supply chains in Italy, Spain, Slovenia and Portugal on summer and black truffle, pine nuts, acorns and pennyroyal. The results show the deep differences in the production chain among Mediterranean countries, which can be used to design and implement corrective measure to increase their efficiency.

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1. Supply chains and their economic actors

The present chapter introduces the general concept of supply chain and the main indicator used to describe performances and structure. Wildfood supply chains have rarely been described in the literature due to the difficulties to access information and also to the high level of informality that characterizes the wild food market in Europe and in Mediterranean countries. After a brief introduction of the definition of the supply chain and literature review on supply chain analysis applied to wild food in the first subchapter, the second subchapter introduces the indicators used to describe the supply chains.

1.1. Analysis of wild food supply chains: from the concept to the key information

Market, supply chain, economic actor and company are all terms that are used to describe economic phenomena within a given space and time. These concepts have been used in WildFood project to describe the market and supply chain structure of a set of wild food such as summer and black truffle, pine nuts, acorns, mint and rosemary. In general, a supply chain is defined as “*a system whose constituent parts include material suppliers, production facilities, distribution services and customers linked together via the feed forward flow of materials and the feedback flow of information*” (A Gunasekaran, 2001). In other words, a wild food supply chain is a system of economic actors that transfer a product from the forest to the end users, which purchase the product and pay back the product and processes along the entire chain providing direct or indirect information. Compared to other more complex sectors, like car manufacturing, the supply chains analyzed in the project are very simple and typically encompass a group of companies that represents the entire nation or international market for a specific commodity. The main reason for collecting data and information along the wild food supply chains is that there is an almost total absence of public market statistics, or unreliable reported data, for these products. Only a collection of data directly from companies allows us to understand how a supply chain is structured and how it works in the market.

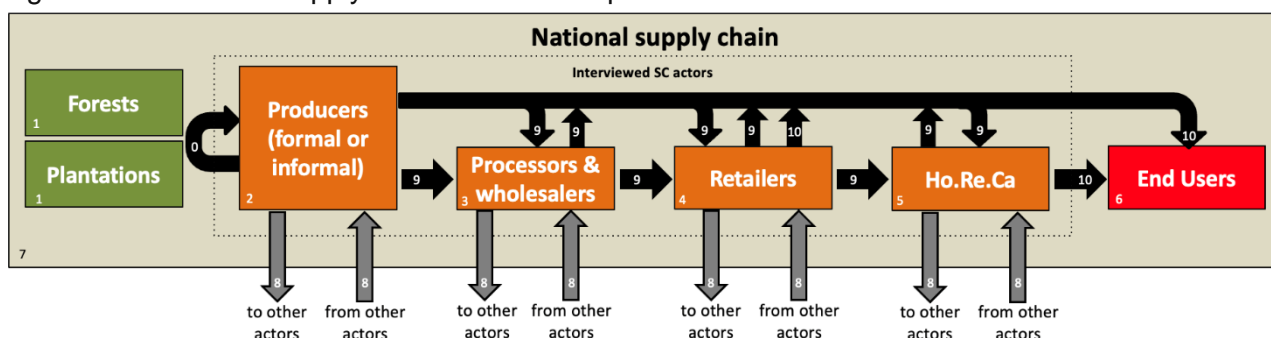
There are several ways to analyze a supply chain and for the project we used an adaptation of the approach proposed by Taylor (2005). Taylor's analytical framework has been commonly used in public and private sectors to reshape the performances of the national or local supply chains, which are often led by public authorities conjointly with private sector representatives. Starting from an initial step, where we strive to understand the core business of the supply chain, which in our case is rather simple, one needs to develop the theoretical map of the actor involved in the chain. For this reason, we introduce a theoretical supply chain (Figure 1), later described in the present paragraph. A following step is the individuation of the companies forming the supply chain and their main targets as well as business opportunities. The activity was developed within the project and it involved the setting up of a database of companies dealing with the target products described in Deliverable 1.1. This database provided information to group companies to target by a direct survey. The latter aimed at characterize the chain structure, namely by identifying its limiting factors and constraints. A common questionnaire was designed to address each category of economic players and to collect relevant quantitative and qualitative information. The key information collected from each company included a general overview of the company on economic and occupational terms, the typology of business model applied on the single economic actor, an open statement section of sector problems and finally a section to identify the selling price of a specific product. The information collected will be used to design general recommendations to achieve better functioning of the wild food chains.



Specifically, this information may be used to help policy makers and/or the supply chain managers set up objectives and actions to add value to the wild food products as well as to improve the social and environmental impacts generated by the chain. In practice, the recommendations can be used to design an action plan to be followed by the companies that are part of the supply chain. The literature reports very few examples of analysis of wild food supply chains in Europe. (e.g., Brenko et al., 2019; Anton Brenko et al., 2022; Oliach et al., 2021). These authors described and mapped the supply chains of mushrooms, truffles and aromatic plants at country level in different Mediterranean countries. Nonetheless, they do not report metrics, indicators or other parameters to describe performances in quantitative terms. The Wildfood project represents an effort to add knowledge and better understanding of the structure and performances.

The theoretical scheme of the wild food supply chain was represented based on four key segments: producers, processors or wholesalers, retailers, and Ho.Re.Ca. (hotel, retailer and catering). The latter includes specialized retailers, who represent an important economic segment within the supply chain of some products such as truffles. Each economic actor that integrates the supply chain is directly or indirectly connected to the key segment that allows the existence of the supply chain itself, i.e. the final consumer who not only pays the entire production chain, but provides important information that allows companies to change the way of production or the product itself placed on the market. Figure 1 schematically represents the structure of a general wild food supply chain.

