



Linking Cork to Cork Oak Landscapes: Mapping the Value Chain of Cork Production in Portugal

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Traditional farming landscapes in South and Central Portugal, known as montados, are affected by global socio-economic and biophysical pressures, putting the sustainability of the systems in jeopardy. Cork oak trees (*Quercus suber* L.) are characteristic features of these complex agro-silvo-pastoral agroforestry systems, delivering a globally important product, cork. The increasingly distant, global scale of decision making and trade can consequently be observed on the local, landscape, scale. In this study, we use a value chain approach to test the concept that landscape products can ensure sustainable management of the landscape of origin. We interviewed agents—cork producers, intermediaries, industrial transformers, and winemakers—about the challenges they perceived in the business and how these were connected to the landscape of origin. We illustrate the network of agents and sub-actors involved in the sector and highlight the most prominent concerns. We conclude that this approach can reveal the major points for determining the future of the montado, and we suggest that collaboration amongst value chain agents can be a pathway to landscape sustainability.

Keywords: landscape products, traditional farming landscapes, value chain analysis, montado, landscape sustainability

INTRODUCTION

Traditional farming landscapes worldwide bear many relevant environmental and social values, but are threatened by multiple socio-economic and biophysical pressures (Plieninger et al., 2006). Defined as low-intensity systems characterised by a continuation of practices across generations (Bignal et al., 1996), these extensive farming systems are influenced by socio-economic factors and political decisions. These have often affected the local landscape negatively by eradicating small-scale landscape structures i.e., homogenisation and agricultural intensification as well as forest degradation and landscape simplification (Ingram et al., 2018). In such a context, fertile lands are either intensified or converted into urban settlements and marginal farming land is abandoned as a consequence of lack in profitability and rural outmigration (Plieninger et al., 2016). These pressures are increasingly operating across large geographic scales, with global changes putting local land use sustainability in jeopardy (Meyfroidt et al., 2013). Global supply and trade in alternative energy (i.e. biofuels), foodstuffs, and textiles is booming in an attempt to keep up with

consumption levels from a growing global human population and associated demand (Liu et al., 2013). This is increasingly putting stress on the ability of ecosystems and landscapes to sustain biodiversity, supply ecosystem services, and ensure ecosystem integrity and landscape character conservation in the mid to long-term scale (Blatter et al., 2017).

In the course of globalisation, land use decision making is shifting from local to non-local actors (e.g., carbon offset markets, and consumer demands with associated consequences such as deforestation). However, the complex interactions emerging from such a shift in scales are not always straightforward (Gezon, 2010), and there have been many attempts to illustrate many sets of socio-ecological connections, for instance through theories and concepts such as World System and dependence theory (Wallerstein, 1974), and more recently teleconnections (Liu et al., 2013). In order to better disentangle landscape decision making at the local level, a well-established strategy often used in rural development studies and economic geography is value chain or commodity chain analysis (Bockel and Tallec, 2005; Ibarrola-Rivas et al., 2020). This approach is used to identify the geographical distribution of any given product or commodity, including vertical structures such as the processes the product undergoes, and which actors are involved and how they are organised (Coronado et al., 2020). This has in numerous cases been used to illustrate the valorisation of products originating from a specific area and its relation to the global market (Kizos and Vakoufaris, 2011; Rueda and Lambin, 2012; Thyresson et al., 2013). To include horizontal structures in the analysis by using for example social relations and local histories in order to mediate the connections within the value chain on a local scale, has the potential to assess environmental impacts on the production system. However, value chain analysis is mainly focused on biophysical changes whilst socio-cultural changes are not usually explored (Bolwig et al., 2010). By taking a socio-ecological or landscape approach perspective on value chains, the actors within the value chain are put in direct connection to the landscape of production. By not treating landscapes or actors as mere resources for production, the aim is to opt for a holistic entity by integrating cultural and social aspects from all actors along the chain as well (Matthews and Selman, 2006). Thus, this approach makes it possible to connect “worlds of production” with “worlds of consumption” (Goodman, 2002).

Some products unique to a certain geographical area have led to the development of labels acknowledging these specific characteristics in order to ensure production or management standards but also to inform consumers about provenance and processing (Ilbery and Kneafsey, 1999; Goodman, 2002; Flinzberger et al., 2020). These products can be referred to as “landscape products” that exemplify established value chains contributing to landscape sustainability (García-Martín et al., 2020). Landscape products are hereby defined as niche products originating from a distinct landscape with embedded local culture and multiple functions, as compared to “place-less products” stemming from homogenous landscapes in industrial mass production systems (Schmitt et al., 2018). Examples

of the former include olive oil, Iberian ham, argan oil, or single origin coffee under certain production conditions (Lybbert et al., 2002; Teuber, 2010; Kizos and Vakoufaris, 2011; Rodríguez-Estévez et al., 2012). These products are often sold at higher prices whilst communicating the values of the specific certification (García-Martín et al., 2020). Together with an increase in consumer awareness about production conditions—especially food products (Ilbery and Kneafsey, 1999)—there is an opportunity for landscape products to integrate or promote sustainable management practises and a chance for an increased number of producers in rural areas to access the global market (Rueda and Lambin, 2012; Lysák et al., 2019).

