WildFood

WildFood Project

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

Guidelines for product quality, safety and sustainability

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Executive summary

The present deliverable includes a set of guidelines to ensure the quality, safety and sustainability of wild food products (WFP). These guidelines originated from the innovation actions carried out in the WildFood project, covering very diverse topics:
(1) sustainable production of rosemary essential oils: the optimization of the hydrodistillation process of *Salvia rosmarinus* (L.) Schleid. was suggested, with recommendations for the duration and temperature used.
(2) sustainable production of acorn flour – monitoring by forest inventory was discussed and alternative drying processes using stove are proposed and compared to the traditional process.
(3) quantifying pinecone production of *Pinus pinea* with sensors and drones – innovative remote sensors to carry out monitoring and harvesting planning are presented.
(4) sustainable harvesting of fungal yields – monitoring and identification procedures are described.

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Introduction

The overall aim of the WildFood project (2020-2023) is to promote the implementation of joint innovative strategies by the different actors in the value chains based on wild and semi-wild food products (WFP) in the Mediterranean area in view of improving the quality, safety and sustainability.

Wild food products are strongly connected to the local economies, rural livelihoods, biodiversity conservation, traditional knowledge, territorial identity, gastronomy and other cultural values. Moreover, their sustainable use contributes to the conservation of Mediterranean forests.

The socio-economic contribution of forests to livelihoods and the impact of their use on the environment are essential components of modern concepts for sustainable forest management and as a result, the value of non-wood forest products is being rediscovered.

One of the specific objectives of the project is to design and demonstrate innovative solutions for tackling the pressing challenges of the agri-food value chain in terms of quality and sustainability.

Taking that into account, several innovation actions were carried out in different Mediterranean countries, by gathering existing information and implementing pilot projects and study cases, at local level and in different stages of the targeted products chains (Table 1).

Table 1. Innovation actions carried out within the WildFood project's framework

	Pilot projects (coordinating partner)	Product	Location
1.	Implementing a new production and transformation process for aromatic plants (INRGREF)	Rosemary and myrtle	Morneg, Ben Arous, Tunisia
2.	Prediction systems for the annual supply of acorn and flour as raw material for human food products (ISA)	Acorns	Center and Southern regions, Portugal
3.	Establishing mycological parks to assess and control mushrooms collection and guarantee a sustainable mycological use with appropriate mushrooms collection, while integrating social function in this activity (innovation in production and use) (CTFC)	Mushrooms	Tarragona, Spain
4.	Quantifying pinecone production, with sensors and drones (CTFC)	Pine nuts	Catalonia, Spain
5.	Participating in development of innovative biological agents in pest control on truffle sites/plantations (SFI)	Truffles	Ljubljana, Slovenia

6.	Preparing of laboratory protocols for certification and identification of truffles (SFI)	Truffles	Ljubljana, Slovenia
7.	Elaborating a production monitoring protocol for truffle (UNIPD)	Truffles	Veneto and Friuli, Italy
8.	Implementing some innovation systems for production, transformation and distribution of acorn related products, namely production, transformation, packaging and distribution (ISA&HFM)	Acorns	Alentejo, Portugal

This deliverable encompasses a set of guidelines including techniques and know-how to ensure the quality, safety and sustainability of certain wild and semi-wild food products, based on the experience and experimentation provided by some of these pilots, namely:

1. Sustainable production of rosemary essential oils: the optimization of the hydrodistillation process of *Salvia rosmarinus* was suggested, with recommendations for the duration and temperature used.
2. Sustainable production of acorn flour – monitoring by forest inventory was discussed and alternative drying processes using stove are proposed and compared to the traditional process.
3. Quantifying pinecone production of *Pinus pinea* with sensors and drones – innovative remote sensors to carry out monitoring and harvesting planning are presented.
4. Sustainable harvesting of fungal yields – monitoring and identification procedures are described.

For each pilot case the information was provided following the same organization:

- Purpose and scope
- Target groups
- Description of the process
- Guidelines for product quality, safety and sustainability

There are many opportunities for increased value generation along WFP production and processing chains. The introduction of quality and safety standards, or the promotion of innovative and sustainable methods, can be of crucial importance to achieve and provide a high-quality product. This will stimulate the economy in rural areas and can be particularly successful if the actors are well organized along value chains.