Figure 1: Theoretical supply chain of wild food products



Note: 0: action of wild harvesting by producers that collect the wild food in the forests; 1: forests areas and plantations; 2: producers both formal companies with VAT code or informal commercial producers; 3: processor or wholesalers that purchase raw materials for re-selling or for further processing; 4: retailers that sell to the end users or other companies of the supply chain like hotels, restaurants or caterings; 5: Ho.Re.Ca. hotels, restaurants and caterings; 6: end users that purchase the raw or processed products; 7: National boundaries of the supply chain; 8 import or export activity to actors included end users of third countries (i.e. tourists or private user); 9: B to B economic relationships; 10: B to C economic relationships. The arrows directions of arrow 9 and 10 represent the product flow.

The forest is the main place of production of wild products (Figure 1), which are harvested by commercial or professional collectors. The plantations are also sources of semi-wild product, yet the latter are produced by farm activities, rather than being provided by wild gathering. As to the activities by the key economic players, the arrow “zero” indicates the harvesting activity of the producer who goes to the woods or plantation to collect one or more products useful for their activity. Some products, such as some medicinal herbs, mushrooms, berries or truffles, can be marketed directly from the producer to the final consumer (arrow number 10), however, not all products can be delivered to the end user as such. For example, it is difficult to market pine nut directly from the producer to the final consumer, because the pine nuts need to be removed from the cones, shell the pine seeds, packed and distributed in a final package; on the other hand, the direct sale of truffles is easier, because it is usually sold as it is harvested. The direct marketing to the end user also depends on the marginality of the single economic actor involved in the sale. Consequently, small quantities of wild foods can be easily marketed by the producer, while when the volumes of the marketed product increase, a sale to wholesalers or processors is necessary. This happens for all types of



wild food products. If available in large quantities, the economic role of trader or processor becomes strategic for the entire supply chain. Wholesalers and processors are two types of businesses but often they developed jointly and the companies run both wholesaling and processing activities. Usually, their main clients are represented by the retailers and Ho.Re.Ca.. Processors are fundamental for some products, because the transformation of raw products into final or semifinal products allow marketability. Moreover, it is a way to increase the added value of the raw material. Retailers and Ho.Re.Ca. are key categories, because they mostly deal with the final users and consequently, they need to understand the demand and interpret the end user's wills through product packaging and price setting. It is not rare that restaurants include also the gathering activities, but they are usually located close to the area where the wild foods are sourced.

1.2. Comparability: indicators and representatives of the results

The wild food supply chains move products from forests or specialized plantations to the end user, which pays back the production, delivery cost and other additional services. A product supply chain can be divided into three parts: production of the raw materials, raw material processing into the final product and distribution of the final product to the end user. Generally, the supply chain analysis aims to assess the minimum production cost of a product and the related distribution cost to deliver the final product to the consumer through the network of companies involved (Beamon, 1998). However, the supply chains involved in the wild food sector are characterized by almost total absence of data and a fragmentation of the information that leads to information asymmetry among the companies involved in the chain, which act with an opportunistic economic behavior (Gereffi, 1999; Gereffi, et al. 2005), because it is rather simple to switch from one partner to another. Hence, the applicability of complex analysis model is limited. On the other hand, simple analysis allows to unveil important information about wild food supply chains that can be used to improve both the overall knowledge of the its structure and functioning and its performance either on production or delivery.

The supply chain performance measurement represents a way to describe the characteristics of the supply chains and provides information to support technical, economical and managerial adaptation to changes on demand or shortage of raw material. The indicators to measure the supply chain performances can be classified as qualitative or quantitative. Qualitative indicators encompass customer satisfaction, variety of products, flexibility, information and material flow, and others that are continuously tested by researchers on supply chain management. Quantitative indicators have been commonly used since the beginning of supply chain studies because they are the most effective and efficient to describe the overall performance of a given supply chain. Quantitative indicators can be further divided into financial and non-financial indicators. The relationships among the economic actors involved in the chain provide sources of financial and non-financial information, among which the financial information represents sensitive and crucial information to use for analyzing the supply chain. Non-financial data is also useful for understanding the role and classification of the individual economic operator within the production chain, as well as providing a wealth of information relating to the ability of the individual economic operator to produce goods and services. In the questionnaire submitted to the supply chain actors both typologies of indicators were considered. Qualitative information was asked at the beginning of the questionnaire, while the quantitative one was asked in the last part of the questionnaire (see annex 1). Table 1 reports in synthesis the most common financial and non-financial indicators commonly used by supply chain managers, policy makers and scholars in the studies devoted to the implementation of new strategies



or policies in order to enhance the performances of the whole supply chain.

Table 1: Key performance indicators for the supply chain analysis

Financial	Non-Financial
Inventory cost	Accuracy of scheduling
Overhead cost	Bidding management cycle time
Return on investment	Capacity utilization
Scrap/obsolescence cost	Compliance to regulations
Selling price of good and services	Conformance to specifications
Stock-out cost	Delivery reliability
Transportation cost	Forecasting accuracy
Value added	Labour efficiency
Warranty cost	Lead time for procurement
	Lead-time for manufacturing
	Perceived quality
	Perceived value of product
	Process cycle time
	Product and service variety
	Product development cycle time,
	Product development time
	Production flexibility
	Supply chain response time
	Value added

Source: (Gunasekaran and Kobu, 2007) modified.

The supply chain works thanks to the difference in price from a downstream actor to an upstream actor. Consequently, the greater the price difference between one economic player and the next, the greater the economic and strategic role of a single type of company in that particular segment of the supply chain. Conversely, the smaller the price difference, the greater the standardization and diffusion of the product sold with consequent lower margins and greater quantities. In other terms, the selling price is a universal indicator as it allows to quickly summarize positive and negative factors relating to the position of the economic player within a given territory as well as regarding its role within the supply chain. The annual turnover is also important as well as the number of employees and the indicators that can derive from the interaction of socio-economic data of companies, but unlikely they can provide outputs related to the structure or performance of the single supply chain. Among the most significant data surveyed during data collection, the selling price of wild food products is the most significant for describing the structure of the supply chain. The comparison of sales prices between the individual players in the supply chain allows us to describe the price increment from the producer to the final seller, with the possibility of calculating the gross added value generated by the supply chain. The economic description of the supply chain through a universal indicator, which is the price, allows the comparison of several supply chains of the same product. Despite its simplicity, the selling price is considered an indicator that can be used to describe the structure of any supply chain, while archiving other indirect information about structure and role of each single economic actor included in the supply of a given product. Certainly, among the main limits, the representativeness of the sample of selected companies can lead to weak outputs, but usually the market of a given wild food product reacts quite immediately to any price change, according to the daily or weekly availability of the raw material that enters in the chain. Hence, we can assume the existence of country level market in each supply chain as well as an international market. In the following chapters, we report the outputs of the survey.