From a landscape approach perspective (Angelstam et al., 2019), the value chains of tropical products such as coffee and cocoa are well-described, although other globally important commodities also exist which are, however, much less addressed. Cork, the outer bark from the cork oak (*Quercus suber* L.), originates from forests and agro-forestry systems limited to the Western part of the Mediterranean Basin. These cultural landscapes are known as montados in Portugal and dehesas in Spain (Pinto-Correia et al., 2011; UNESCO, 2017). They are illustrative examples of traditional farming landscapes with multiple environmental, economic, cultural, and social values (Eichhorn et al., 2006; Surová et al., 2018), and they have since the Middle Ages ensured livelihoods for the local human population, resulting in valuable cultural landscapes, whilst also functioning as habitats for wildlife (Carrión et al., 2000; Pinto-Correia and Fonseca, 2009; Wolpert et al., 2020). Such multi-functionality has shaped an inevitable set of bonds and a biocultural identity resting in fragile balances between economies, culture, and nature (Acha and Newing, 2015). However, the multiple functions stemming from this system experience internal and external stresses, provoking shifts in the sustainability of resource utilisation (Costa et al., 2009; Costa and Oliveira, 2015).

In this study, we argue that the value chain of cork and the interconnectedness with the montado landscape have a high potential to illustrate the positive impact of value chains for the sustainability of producer landscapes, and to reveal leverage points for influencing landscape sustainability outcomes along the value chain. In order to disentangle the connections between the landscape product, cork, and the landscape of origin, the montado, we take a closer look at the value chain using approaches defined by Kaplinsky and Morris (2000) and Bockel and Tallec (2005). The main goal of this study is to map and evaluate the value chain of cork in Portugal from an explorative perspective (Miles et al., 2014). To do so, we (1) map and characterise the key actors and activities involved in the value chain of cork, (2) record the flows of finance, goods, and services along the value chain, and (3) evaluate the challenges that each actor faces along the chain. The novelty of our approach is that we address these three goals from a landscape sustainability perspective, under which cork is considered a landscape product contributing to the sustainability of its landscape of origin, the montado.

METHODOLOGY

Case Study

Landscape of Origin: The Montados of Southern and Central Portugal

The cork oak montados of southern and central Portugal are old and highly valuable land-use systems (Acha and Newing, 2015), covering up to 23% of the total forested area in Portugal (Costa et al., 2009). They dominate the rural land-use systems of the region Alentejo but also appear further to the north and south in the regions Ribatejo and Algarve (Figure 1). Alentejo, in particular, is defined by sparse and scattered distribution patterns of human population (Bugalho et al., 2011). Farmland properties mainly consist of large family owned estates ranging between 200 and 2,000 ha whilst smallholders are rare and concentrated around small towns and river valleys (Muñoz-Rojas et al., 2019). The montados are complex agro-silvo-pastoral systems that rely on human management practises based on multi-functionality in order to maintain a stable state (Bugalho et al., 2011; Pinto-Correia et al., 2011). They are characterised by the sparse presence of cork oak (*Quercus suber* L.) and holm oak (*Q. ilex* subsp. *ballota* Desf.) on grazed pastures, providing habitats for a diverse wildlife as well as delivering multiple other regulating and cultural ecosystem services (Figure 2) (Pinto-Correia et al., 2011).

The diversity of products provided by this system includes cork, meat products from sheep, cattle, and pigs, mushrooms, honey, aromatic herbs, and firewood. In the last century, the montado system experienced a polarisation of land use management models consisting of the intensification of fertile and accessible lands in parallel with the abandonment of less productive sites (Acha and Newing, 2015; Pinto-Correia et al., 2019; Wolpert et al., 2020). As marginal lands are abandoned, the woodlands become increasingly vulnerable to the risk of wildfires, the chances of which are increased by prolonged periods of drought (Pinto-Correia and Godinho, 2013; Leite et al., 2020). Pests and diseases have also been reported as a significant problem, particularly affecting cork production (Bugalho et al., 2009; Pinto-Correia et al., 2011; Acha and Newing, 2015).

Besides the heightened biophysical vulnerability, the montado has been impacted by socio-economic trends such as over-harvesting of cork bark and extreme pruning for firewood and charcoal production, as well as intensification of grazing especially by cattle (Bugalho et al., 2011). Cattle rearing is dependent on financial support from the EU Common Agricultural Policy (CAP) and when the grazing pressure gets too high, the natural regrowth of cork oaks and other tree species is prevented (Bugalho et al., 2011; Pinto-Correia and Godinho, 2013). Along with the complex challenges to rejuvenating cork oak trees, inefficient management of old trees and a homogeneity of tree age threatens the high levels of biodiversity and habitats which are protected by EU law (Berrahmouni et al., 2009). Not all land managers attempt to diversify their production systems, so mutually conflicting policies and conservative attitudes toward farming from land managers themselves hampers the maintenance of the multi-functional montado (Pinto-Correia and Godinho, 2013; Pinto-Correia et al., 2019).