The factsheets of the pilot projects as well as other information and deliverables can be consulted on the project website: https://wildfood.ctfc.cat/.

1. **Sustainable production of rosemary essential oils**

Purpose and scope

The purpose was to achieve an efficient and optimized process of producing rosemary essential oils, improving its quality and yield in a sustainable manner.

Target groups

Aromatic and Medicinal Plants markets, consumers.

Description of the process

Figure 1. Steps of collection and transformation of rosemary into essential oils.

Rosemary is one of the main species exploited on a large scale in Tunisia. It is used, either in natural form as culinary or medicinal plants, or in the form of essential oils or extracts.

Harvesting – By harvesting the leaves as soon as the flowers begin to appear, you'll get the best flavour and the most aromatic leaves. As with most other herbs, the best time of day to harvest is in the morning. (1) wait until spring or summer to harvest rosemary, (2) select which branches of the rosemary to harvest, and (3) cut off the top (5 cm) of each sprig with shears or scissors.

Drying / Conservation – Like many other Mediterranean herbs, rosemary is traditionally preserved by drying: (1) shake rosemary sprigs lightly before drying to remove dust and dirt; (2) hang rosemary bouquets in a dry, clean, dark place; (3) avoid direct sunlight, as it weakens the aroma of the herbs; (4) remove the

dried leaves from the stems and store in an airtight container; (5) dried rosemary can be stored for a year or more. If you don't want to wait that long, you can also try drying rosemary in the oven at 30°C.

Processing and packaging – Rosemary can be processed in a number of ways, to make dried leaves or oil. It is advisable to use as little packaging as possible, and to size it to suit the consumer.

The yield of aromatic and medicinal plants in essential oil and active principles is very influenced by the type and duration of drying. For this reason, we will study the effect of the type and duration of drying by developing a drying table for the main species used at the GDA Borj Essougui (Tunisia). This will allow to have good yields of essential oils with better organoleptic and biochemical properties. It will also minimize energy costs by knowing the optimum duration of extraction.

Experiments were conducted to determine the evolution of yield and composition of rosemary essential oils as a function of steam distillation and drying time (Figure 2). The vast majority of Rosemary essential oil is produced by steam distillation. Steam distillation is the most commonly used process for extracting essential oils. Pressurized steam, made in a separate chamber, is then circulated through the plant material. The heat of the steam forces opens the tiny intercellular pockets in which the Rosemary essential oil is contained, releasing the oils. During steam distillation, the temperature of the steam should be moderated so that it is high enough to open the oil pouches without destroying the plants, fracturing or burning the essential oils. The Rosemary essential oil can be divided from the water by either decanting off the water or skimming off the oil from the top. The water obtained as a by-product of distillation is referred to as floral water quantity or distillate and retains many of the therapeutic properties of the plant.