2. Survey results

All partners of the WildFood project were involved in carrying out a survey for the description of a selected number of wild foods between the end of 2021 and August 2022. The survey has been developed to collect information and feedback from actors involved in the supply chains of four main wild food products: truffle (summer and black ones), pine nuts, aromatic plants (pennyroyal, rosemary and myrtle), acorn. The questionnaire utilized in the survey has been organized in five parts: (i) main characteristics of the respondent organization, (ii) its business model, (iii) the role of certification in its supply chain, (iv) the socio-environmental aspects of the supply chain (v) and the price of products along the value chain. The results presented in the chapter derive mainly from an analysis of the answers of the last part of the questionnaire. Depending on the relevance of the wild food products in partner countries of the project, the interviews were organized in the following way:

- For the truffle value supply, the survey focused on Italy, Slovenia and Spain, with the distinction that Spanish actors were mostly involved in black truffle supply chain, while Italian and Slovenian actors were mostly involved in summer truffle supply chain;
- For the pine nuts value chain, the survey focused on Italy, Spain and Portugal;
- For the acorn value chain, the survey focused on Portugal;
- For the aromatic plants (rosemary, myrtle and pennyroyal), the survey focused on Tunisia and Portugal.

The structure and questions included in the survey were the same for all products and for all countries, to facilitate the following comparative analysis among countries of origin. As described in table 2, the survey has collected responses from 130 different actors, which ranged from producers to the Ho.Re.Ca. sector. Almost half of the interviewed actors were producers since these represent the key actors of the wild food supply chain. Being able to involve more than 60 producers of wild forest products in the interviews represents a good basis for analyzing the main economic and social features of the value chains considered. In fact, many of the supply chains considered represent a niche, with the presence of few formal actors and several informal ones, and therefore it was often not easy to find contacts of companies willing to respond to the questionnaire.

Table 2: supply chain questionnaire responses

Partner	Product	Producers [n]	Wholesalers [n]	Retailers [n]	Ho.Re.Ca. [n]	Total
Italy	Summer truffle	11	13	1	3	33
Slovenia	Summer truffle	4	1			5
Portugal	Pine nuts	9	3	1	2	15
Spain	Pine nuts	5	2	5	5	17
Italy	Pine nuts	6	2			8
Tunisia	Pine nuts	1				1
Spain	Black truffle	6	2	4	1	13
Portugal	Pennyroyal	7	1	2	2	12
Portugal	Acorn	7	5	5	4	21
Tunisia	Rosemary	3				3
Tunisia	Myrtle	2				2

Note: green color corresponds to the supply chain which archive the minimum number of responses suitable for the quantitative analysis; yellow refers to useful data for some group of companies, and orange means dataset that cannot be used for analysis.

For instance, in Italy and Slovenia the high level of informality of the sector led to a zero-response rate on retailers and Ho.Re.Ca., and a limited response on producers and wholesalers. Among the reasons for the drop rate, informal market is the main cause, which has direct effect on the declaration of the country of origin and the communication through labelling. Even more complex



was the situation in Tunisia, where companies systematically refused to answer the questionnaire. The non-answer is actually a useful information, which gave us a key element that characterized the wild food chains: the opportunistic attitude of the economic players involved in the chain. Despite the length of the questionnaire, the majority of the companies agreed to answer because similar projects were useful to promote legal changes or improvement of the supply chain organization (Martinez de Arano, et al. 2021; Oliach et al., 2021; Vidale, et al. 2016). However, the total respect of privacy should be better considered in similar future work. These aspects were also mentioned by the interviewed companies in the debriefing section of the questionnaire, right before end. Informality, high taxation rate, smuggling and stealing of raw material have been highlighted as major problem of the sector, which intrinsically explain the high drop rate, especially in those countries where informal transactions are widely diffuse and tolerated by the authorities.

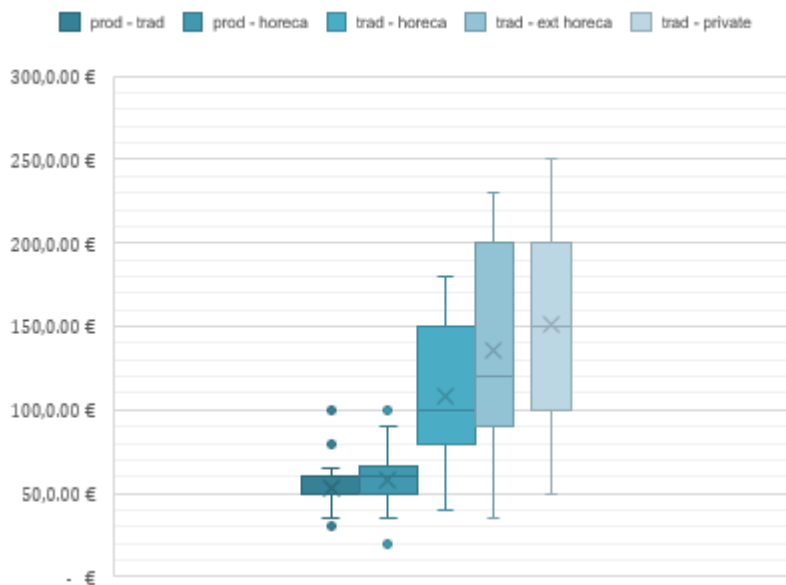
In the paragraphs here below, we will report the analysis of the different supply chains according to the available data collected from the survey. The analysis considers the selling price evolution along the truffle, pine nuts and acorn supply chains, as proxy to describe their structure and performance of the national chain. The figures in the paragraphs here below report the selling price distribution in boxplots. In order to understand the results, we can say the line inside each box represent the median and “x” point the mean, while each box of the boxplot report the values within the first and third quartile, the single dots represent the outliers and the whiskers the data range. The data can be interpret looking at the difference on the data median and mean between the main common type of transactions. For example, if we look at figure 2, the selling price between producer and trader, and the selling price between producer in HoReCa does not differ statistically one from the other, and it corresponds to an opportunistic behavior of the producers; this can be understood looking at the medians and the ranges of the selling price boxplots of the two types of transactions (producers vs traders and producers vs HoReCa). Another example can be retrieved looking at selling price range between producers vs HoReCa and traders and HoReCa, which at first glance is very different, and it shows a clear role of traders on the added value creation transferring the production to other national customers. It is worth to be mentioned the interpretation of results was a crucial task especially on the performance comparisons between countries, but we had to combine the survey results with information collected in other projects, grey literature or confidential communications by the interviewed companies.