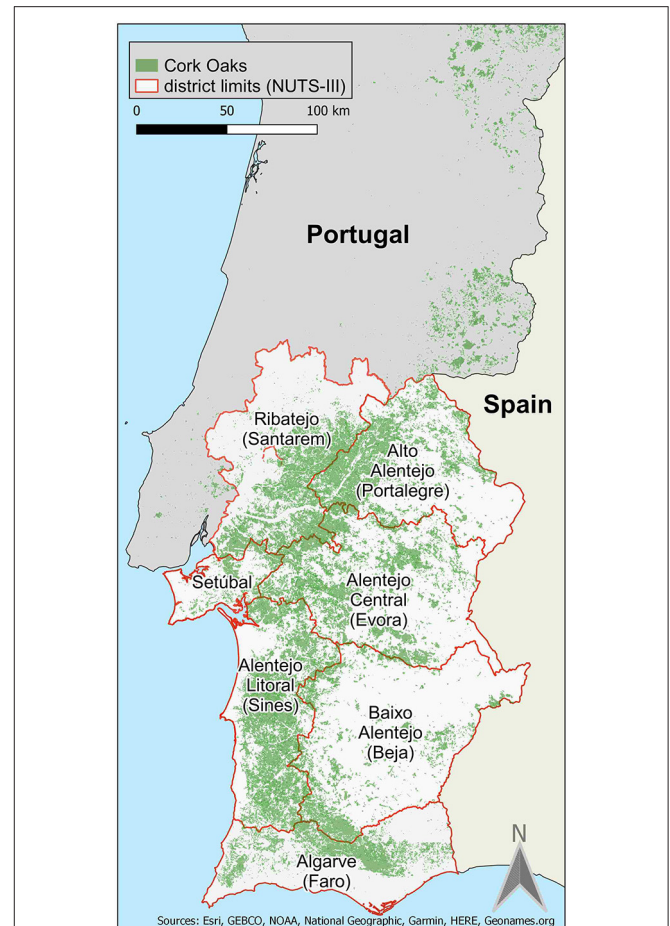


FIGURE 1 | Map displaying the current distribution of *Quercus suber* L. in Portugal, and the administrative borders of the associated districts (NUTS-III).

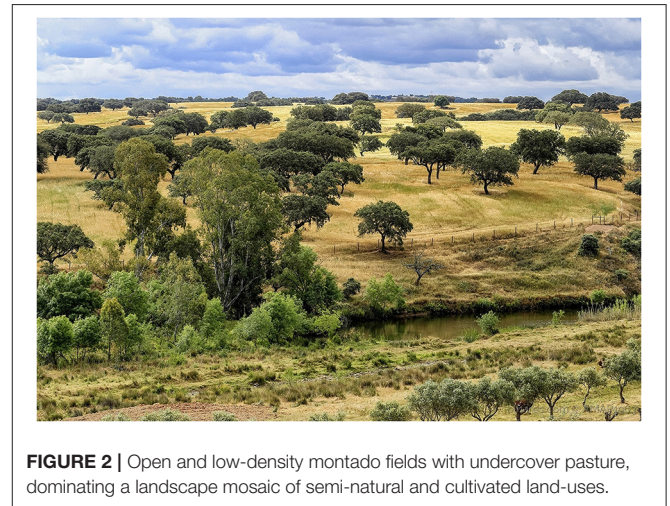


FIGURE 2 | Open and low-density montado fields with undercover pasture, dominating a landscape mosaic of semi-natural and cultivated land-uses.

Landscape Product: Cork

Portugal is currently the world leader in cork production, delivering up to 100,000 tonnes per year, 55% of the world

production, of which 90% is exported (Aroso et al., 2017; Camilo-Alves et al., 2020). The global cork market reaches annual revenues of US\$329 with 70% of the income coming from wine bottle stoppers, although these only represent 40% of the entire cork production (Berrahmouni et al., 2007; Bugalho et al., 2011; Camilo-Alves et al., 2020).

Since the 1980s, cork has experienced a price devaluation followed by years of low production into the 2000s (Pinheiro et al., 2008; Paulo et al., 2016). Along with the critique of cork quality and the presence of 2,4,6-Trichloroanisole (TCA) in natural corks (a fungal metabolite causing tainted wines), the cork industry has had to compete with substitute bottle stoppers made of alternative materials such as plastic, aluminium screw-tops, or synthetic materials (Silva Pereira et al., 2000). Attempting to improve the quality and thus the competitive factors of cork, recent field research has been conducted on cork regeneration in a plantation style with improved irrigation and fertigation in order to combat drought and root stress (Camilo-Alves et al., 2020; Leite et al., 2020). On the other hand, industries are developing market openings for new products made from lower quality cork and left-overs from stopper production, reducing the dependency on the wine sector (Costa and Oliveira, 2015; Aroso et al., 2017).

The various new uses for the material have the potential to open up new markets and in combination with other incentives trigger a more sustainable development of the montados (Costa and Oliveira, 2015). In order to add value to the product and to help reverse some of the negative market trends, producers have engaged with certification schemes such as the Forest Stewardship Council (FSC) to ensure a standard of sustainably harvested wood and non-timber forest products (NTFP), as well as utilising this as an added value in terms of social and ecological responsibility (Bugalho et al., 2011; Costa and Oliveira, 2015).