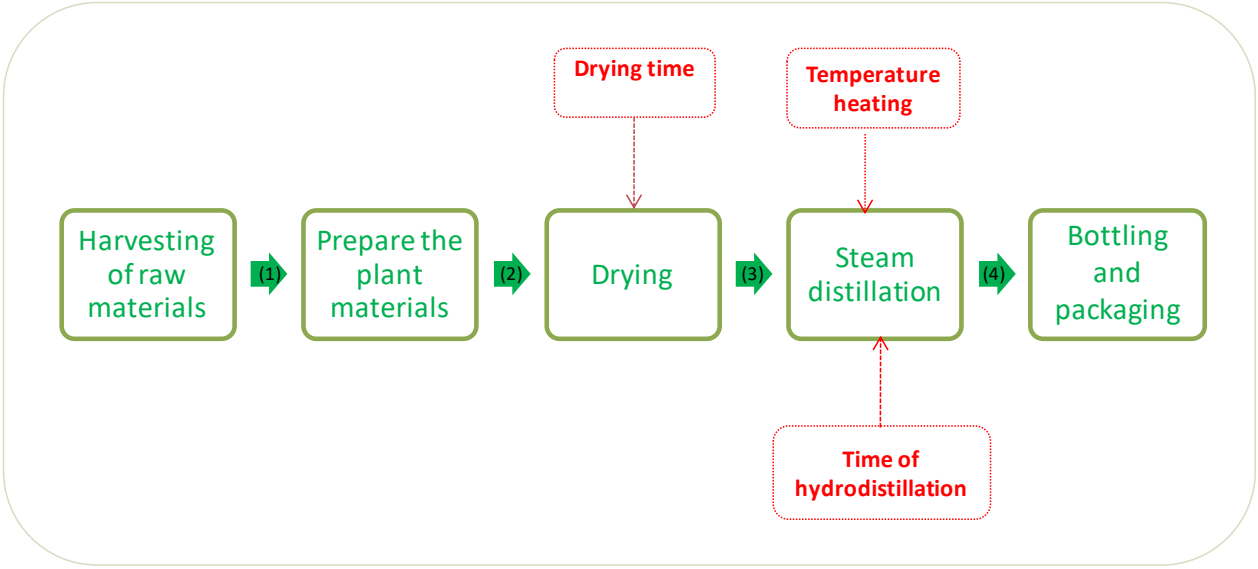

Figure 2. Process of rosemary essential oils extraction by controlling the following parameters: Drying time, temperature heating and time of hydrodistillation.

The first thing to do is to prepare plant material for distillation by removing the excessively woody parts. At this stage, we can reduce the size of the long branches, also to facilitate loading into the boiler. Extraction was performed under different drying conditions and extraction times by varying the temperature. The pressure was set at atmospheric pressure. However, 1 kilogram of rosemary leaves was tested for each experiment. Three drying times were tested: 0 days, 7 days, and 14 days with three different distillation

times of 150 min, 180 min, and 210 min, in order to compare their efficiency in terms of oil yield and oil composition. The results are presented in Table 1.

Table 1. Experimental design of the optimization of the hydrodistillation process of *Rosmarinus officinalis* for each experiment. Experimental conditions for a maximization of the yield are indicated in bold.

Number of experiment	Time of Hydrodistillation (min)	Drying time (Days)	Temperature heating	Yield (%)
1	150	0	250	1.22
2	210	0	250	1,79
3	150	7	300	1;54
4	**210**	**7**	**250**	**2,26**
5	210	14	250	2,10
6	180	7	300	1,74

For the rosemary essential oil, a hydrodistillation time of 210 min, a heating temperature of 250°C, and a drying time of 7 days are the optimal experimental conditions for a maximization of the yield towards a value of 2.26%. These results can be a basis for the extrapolation of the optimization of the experimental conditions for the extraction of essential oils by pilot or industrial process. Therefore, they can represent a great economic interest, especially after the confirmation of the effect of the hydrodistillation time and the duration of the drying on the maximization of the yield.

Chromatographic analyses of the different samples allowed us to determine the chemical composition of the essential oils of rosemary. A total of eleven components were detected and identified during these analyses (Table 2).

Table 2. Chemical composition of the studied essential oils extracted by the two types of distillation. Mean value of 3 trials ± Standard deviation. The five most relevant composites are identified in bold.

Number	Composites	Industrial Hydrodistil-lation (%)	Hydrodistillation by Clevenger (%)
1	**Alpha-pinène**	**11,27 ±0.76**	**9,84 ±0.57**
2	**Camphène**	**4,53 ±0.28**	**4,27 ±0.39**
3	**Beta-pinène**	**8,11 ±0.17**	0,10 ±0.00
4	Beta-myrcène	1,25 ±0.01	1,94 ±0.03
5	**1,8-cineole**	**41,28 ±2.52**	**51,77 ±1.97**
6	p-cymène	2,23 ±0.25	0,51 ±0.09
7	**Camphre**	**22,82 ±1.96**	**22,31 ±1.03**
8	Acetate de Bornyle	**5,53 ±0.11**	1,02 ±0.05
9	Alpha-terpinéole	1,72 ±0.04	**5,04 ±0.07**
10	Bornéole	0,96 ±0.02	2,80 ±0.01
11	Verbenone	0,06 ±0.01	0,11 ±0.01
	Total	**99,75**	**99,70**

The analysis of essential oils by chromatography shows that the chemical compositions and majority compounds are different and variable depending on the extraction method used. This variation can be very interesting during the industrial research of a compound in quality and quantity and the method of distillation used. The principal 3 compounds of rosemary essential oil, obtained by hydrodistillation are: α-pinene (9.84-11.27%), 1,8-cineole (41.28-51.77%), camphre (22.31-22.82%).