2.1. Truffle supply chain²

The price evolution along the summer truffle supply chains of Italy and Spain has been analyzed through the data collected by the economic actors that are active part of the chain. Figure 2 reports the results of selling prices set by different economic actors in the Italian fresh summer truffle supply where there are three principal actors: the truffle picker or farmer; the trader/transformer and

Figure 2: Price [€/kg] along the Italian summer truffle supply chain



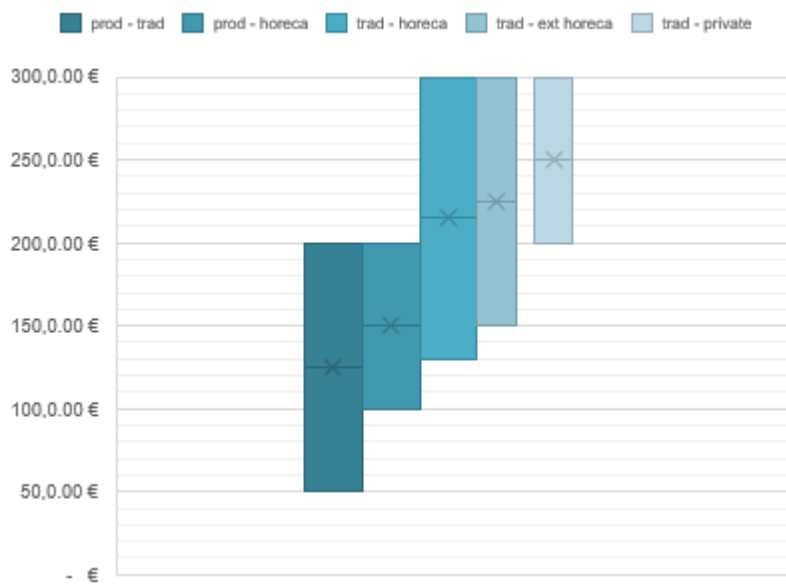
HoReCa. As mentioned in chapter 1, the supply chain works because there is a price difference between producers and end users, and the higher the price difference is, the more economic space for middleman or other economic actors there is. Figure 2 simply reports the price difference mechanism between summer truffle producer and traders where there are two main blocks of prices: a producer selling price and a trader selling price. It is very interesting to see the economic behavior of the producers which mainly accept a price that might be linked to their personal opportunity cost, regardless of who is the buyer of

their products. This behavior highlights also a general asymmetry of the market information as well as a quite high distance between the source areas and the areas where the truffle is consumed. In fact, the price set up for traders and HoReCa is practically the same, confirming that their attitude is simply opportunistic rather than organized and structured within a supply chain agreement designed for minimizing the cost and increase the overall marginal utility of the chain. Another important information is related to the last part of the supply chain, or in other terms the part that is closer to the end-user. Figure 2 shows the coexistence of at least three summer truffle markets for the Italian supply chain: the local summer truffle market close to the production areas; the internal market based on the cities or touristic areas where there is a higher spending capacity of the HoReCa customers; and finally, the European, or international, market for HoReCa, where the traders receive an average of 35 €/kg more compared to the internal market. It is quite clear that the structure of the supply chain is based on the market information asymmetry and the incapability of producers to reach richer market. This led to a crucial role of a set of economic operators that allowed the truffle to be transferred from forest or plantation to national or international customers. The structure of the present supply chain is an outcome of the high level of informality of producers, mainly private people collecting and selling truffles, or very few companies with one or few employees. Somehow traders can have a role in the supply chain because quantities produced by a single picker or farm are too

² Each figure reported in the next paragraphs has common labels where “prod” state for formal or informal producers like truffle picker and farmer; “trad” for processors and wholesaler; “HoReCa” for national hotel, restaurant and catering where we include also retailers; “ext HoReCa” for international hotel, restaurant and catering where we include also retailers; “private” is for private end users.