Methods

We conducted a value chain analysis and mapping of the cork value chain, identifying the main agents and activities in bottle stopper production, following Bockel and Tallec (2005). Based on the descriptions of harvesting and post-harvest processes described by Pereira (2007a) and Mendes and Graca (2009) we identified four key agents and stages along the value chain, namely: Cork producers, intermediaries, industrial transformers, and consumers. Between November 2020 and January 2021, we developed four different semi-structured questionnaires, one for each of the key agents identified in the value chain. The semi-structured questionnaires were tailored to each agent and included sections relating to the characteristics of production systems and of key activities performed along the value chain of cork bottle stoppers. The aim of the questionnaire was to elicit information on activities, organisation, and challenges experienced by each agent regarding their position in the value chain, as well as potential effects of non-key agents in the value chain.

The strategy for reaching the various actors differed depending on the type of agent. The cork producers were identified from previous fieldwork campaigns, ensuring that a

TABLE 1 | Categories of actors selected for interviews and number of replies.

Nodes of the value chain	Number interviewed (N)	Response rate %
Cork producers	17	68
Intermediaries	14	21
Industrial transformers	16	22
Winemakers	15	24
Total	62	–

minimum degree of mutual confidence and trust already existed, thus increasing the chances of participation and the reliability of the answers obtained (O'Reilly, 2009). Intermediaries were selected from the directory of the Portuguese Cork Association (APCOR), the largest organisation in Portugal “open to all companies operating in the fields of production, marketing or export of cork products” (APCOR, 2021a). Intermediaries were selected based on their activity description i.e. “cork preparation” (APCOR, 2021b). Transformers, understood as producers of bottle stoppers, were also identified also through the APCOR directory. We further included winemakers from each of the 14 wine regions in Portugal (IVV, 2021) as final consumers of cork products. Between February 2021 and May 2021 all actors were contacted either via phone or email.

In total we identified 25 cork producers, with some of whom prior contact and interactions already existed through previous research on the montado. Others were identified through a snowball approach. In the end, 17 producers replied to our questionnaire (Table 1). As for the intermediaries, 67 were identified in the APCOR directory, and 14 responded. Regarding transformers, 171 were identified from the directory, then reduced to 72 by cross-checking with the Portuguese directory of enterprises, Raciús (2021), and in the end we obtained 16 responses. As for winemakers, we identified 62 of a mix of organic, conventional, and specialised wine businesses scattered across the 14 wine regions in Portugal. Here, we obtained 15 responses. Our sample size represents a small selection of the industries related to the overall cork industry and thus does not represent a complete picture of the whole sector, for which a much more comprehensive study would be needed. Each interview took around 1 h and was conducted by Portuguese native speaker field assistants.

The replies were coded *in vivo* according to predominant and repeated topics (Bernard, 2018), thus presenting the results as a coherent written text based on the answers from the open-ended questions. These are supported by frequencies in counts or percentages as well as statements *in verbatim* attributed to specific respondents. The flow chart was constructed according to suggestions on value chain graphic displays by Bockel and Tallec (2005), which include numerous possibilities for combinations of stakeholders and functions such as finance, goods, and processes. We included all agents and sub-actors in order to present a graphical overview of the processes and stakeholders involved in the value chain.