Guidelines for product quality, safety and sustainability

- ✓ Respect the quantity of phytomass (Plant, seeds, flowers, etc) to be collected annually, and do not collect PAM on slopes exposed to erosion. Never harvest all the plants in a defined area. Keep a reserve of approximately of around 20% to 30% of individuals on the harvested area (plot) to guarantee the regeneration of the species. Avoid collecting in high-risk areas where the species may be polluted or contain a toxic substances.

- ✓ Once the collection operation has been completed, it is necessary to ensure that the collected product receives the correct post-collection treatment to ensure the physical, chemical and organoleptic quality required by the customer, while avoiding any deterioration or contamination of the product.

- ✓ The collected material must not be exposed to direct solar radiation to avoid that its chemical and organoleptic characteristics (essentially its color) are not affected. The product must be protected from rain and excess humidity. The final product (dried leaves, seeds, flowers) should have a moisture content of 8 to 10%, which is the optimum humidity which allows storage in good conditions while preserving quality.

- ✓ Once dried, the collected material must be packaged as quickly as possible to protect it from possible pest attacks or other sources of contamination, including cross-contamination.

  Packaging must be clearly identified with the label, if available, the scientific name or code of the plant collected, the code of the processing batch, its origin, the name of the supplier, the date of collection, the date of packaging and the weight of the bag packed, and ensure that all processing and packaging operations and activities are regularly recorded.

- ✓ The yield of aromatic and medicinal plants in essential oil and active principles is very influenced by the type and duration of drying. For this reason, a suitable drying table needs to be adapted for each species collected by the GDA. This will allow to have good yields of essential oils with better organoleptic and biochemical properties. It will also minimize energy costs by knowing the optimum duration of extraction.

2. Sustainable production of acorn flour

Purpose and scope

The purpose was the development of processes, in all stages of the acorn flour production chain, that promote a sustainable acorn production in the *Montado*, guarantee the quality of the products, and maximize the usage of the collected acorns under a bioeconomy context. These are critical steps to accompany the increase interest observed for acorn products.

Target groups

Montado managers and acorn processors.

Description of the process

Monitoring – The key topics to be monitored are the soil and the produced amount of acorns. The maintenance of the *Montado* productive potential is associated to their resilience, which is especially dependent on the soil. Soil analysis can be carried out at any time of the year, avoiding very dry or very wet soils.

On average, the density of these agroforests is 80 trees per hectare, but they can reach higher densities of around 120 trees or more. Regarding acorn production, the traditional forest inventory with tree measurements can provide information for the use of production models at the individual tree level. The collected data showed that the variability is greater in the cork oak than in the holm oak. The currently existing models apply only for holm oak. Investment is needed in more data collection to develop models for cork oaks and other oak species that also produce acorns.

It is also possible to invest in monitoring methods such as those tested in the case of pinecones (one of the Spanish pilot projects), but for the case of acorns there is still very little information on the subject. Given that acorn production has a natural variation, having years with more and less production,the way of having a more stable harvest is to invest in different varieties of holm oaks. This diversity is a natural feature of *Montado* and should be maintained in every kind of installation. The maintenance of a healthy producing system will depend on soil quality, life and aeration. Mobilization must be completely avoided and the shrubs, naturally present in *Montado*, should be controlled using grazing by livestock and machines that cut the shrubs without ploughing the soil.

Harvesting – Harvesting with motorized sticks (Figure 3), a technique used in olive trees, will break branches and damage the trees, reducing next year's production. The use of traditional sticks for harvesting produces the best results. Acorns can be harvested in green, when they have no pest attacks (September to October) or mature (November to December). For the latest, an increased risk of acorn damage by insects or other biological agents exists. In fact, it is known that harvesting too late can lead to the loss of important amounts of acorns.

Figure 3. Harvesting with traditional sticks

Drying / Conservation – Drying is a key point to the conservation of acorns (Figure 4), as well as to reduce the presence of tannins. Drying can be a very energy-intensive process. A fast-drying process, however, makes it possible to avoid fungal contamination and prolong the shelf life of whole acorns and acorn flour. Winter temperatures and humidity do not allow more than 20% water to be extracted from acorn, so forced drying using heating and a wooden platform is a requirement to obtain a good product.