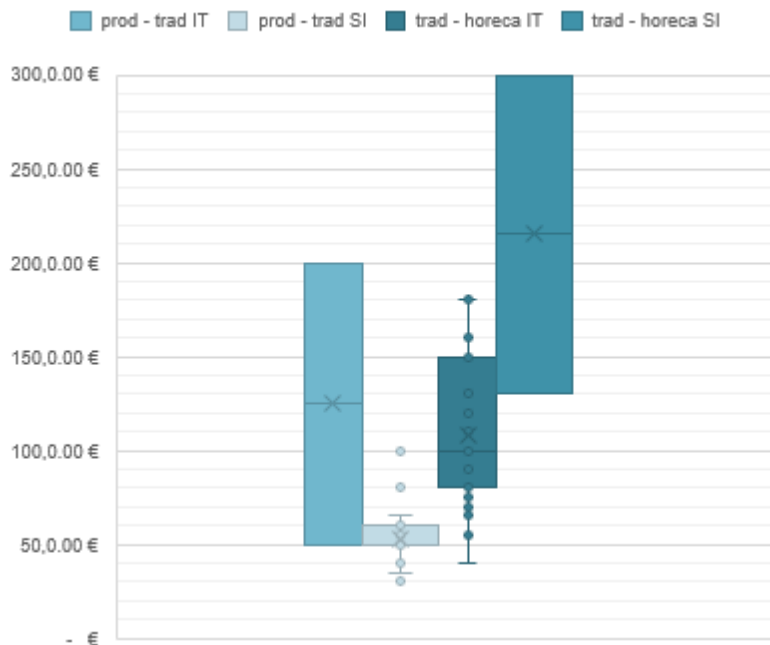


Figure 3: Price [€/kg] in the Slovenian summer truffle supply chain



allowed to understand the highly opportunistic behavior of the producers and traders which are practically bind to the touristic market. Regardless of who is the buyer, both producers and the only middleman interviewed set the same price; this looks like a proxy to an overall problem on the supply chain management, which is generated by an unsuitable harvesting law and a high level of taxation

Figure 4: Price comparison between similar IT and SI players



or bureaucracy applied to the commercialization of wild summer truffles. It is worth mentioning that the few respondents did not report their name, even though data is kept confidential and none of the respondents will be mentioned in public or internal documents. Practically, the interviewed agreed to respond to the questionnaire if only it would have been totally anonymous, for avoiding any risk of control from the Slovenian authorities. Once more, their valuable answers allow us to state that the actual structure of the supply chain is linked to the highly restrictive norms applied to collection and commercialization of truffles. Their suspicious attitude is comprehensible, because any declaration can be handled in an improper way, especially in the case of informal transaction between economic player running in the black, or better, informal market like in this case.

small to fulfill an average demand of supply. However, a radical change on the structure of summer truffle supply chain can occur if only producers start to crop truffle in large specialized plantations, or they organize themselves into small cooperatives. Moving into the Slovenian summer truffle supply chain, the level of informality and opportunistic behavior of the economic players involved in the supply chain becomes more evident and clearer. The low response rate to the questionnaire is the first evidence of a high level of informality. The few answers

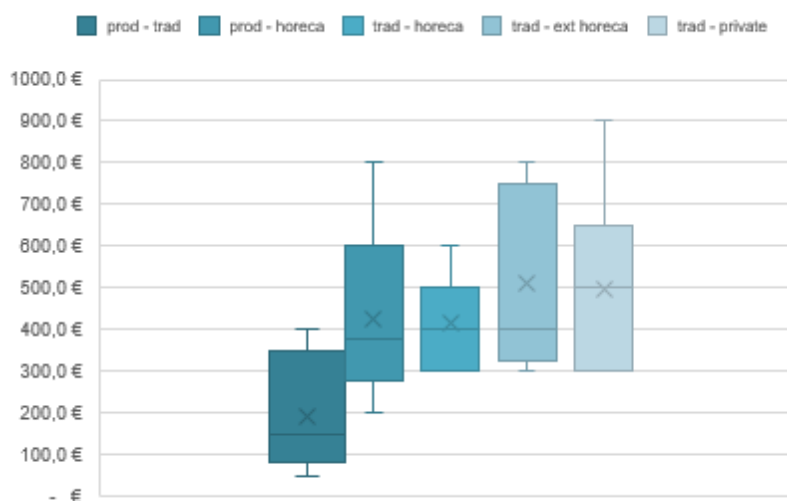
allowed to understand the highly opportunistic behavior of the producers and traders which are practically bind to the touristic market. Regardless of who is the buyer, both producers and the only middleman interviewed set the same price; this looks like a proxy to an overall problem on the supply chain management, which is generated by an unsuitable harvesting law and a high level of taxation or bureaucracy applied to the commercialization of wild summer truffles. It is worth mentioning that the few respondents did not report their name, even though data is kept confidential and none of the respondents will be mentioned in public or internal documents. Practically, the interviewed agreed to respond to the questionnaire if only it would have been totally anonymous, for avoiding any risk of control from the Slovenian authorities. Once more, their valuable answers allow us to state that the actual structure of the supply chain is linked to the highly restrictive norms applied to



If we compare similar economic actors of the Italian and Slovenian supply chains, it is almost immediate to see the high difference on the selling price. Slovenian producers have a very large price range, which indicates that there are producers very close to restaurants and end-users while others are located in remote areas and they need a middleman to sell their harvest. The high selling price of Slovenian producers drag price around three folds of the selling price of Italian producers, and similar behavior occurs between Italian and Slovenian traders. The national media has reported in the last few years a set of cases where foreign informal buyers come to Italy to purchase large quantities of Italian summer truffle from the local producers. Austrian and German tourism is another cause of higher prices among Slovenian producers and traders of truffles. In fact, their spending capacity is relatively higher compared to the Slovenian or Italian one, which leads to a better selling price. Probably the tax reduction on the commercialization of truffle in Slovenia may lead to a more structured supply chain, with an improved economic role of the middleman.