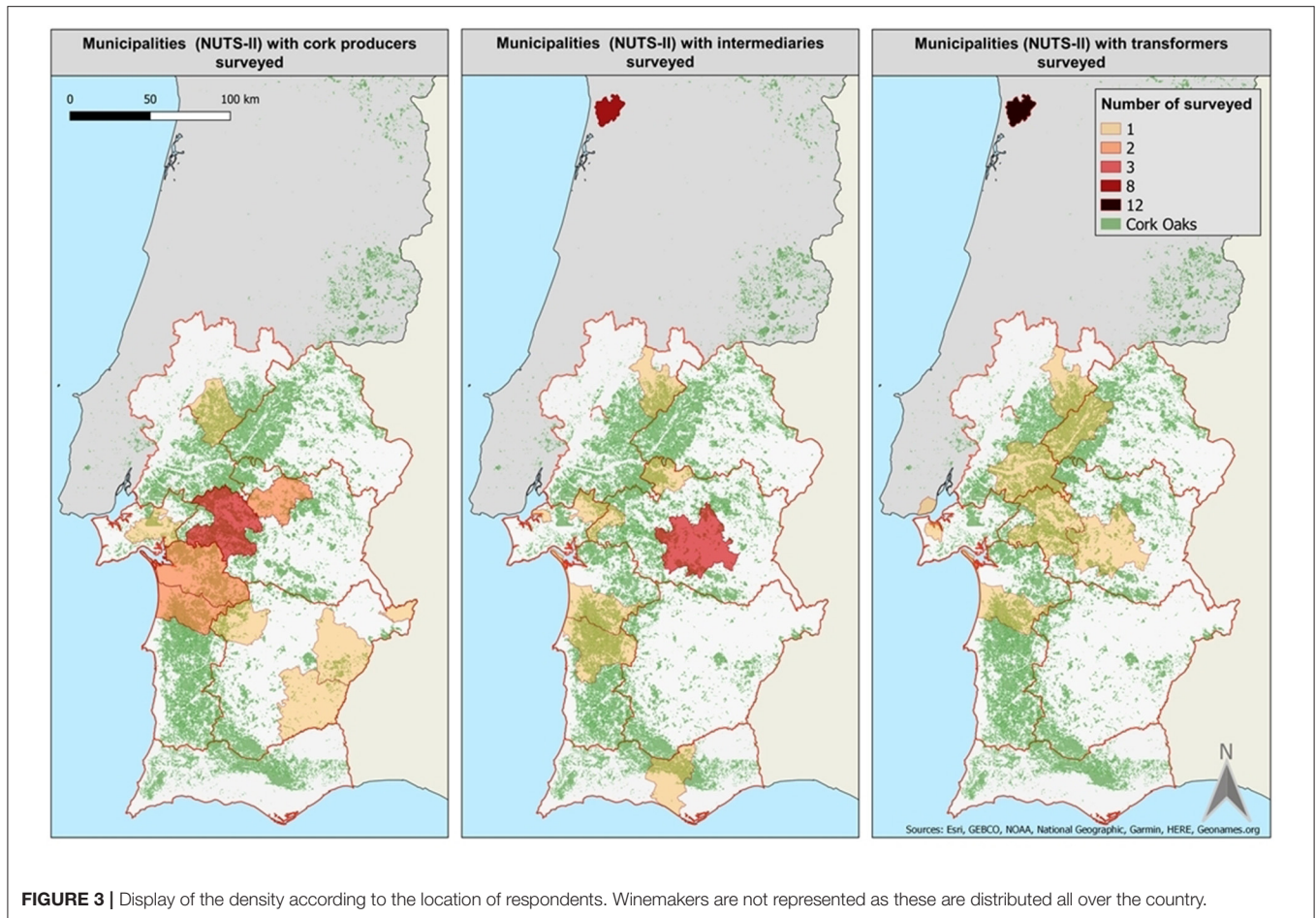


FIGURE 3 | Display of the density according to the location of respondents. Winemakers are not represented as these are distributed all over the country.

RESULTS

Mapping and Characterisation of Key Actors and Activities of the Value Chain

Common for producers, intermediaries, and industrial transformers was the distribution around Alentejo; however, advancing with the value chain, the latter two were concentrating in the north of Portugal (**Figure 3**, for details see **Table 1** in the **Supplementary Material**). For the full range and details of the activities, please see **Table 2** also in the **Supplementary Material**.

Producers

The cork producers whom we interviewed were located mainly in Alentejo (88%) and Ribatejo (12%) (**Figure 3**). The mean farm size of our respondents was 1,863 hectares ($SD \pm 2,605$, median 750) and the mean number of cork oak trees per ha was 67 ($SD \pm 58$). Whilst cork oak was the predominant species in all the montados studied, these were accompanied by a mixture of holm oak and stone pine (*Pinus pinea* L.). All respondents indicated multiple sources of farm income (**Figure 4A**) and cork in all cases contributed to farm income in different proportions (**Figure 4B**). Amongst the multiple sources of income, livestock rearing (71%), sale of firewood (59%), sale of hunting licences (53%), and olive production (47%) were most common, along with a mix of other

activities (47%) such as leasing of agricultural land, cultivation of maize, rice and wine, recreational offers, pine nuts, and vegetable production (**Figure 4A**). Most respondents (29%) replied that cork contributed 25–50% to the total farm income, followed by 24% of respondents where cork contributed only <5%. A total 18% of respondents replied that cork contributed 75–100%.

In addition to the multiple types of income, we also considered financial support from the CAP. Amongst our respondents, 88% received support from pillar 1 in form of basic payment (82%) and support for livestock rearing (76%). As for pillar 2, 82% of our respondents received financial support for various categories (**Figure 5**), most importantly for extensive grazing (59%) and for activities in unfavourable areas (53%).

In regards to certification of woodland management, 35% replied that they did not certify their production of cork. However, 65% replied that they did, divided between the Forest Stewardship Council (FSC) (41%), both FSC and the Programme for Endorsement of Forest Certification (PEFC) (27%), Integrated Production (funded by the CAP in pillar 2) (24%), and Organic (12%). Amongst our respondents, 53% were members of regional cork producer associations. These members received aid in communicating information about cork and the montado (67%), technical assistance (41%), training of personnel (12%), and improving commercialisation of cork (12%). The cork

TABLE 2 | Overview of challenges mentioned by our respondents.