A first drying is done by spreading the acorns on a dry and clean surface. After that, forced drying using heating is used, with a system imitating the old-fashioned ways of drying acorns, in the smokehouse on a wooden platform.

However, other drying methods should be tested, as there is a need to improve this process in order to make it faster, less expensive and more energy efficient. In the laboratory, samples of acorns were placed to dry in ovens. Drying curves were obtained where it can be observed that acorn drying at 70ºC for 14 hours does not allow reaching dry weight at 0% humidity. To reach this requirement, acorns need to dry at 100ºC for at least 10 hours (Figure 5).

Figure 4. Drying methods: (a) spreading the acorns on a dry and clean surface and (b) forced drying using heating and a wooden platform

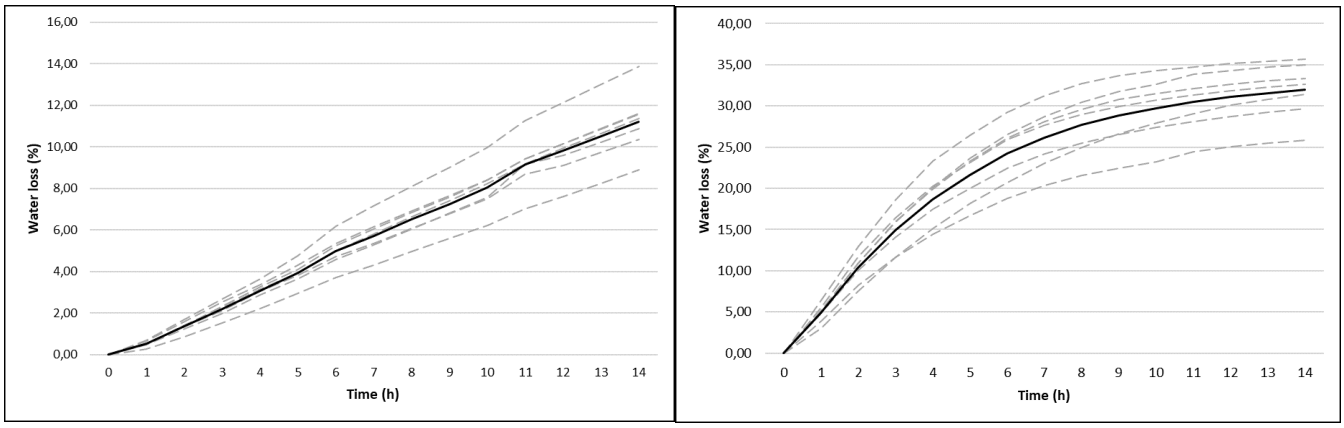

Figure 5. Drying curves at 70ºC and 100ºC, respectively, for holm oak acorns with shell. The solid black line represents the mean.

Shelling and Selection – Acorns are broken into pieces before shelling, using appropriate machinery for both processes (Figure 6). Acorn shells are used to feed swine cattle, also constituting an excellent ground cover. They can even have economic value if sold to pharmaceutical companies, as 36% of shell is lignin and up to 10% are tannins, with proven antioxidant and antimicrobial properties.

Figure 6. Shelling method: a blower separates the kernels from the shells

Processing and packaging – Acorns can be processed in several ways, to make flour or oil. The flour can be roasted to make a coffee substitute, or it can be added directly to other preparations, such as acorn bread or cookies. Healthy, low carbon footprint, delicious, and biologic products can be made with acorns. It advisable to use as little packaging as possible, sizing it to the orders (Figure 7).

Figure 7. Various acorn-based products on display at a local fair

Certification – An organic production certification is possible, though even without certification, a farm can practice agroecology, enriching it with the social and ecological components that are advocated by organic certification.

In addition to organic certification, which can be costly, other types of certifications may apply and be best suited. An example of such is a short supply chain certification provided in some regions, still on a small scale. It gives guarantees to consumers that the products are in fact originating from local production, within a maximum radius of certain kilometres from the place of consumption or sale to the final consumer. This kind of certification is carried out by an external certifying entity, requires few documents and therefore does not have many associated costs.