Finally, we decided to report also the Spanish black truffle supply chain, because it is worth to compare the effect of truffle national policies on the structure of the supply chain and their direct and indirect effect on each economic player typology (see figure 5). Black truffle producers have almost substituted the local middleman on the distribution of their fresh truffles, selling directly the truffles to HoReCa, with an average price that is the same of the traders. Only traders dealing with the

Figure 5: Price evolution along the Spanish black truffle supply chain



international market have a reasonable price difference which allows a key economic role in the supply chain; however, the diffusion of social media and online platforms reduces the distances between the end-user and the producer in Spain, which allows to obtain higher revenues. In other terms, middleman like traders, processors and wholesalers are the weakest part of the supply chain, with a fragile position that might be incapable to compete with a better and coordinated production at the producer level. Practically, in few years

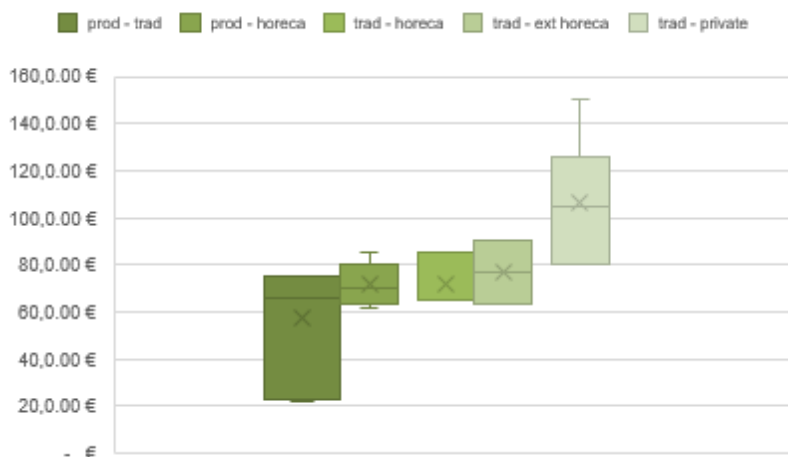
middleman can disappear from the Spanish black truffle supply chain in case producers organize themselves into cooperatives or consortium for selling in the international market. It's a paradox, but the direct selling by farmers to the end user in general reduces the overall added value generated by a structured supply chain. The implications can be several but among of them it will reduce the ability to understand the evolution of foreign demand of black truffle or their transformation into canned products.



2.2. Pine nuts supply chain

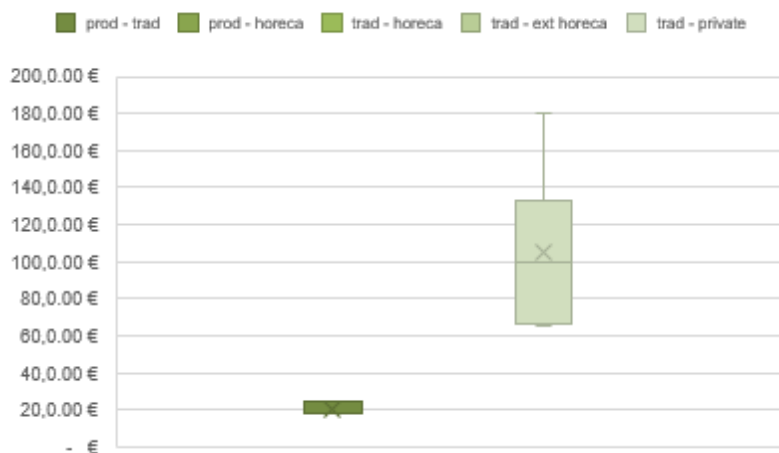
Pine nuts supply chain is the most complete dataset collected with the survey and its analysis allows to see the structure of the supply chain from a market perspective. In Italy, the structure of the supply chain shows clearly a limited price gap between the producer and the trader selling at the HoReCa (see figure 6).

Figure 6: Pine nuts price [€/kg] along the Italian supply chain



are quite a few in all country. Probably the evolution of the Italian supply chain will be the simplification of the chain into producer and retailers. This has already occurred in Spain (see figure 7), where the supply chain has been deeply shortened. In this case the integration of sorting and packaging activity are held by retailers or traders that sell to the end user at retail level. Producers, in this case, are simply devoted to the production of shelled pine nuts in bulk or cones. The simplification of the supply chain is typical of mass market products such as pine nuts. The producers generate byproducts like fuel wood from the cones, which increase the value of the final product, and it can be seen as lower price for the producer. Finally, the

Figure 7: Pine nuts price [€/kg] along the Spanish supply chain



Portuguese supply chain can be considered well-structured chain with a high level of specialization of the economic actors (see figure 8). Producers are specialized in pine cone production, with a limited price variability that ranges between the 0.9 and 1.2 €/kg³ (6.3-8.4 €/kg pine nuts equivalent – 7% yield). The specialization is probably due to the high extension of the production area, which allows to reduce the costs linked to the plantation management and pine cone harvesting and storage. The trade and processor price reflects their concentration on drying cones and unshell the

³ The producer price is reported in shelled pine nut equivalent. The calculation was done assuming 7% pine nuts yield as stated in the questionnaire by three respondents.



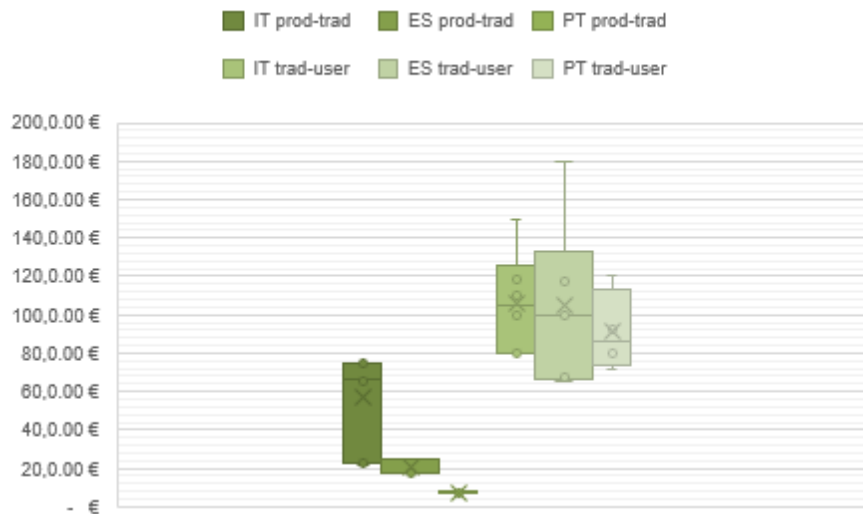
Figure 8: Pine nuts price [€/kg] along the Portuguese supply chain