Challenges	Producer (N = 17)	Intermediary (N = 14)	Transformer (N = 16)	Winemaker (N = 15)
Montado related				
Drought	82%			
Pests and diseases	94%	7%	6%	
Soil degradation	35%	7%		
Climate change	41%	7%	6%	
Damage from cattle grazing	6%	7%		
Decrease in montado health	35%	21%	18%	
Lack of montado rejuvenation	6%	7%	6%	
Lack of skilled labour	12%	7%		
Over-exploitation		7%		
Market related				
Low quality of cork	24%	21%	24%	47%
Sector monopolism	29%	14%	6%	
High demand, low supply	12%		18%	
Market trends		14%	18%	
Price volatility	29%		18%	13%
Reduced number of buyers	6%	7%		
Price negotiation		7%		7%
Financially unstable clients		28%		
Competition w/other companies		35%	24%	
Competition w/other materials			36%	27%
Negative publicity		7%		
Covid-19 (low demand)		28%		
Covid-19 (marketing)			6%	
Marketing			12%	
Low standards in industry			6%	
Wine taint (Trichloroanisole, TCA)			6%	100%
Clients' lack of knowledge				13%

The qualitative statements were coded into the categories below. The proportion represents the frequency of the challenges mentioned per agent.

was harvested by skilled workers, *descortiçadores*, or debarkers, that were contracted on a seasonal basis.

Intermediaries

Our respondents were located in the municipality Santa Maria da Feira in the district of Aveiro in the north of Portugal (43%), and in Alentejo and Algarve (57%) (Figure 3). Amongst our respondents, 29% were members of APCOR from whom they received advice on commercialisation and information sharing (40%), legal advice in general (40%), and advice for contract negotiations (20%). In terms of certification and product quality guarantee, 43% of our respondents adhered to Systecode defined by the European Cork Confederation, C.E. Liège (2021a). The cork was prepared for further

transformation into final products, namely, it was cleaned and sorted, and afterwards boiled and sorted again according to quality.

Transformers

The businesses were located mainly in Aveiro (63%) and in Alentejo (38%) (Figure 3). Amongst our respondents, 81% were members of APCOR from whom they received assistance with information sharing (38%), training of personnel (23%), technical assistance (23%), legal counselling (23%), support for internationalisation of the business (15%), and contract negotiation (8%). In order to ensure a reliable production chain, 87% of our respondents adhered to certification schemes. Most of our respondents (46%) adhered to the International Organisation for Standardisation (ISO) (ISO, 2021) and 29% to Systecode. Only a small part of the businesses in question adhered to FSC (21%) and PEFC (4%). The industrial transformation of cork included further sorting according to quality and the actual production of bottle stoppers. The most common type was the natural stopper, however left-over material was ground and pressed into technical stoppers (Figure 6).