Guidelines for product quality, safety and sustainability

- Natural regeneration of trees is effective and inexpensive. Proper stocking density management is important to achieve good natural regeneration, not necessarily consisting of less cattle, but of a suitable grazing method. Holistic Grazing Management, for example, implies greater heading, with more positive results in tree regeneration. Not pruning the trees until quite late prevents them from being broken by the animals that tend to scratch themselves on them. These are, nonetheless, techniques that need further support and validation from academic studies. Shading is essential for good regeneration. That is, in areas of low density of trees regeneration is much more difficult and has to be done with the support of shrubs or other pioneer trees.

- Performing annual monitoring of production by forest inventory and visual estimation or using production models is valuable for mapping of the holm oaks and cork oaks and whether they are middle-aged or young trees, or mixed stands.

- The traditional harvesting method, despite everything, remains the most effective and causes less damage to the trees. The holm oak is more fragile than the olive tree and the use of electrical equipment to collect acorns ends up breaking many sprigs that then mix with the acorns and are difficult to separate.

- After harvesting, spreading the acorns on the ground and turning them allows for the birds to eat the worms. However, they can't take too long to be placed to dry in the dryer so that they don't become rotten.

- It is recommended to dry about 15 days at room temperature and 15 days in a dryer with forced heating. The process has to be continuous, with no waiting between the two phases. In air drying one should try to protect the acorns because it's rainy season, therefore humidity is high. Flip the acorns often. In forced drying use palotes, but turn the acorns with a stick every day.

- The product can be immediately floured, or roasted and subsequently floured. It can also be frozen and processed as needed. If not previously dried, acorns turn black when frozen, as if cooked. Hence the need to dry the acorns prior to freezing.

Guidelines for product quality, safety and sustainability

The organization of the pinecones collection in terms of human resources and machinery needed for the collection it is of high importance to guarantee an efficient and safety collection of the cones within the harvesting season. The estimation of the cones production of a specific area (forest, municipality, etc.) in sufficient time, previously to the harvesting season, provides helpful information to plan a more sustainable harvesting.

To estimate cones production with sensors and drones it is recommended:

- To plan accurately the drones' flights (area to cover, time of year and type of camera).
- To follow specific protocols about how to do the flights and images catching.
- To use specific models developed by specialists for processing the images and estimating forest variables, and more specifically, cones production.

3. Quantifying pinecone production of *Pinus pinea* with sensors and drones

Purpose and scope

The general objective is to establish a protocol and/or tool for direct quantification of pinecone production with remote sensors that allows a quicker and more objective evaluation than the current visual procedure.

The objective is to evaluate pinecone production in sufficient time to organize the correct collection of cones in time and space, thus increasing the efficiency of a key phase of the pinecones harvesting as it is the evaluation of annual production, and avoiding non controlled collection outside the harvest season, which brings major dangers, as the harvesting of non-mature pinecones.

Target groups

The innovation is important and useful for different sectors of the value chain, as producers, pickers,

harvesters and processors. For example:

- pine forests owners (private or public) can know the potential value of the annual harvesting, which allow them to organize the correct collection of cones in time and space, with proper harvesting techniques, avoiding illegal collection outside the harvest season or pinecones robberies, also help them to negotiate the conditions for the pinecones sale or collection subcontracting.
- harvesting companies can know more precisely the total production and proximately value for a specific forest area and plan the most profitable and sustainable method of harvesting (estimate the needs for mobilizing machinery and human resources for a campaign) within the pinecones harvesting campaign, avoiding the collection of non-mature pinecones.
- processing companies can plan the processing, commercialization and marketing campaigns with less uncertainty.

Description of the process

Pinecones producers and harvesters, with the use of the tools and protocols for direct quantification of pinecone production with remote sensors, will get a quicker and more objective evaluation of production than the current visual procedure.

The procedure to get an estimation of pinecones production follows two main steps:

1. Design the flight planning, images acquisition and type of sensors:
    i) precisely define the area and trees that will be covered by the drone flight, considering the areas restricted to the use of unmanned aerial vehicles (UAVs)
    ii) time of year (preferably around May when flowers are more apparent)
    iii) use of RGB camera
2. Use an artificial intelligence model, including image processing, that estimates the quantity of pinecones of 1 year, from RGB images taken from a drone. It has a good accuracy to estimate the 1st year pinecones (more visible in the higher parts of the tree). Since the pinecones estimation is done on May, pinecone producers and harvesters have enough time to organize the correct collection of cones in time and space, with proper harvesting techniques, avoiding illegal collection outside the harvest season and collection of unmature pinecones. Official harvesting season for pinecones of *Pinus pinea* starts on November.