Note: producers' price was reported for pine cones and then recalculated in shelled nut equivalent for comparing the prices along the chain.

can range between the ~70 €/kg in half kg pack till ~120€/kg in small package of 50 g. The Portuguese pine nuts chain should be considered a well function model compared to the Italian one, and more performing in terms of lower selling price with regards the Spanish one. This is also supported by the trade data reported in the deliverable 1.3 (Vidale, et al., 2021), which shows a positive trade balance with a negligible importation by Portuguese companies. Looking at the Italian and Spanish supply chain it is worth to mention how each group of economic actors integrate sorting, packaging and distribution activities. In Spain retailers and distributors integrated their activity from

Figure 9: Producer and final user prices [€/kg] in Italy, Spain and Portugal



Note: Portuguese producers' price was reported for pine cones and then recalculated in shelled nut equivalent for comparing the prices along the chain.

production level it differs a lot due to the unspecified activities carried out by producers and intrinsically grabbed inside the price. Probably, without a strong public help on the replacement of pine nuts forest in Italy, the producers will evolve into specialized importers that just buy cone or unshelled nuts in a very near future. The adoption of Portuguese model, as well Spanish one, in the Mediterranean basin would be a guarantee to increase the efficiency of the supply chain. However, only national wide planning can archive a significant impact, due to the long production cycle of the

pine nuts seeds; once again the price range is very limited as it occurs in a typical specialized segment of a supply chain. Their main customers are the retailing system, which has the highest price range variability once selling at the final customer, mainly due to the packaging costs. In fact, as the respondents reported, the smaller the package the higher the price, which

sorting to retailing, while Italian supply chain allocates sorting to the producers and retail packaging to traders. Moreover, in Italy, producers are also importers of cones from the international market, hence they specialized their activity and role on sorting and wholesaling, while traders specialized on retail packaging for large retailing system and distributors. The price can be quite similar at retail level, but at



pine nuts tree.

2.3. Acorn supply chain

The Portuguese acorn supply chain is a very niche market. In Portugal and up to the democratization process started in 1974, acorns were consumed regularly by rural populations. As far as the poorest people were concerned, until that time, acorns were used as a staple food, key to sustain the population. In Spain, acorns also provided a key food product to sustain rural populations especially

Figure 10: Price evolution along the Portuguese acorn supply chain



during the Franco dictatorship. After the late 70s, at least in Portugal, there was an abandonment of acorn consumption due to the "bad memory" associated with the famine period. In 2008, the use of acorns for human consumption was revived by an agricultural company, followed by other companies. Together they form an Iberian association called Confraria Ibérica da Bolota that aims to promote the consumption of this semi-wild product. In the 70s and 80s, as a consequence of the the low price of labour, it was also a common practice to collect

acorns to deliver to factories that produced cooking oil from seeds such as sunflower seeds and sesame seeds. During the acorn season a single factory might process daily about 250 tons. This chemical extraction resulted in oil for human consumption and flour used to integrate animal feed. There were several factories dedicated to this activity in the Alentejo region. Acorns, especially from cork and holm oaks, have also been commonly used as livestock feed in rural farms. The open Mediterranean oak woodlands allows pastures growth, animal production and forestry production, and has evolved over time. Some animal products from these extensive agroforestry systems are highly valued. Nevertheless, this often precludes the possibility of large margins on the commercialization of acorns as the latter are consumed within the system.. Currently, the diversification of products that use acorn flour highlights the potential of alternative uses for acorn and of increasing its consumption up to a mass market level as it occurred in Balkan countries. Despite its high variability at retail level, the acorn flour price can reach over 14 €/kg for good quality flour, while the price of raw acorn remains the same both for animal feed and for further processing as food for human consumption, at around 1 €/kg.

2.4. Pennyroyal and aromatic plants supply chain

Pennyroyal and other aromatic plants have been tackled by the survey, but the limited answers on rosemary and myrtle achieved in Tunisia did not allow to run any analysis. Only pennyroyal supply chain in Portugal can be described synthetically even if not much information has been reported in terms of prices. Pennyroyal is a type of mint collected in the wild. There are very limited number of producers which usually collect the pennyroyal and dry it. The average price is around 5 €/kg of dry plants, but it can go up to 275 €/kg if processed into teabags. The use of pennyroyal is generally



local even though this grass is commonly used in other parts of the Mediterranean area.



3. Lessons learnt and policy implications

The supply chain analysis was a study applied to one of the most ancient human activity: wild food gathering. The comparison of the results from different supply chains highlighted how policy makers can deeply affect the overall performance in structure of a national wild food chain. The way the economic actor operates in the supply chain today is deeply linked to taxation norms in harvesting as well on the price gap between the end-user and the producer. The more restrictive norms on harvesting rights or high-level taxation, the more the informality of the chain can rise dramatically to a sort of accepted informal market that operates on the illegality.

To grab the voice of the interviewed companies we collected their problems and suggested potential solutions in table 3 and 4, that are only partially linked to the results we reported in the previous chapter. The main issues raised from truffle, pine nuts and acorn supply chains have been divided by products and type of actors, both on the problems and the related solutions proposed by the operators. The solutions are divided according to the two main categories of problems identified: i) problems related to cultivation/harvesting and ii) problems related to market transparency.

Table 3: problems of the wild food supply chains by typology of operators.