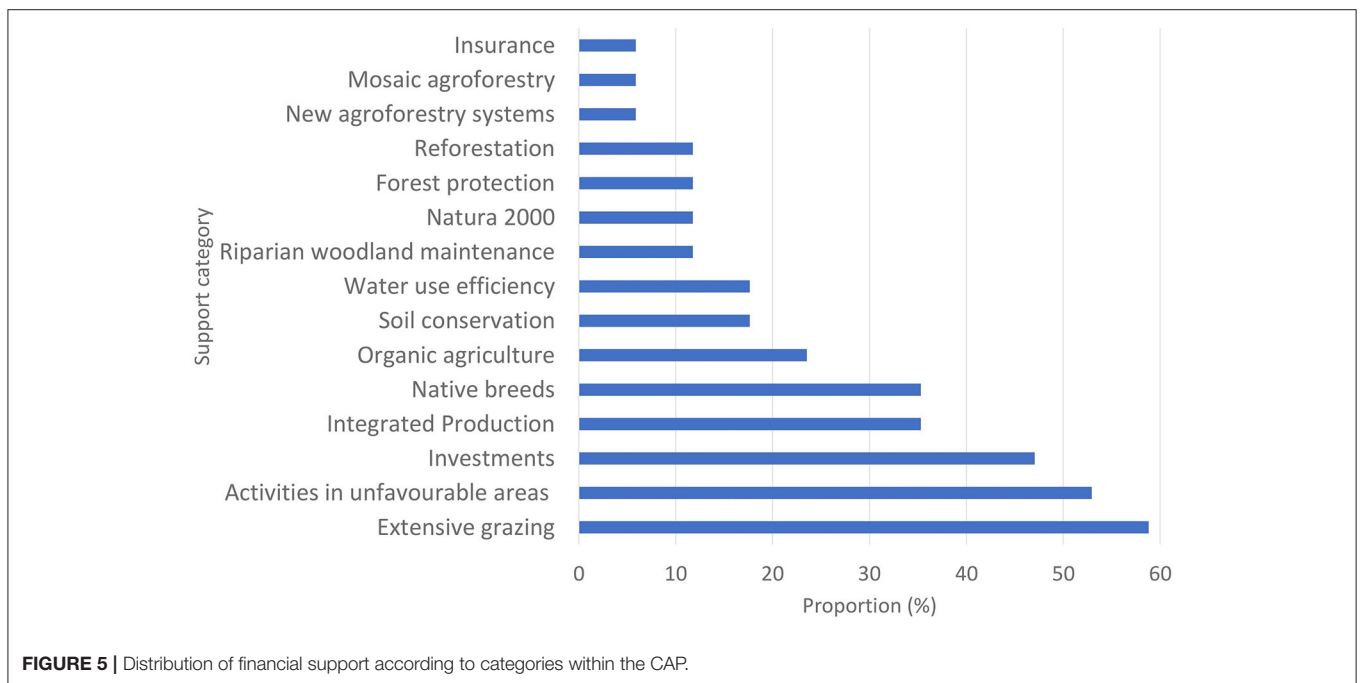
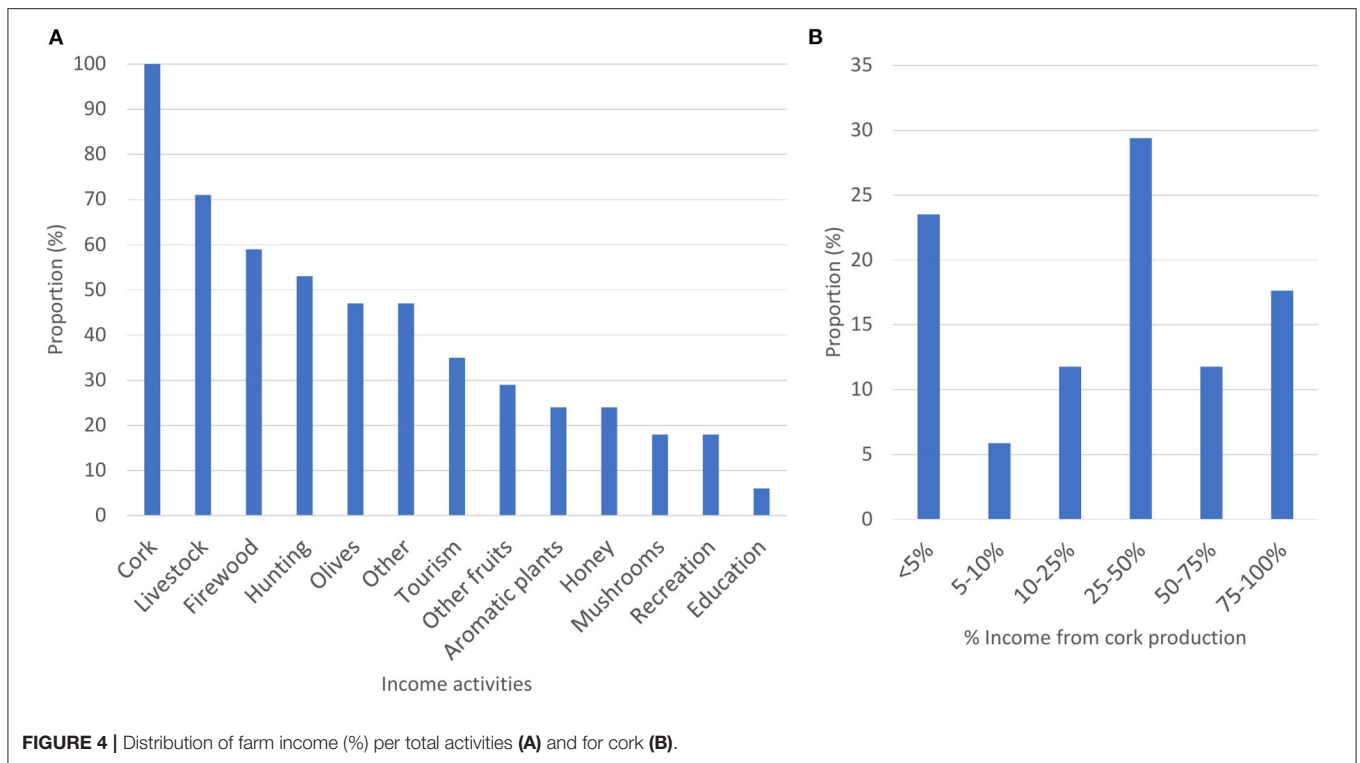
Winemakers

The winemakers who responded to our survey were distributed amongst 11 of the 14 wine districts in Portugal (see Table 1 in the Supplementary Material for the exact location). Amongst our respondents, 93% produced their wine under a certification scheme e.g., Organic (26%), Protected Geographical Indication (PGI) (21%), according to the rules of the regional wine commission (CVR) (37%), or Integrated Wine Production (IPW) (16%). Amongst 40% of respondents, the bottle stopper would be certified, most commonly FSC or a quality seal from the industrial transformer. Most commonly, the wine was certified but not the bottle stopper (53%); however, it also occurred that both the wine and the bottle stopper were certified (40%), or there was no certification at all (7%).

The Value Chain

Producers

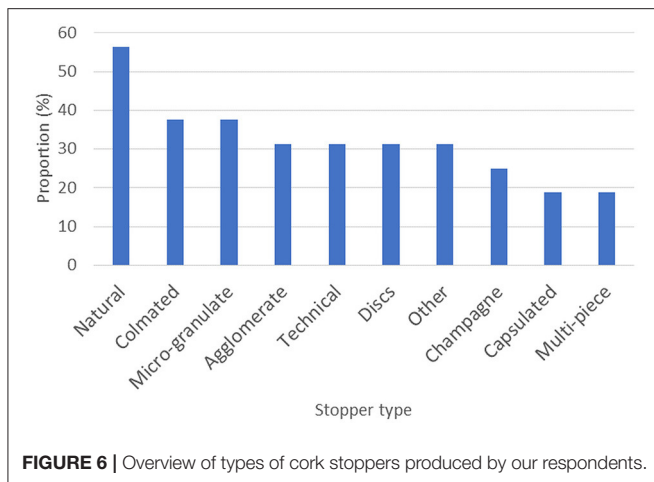
The cork was harvested and measured in kilos or in the traditional measure *arrobas* where 1 *arroba* equals 15 kg. Our respondents stated that the variables considered for assessing the quality included the thickness of the cork (*calibre*), mass, absence of pests, density, porosity, and homogeneity of the cork. Amongst factors that determine the quality, our respondents mentioned the importance of soil quality, overall tree health, correct timing of the harvest, the phytosanitary conditions of the montado, and the necessity of good silvo-pastoral and forestry practises. The price of cork was determined before or after harvest by the producer and several interested buyers based on aforementioned quality factors. Alternatively, the cork was sold at an auction to the highest bidder. The buyers were located at the national market, partly in the north of Portugal (46%) and in the south (54%) (Figure 7).