Guidelines for product quality, safety and sustainability

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4. Sustainable harvesting of fungal yields

Purpose and scope

To guarantee the sustainability of the mycological resource, guaranteeing that the fungal yields don't exceed the productive capacity of the territory whilst guaranteeing the preservation of endangered species.

Target groups

Mycotourism, forest managers, mycological associations.

Description of the process

Inventory of mycological resources – The establishment of permanent plots (recommended size: 100-150 m^2) that need to be inventoried on a weekly-biweekly basis can allow to list the fungal species that appear in the area in the productive period (Figure 8). The protocol establishes the recommendation of fencing the plots in order to prevent uncontrolled harvests. The people in charge of the inventory prospect the interior of the plots looking for the mushrooms (we suggest restricting the inventory to epigeous fungi) and collect all the carphophores that are growing in the area.

Figure 8. Inventory of mycological resources

Identification of fungal species – The different fungal collections that have been collected in the permanent plots are weighed and classified with the help of experts and/or mycological guides (Figure 9).

Figure 9. Identification of fungal species

Establishment of list of mushrooms to be authorized for collection (quantity and quality) – The continuous inventory of mycological plots allows the forest managers to have a list of estimated quantities of mycological resources that are present in the area. Such list may be updated weekly, thus allowing to set a maximum number of mushrooms to be collected per person and/or regulating the maximum number of mushroom pickers in an area.

Mycological paths (optional) – The mycotourism experience can be improved with the help of mycological guides who can help the less experienced people in the process of searching-identifying-picking the different fungal species. The guides can also play a role in the identification of doubtful fungal species.

Gastromycological experience (optional) – The involvement of the touristic sector in the mycological park can also be used to expand the range of products and services offered to the mycotourist (i.e., preparation of mushroom-based dishes in restaurants, fairs, etc).

Guidelines for product quality, safety and sustainability

- The fungal yields are highly dependent on the weather conditions. The temperature and the precipitation are the main drivers of the yearly mushroom emergence. Therefore, the inventory of the mycological resourcers in different seasons are fundamental aiming to capture the variability of the mushrooms offer.

- The kingdom fungi is extremely diverse. The scientific literature reports hundreds of differents species that can appear in the forest area on a regular basis or sporadically. The large part of the carpophores do not have any impact on the human health, but some of them can be very dangerous because they are poisonous. Thus, It is highly recommended to have an expert identification of the mushrooms that are present in the forests.

- The mushrooms are one of the hidden resources of the forests that can be valued generating new economic resources to the rural areas. The mycotourism is an emerging activity that combines the discovery of the fungal diversity with an outdoor activity which is specially recommended for families.

Recommendations

The large number of products, uses, and markets of the WFP leads to complex supply chains that are difficult to trace and monitor from the sources to the consumers. Innovations need to be supported with tailored-made training and capitalization actions impacting a wider audience, thereby increasing quality, safety and sustainability in Mediterranean wild food value chains. Innovative traceability and control systems are needed, along with due diligence at all stages of the value-chains.

To this end, here are some recommendations to follow:

• Research and development to trace sustainable sourcing of wild food products and production methods for semi-wild food products. This includes inventories and monitoring systems, innovative procedures to record quantitative information on collection and trade, and adequate and realistic monitoring procedures to ensure sustainable harvests.

• Ready-to-use techniques and development of new innovations to improve quality and safety in WFP value-chains. This includes systems for risks analysis and critical control points, food safety standards, production innovations, harvesting mechanization monitoring, improvements in manipulation process, pest control, maintenance of equipment and installations, storage, packaging and transport.

• Capacity building on innovative techniques to increase quality, safety and sustainability targeted at different actors at different stages of value chains.

• Adjusted certification schemes ensuring quality and safety. New certification schemes and adapted standards to WFPs can be valuable tools for ensuring quality and safety, as well as providing consumers with the information they need to make informed purchasing decisions.

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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