	Producers/Pickers	Wholesalers	Retailers/ho.re.ca
Truffle	<ul style="list-style-type: none"> • Due to different seasonal conditions, truffle production/collection is not regular in different years; • informal truffle collectors destabilize the market; • The presence of truffle collectors from other countries, many of which are irregular and underpaid, makes the competition between pickers unfair, • An increase of wild animals, such as wild boars, represents a threat for the soil, including in truffle plantations, • Forests are too often treated in an irrational and too intensive way, with mechanical tools that can damage the soil; • Difficulty in obtaining an ecological certification for truffles; • The total abandonment of forest management. • Difficulties in defining a standard quality for truffle irregular quality; • Truffle plantations enter into production too late. 	<ul style="list-style-type: none"> • Lack of standards to define product quality; • The product provision is too dependent on the weather conditions and the current climate crisis seems to accentuate this trend; • Little availability of national product; • Many difficulties in ensuring the traceability of the product; • Difficulties to ensure a regular quality for customers. 	<ul style="list-style-type: none"> • Limited availability of national product; • Provisions in quantities and prices of products too irregular; • Lack of product standardization. • Presence of Informal collectors too relevant. • Selling price disparities among producing countries
Pine nuts	<ul style="list-style-type: none"> • In the last decade, a severe decline in the kernel-per-cone yield has been reported (less profitability for plantations) the rapid expansion of an exotic invasive seed pest (<i>Leptoglossus occidentalis</i>.) • Pine nuts thefts • High costs of collection/harvesting • Increase of extreme droughts that risk of compromising pine nuts production. 	<ul style="list-style-type: none"> • Production too variable among years • Shortage of national products • Prices determined mainly by international wholesalers; • Medium and local wholesalers have very little bargaining power. 	<ul style="list-style-type: none"> • Prices of pine nuts are too high • The national production is too limited • Quality/price ratio is not guaranteed
Acorn	<ul style="list-style-type: none"> • Lack of financial support to preserve the best oak ecosystems to provide acorns • Lack of flow and new business opportunities. • Lack of specialized industries to store and transform acorns 	<ul style="list-style-type: none"> • certifications too complex and too few widespread; • Lack of coordination between technology and research centres; • Lack of standards to define product quality; 	<ul style="list-style-type: none"> • Consumers don't know the benefits of using acorns and their flour • Lack of knowledge of how to properly use acorn • Complexity of product delivery.

Producers reported mainly technical problems related to pests or knowledge gap on cultivation. Also, the lack of financial support has been commonly mentioned probably because farmers are more



confident with common agricultural policy measures that support their investments with non-repayable contributions. The problems highlighted by traders and retailers are more linked to production availability and price definition. On this last, the most problematic issue is the high level of informality that characterizes the sector of wild food. So far, Spain and Italy try to support policy changes to tackle the informal market, but it's still a long way to go due to the high value of certain wild food like truffles.

Table 4: proposed solution to tackle the main problems of the different wild food supply chains

	Solutions to improve cultivation/collection	Solutions to improve market transparency
Truffle	<ul style="list-style-type: none"> • Implement regular economic incentives for new truffle plantations; • Request truffle pickers associations to carry out activities for favouring a forest management capable of supporting the truffle growing; • Collaborations with forest professionals for making more sustainable forest management; • Management of economic incentives to truffle pickers more transparent and fairer. 	<ul style="list-style-type: none"> • New fiscal tools to facilitate the regularity of the sale of truffles by collectors to other actors; • Improving national statistics; • Creation of standards or tools to facilitate traceability of truffles • Development of a national agency for monitoring truffle price (national level) • Support to develop contracts capable of linking truffle plantation and industries
Pine nuts	<ul style="list-style-type: none"> • Financing tools to improve the surveillance of pine nuts plantations to avoid any risk of thefts; • Financing tools to manage (thinning, clearing, pruning) pine natural forests to increase pine nuts production • Innovation in techniques for <i>Leptoglossus occidentalis</i> control and for mechanised harvesting • Financing tools to improve artificial irrigation to counteract the effects of extreme droughts; • Economic support to pine nuts producers through forest ecosystem service payments; • Economic incentives to allow companies to implement strategies to contrast oscillations in the annual production of pine nuts. 	<ul style="list-style-type: none"> • Demand the same requirements on imported pine nuts (such as Chinese and Pakistani ones) as those required on domestic pine nuts. • Improvement of harvest contract between producers and transformation industries; • Reinforce the role of producers' associations • Implement policies for limiting the export of national pine nuts
Acorn	<ul style="list-style-type: none"> • Implement training courses targeting producers/farmers; • Creation of protected areas to obtain high quality acorns 	<ul style="list-style-type: none"> • Encourage the development of an industry focused on acorns, accompanying this development with a targeted marketing strategy, focused on the role of acorns, in terms of nutritional health; • Facilitating a wild food certification process and providing funding lines to support the process; • Creation of a collaborative laboratory dedicated to the valorisation of acorns, with pilot lines for processing, conservation and product development; • Increase the awareness and importance of these products among consumers.

According to the interviewed company statements, a tax reform can slowly drag the supply chain into the formalization of the transactions. According to Martinez de Arano et al. (2021), when a structural tax reform has been implemented at national level, the overall statistics and importance of the entire supply chain increase dramatically, with a new role of the given product in the forest sector. Also the creation of specific economic measures to support wild food supply chain has been commonly mentioned, but this requires more evidence and data to support a strong political action. Probably, the adoption of a common legal framework at European level might increase the role of wild food chain in the forest and primary sector. This would imply a softening of the EU food law application as well as the introduction of a new concept of “collection income” or “picking income” with a high threshold of tax exemption. The present task allowed to show the presence of a market that is not reported in the national official statistic, but it represents a real engine of rural development in a remote area in south Europe. Wild food supply chain is characterized by few formalized transactions, which represent the main obstacle to the development of the sector. If a sector does not exist in the official statistics, it is rather unlikely that the policy makers will financially and economically support the economic players through the most common supporting measures. The



ways to reach these targets can be several, but they should start from the key concepts: tax exemption and minimal bureaucratic procedures.



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5. Annex 1: Supply chain questionnaire





The Partnership for Research and Innovation in the Mediterranean Area will devise new R&I approaches to improve water availability and sustainable agriculture production in a region heavily distressed by climate change, urbanisation and population growth.



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