Intermediaries

Amongst respondents, 70% acquired cork only from Portuguese producers, whereas 30% would be imported (Figure 7). The prices varied according to the quality class of cork (see details in Table 3 in the Supplementary Material). According to our respondents, the price when purchasing

or selling was negotiated based on weight (*arroba* or kg) and by quality via a visual assessment. All respondents reported that the cork would be sold directly to companies within Portugal, mainly to transformers based in the north of Portugal (88%), and 12% would export as well (Figure 7).



Transformers

Amongst respondents, 47% of cork was imported and 53% originated in Portugal. Our respondents expressed the desire for high quality cork as a natural product (57%) with properties that make a multitude of products possible (8%). They also mentioned the importance of skilled harvesting labour (5%), and the origin of the cork and the leading world market in Portugal (16%), along with the environmental benefits of the montado for ensuring high quality cork (14%). In most cases, the final price of stoppers depended on the price initially set by the producers (54%). Amongst our respondents, 50% of the stoppers produced were sold within Portugal, and 50% were exported to other European countries (71%), South America (11%), North America (9%), Asia (6%), and Australia (3%) (**Figure 7**). The buyers were specialised transforming industries or stopper refiners.

Winemakers

The stoppers came from Portugal (88%), Germany (6%), and France (6%). Amongst our respondents, 40% used only natural stoppers for their wines, 53% used both natural and technical stoppers, and 7% used aluminium screw caps. The numbers for screw caps are not considered in the following reflections because alternative materials were not the focus of this study and thus many questions were irrelevant or not answered. Our results showed a distinct fluctuation in the number of stoppers bought by wine producers (see Table 3 in the **Supplementary Material**). Using a natural stopper was perceived as a symbol of a high-quality wine (24%) and tool for the correct ageing of the wine (18%). This connection would be expected by the customers (12%) who also demanded a natural product (12%). However, enhancing the price of poor-quality wine by using a natural cork stopper was used as a marketing scheme (12%). Thus, natural stoppers would increase the final price of the wine (24%). The wines were sold within Portugal (52%) and exported (48%) (**Figure 7**). The wine was sold to distributors (19%), exporters (15%), at wine fairs (15%), to tourists (15%) and at wine tasting events (13%), to speciality shops (9%), online shops (6%), and to restaurants (4%).

Challenges

There was some overlap in the perceptions of challenges reported by the agents. The key challenges common for all agents were related to the overall decrease of the montado health, the low quality of cork available, price volatility, sector monopolism, and the competition against other companies and alternative materials to cork (**Table 2**).

Producers

Amongst the producers, the main concerns were related to drought and pests and diseases, partly due to the mismanagement of the montado and the cork oak trees. The lack of management and the increase of factors related to climate change would result in low-quality material, unsuitable for ensuring a stable profit. Unskilled labour for harvesting, that would result in killing trees, and too small harvests unattractive for buyers was also mentioned. Amongst our respondents, 71% experienced issues with sales, mainly due to price dumping (36%) and challenge finding new buyers (60%), claiming the reasons to be related to the sector monopolism (29%) causing a “closed and highly manipulated market” (Producer 3).

Intermediaries

Apart from the decrease in montado health and low-quality material, our respondents mentioned the competition with other companies and financially unstable clients to be the largest issues. In 2020, during the Covid-19 pandemic, the respondents experienced a low demand for their services. Our respondents (36%) highlighted the sector monopolism as affecting the competitive abilities of smaller companies: “Portugal right now is a monopoly... We, the smaller companies, have to be governed by them. There are 4-5 big groups in the cork industry and that makes it more difficult for us” (Intermediary 1). The unfair competition was also related to “people that buy cork out of the system, with no records and taxes” (Intermediary 9).

Transformers

The main consequences of the low-quality cork were related to price volatility and competition with other companies. The “less availability of the natural product because of lack of trees, and low new investment in replanting trees” (Transformer 4) would lead to unstable or high prices for the prime product, and eventually lead to using alternative materials. The occurrence of Trichloroanisols (TCA) was negative for competition, thus the necessity for guaranteeing natural bottle stoppers free of TCA was stressed. However, it was deemed necessary to point out the competitive advantages of natural cork bottle stoppers “defending the advantages of this product over a synthetic one” and “to discuss the quality of the cork in relation to the wine that is being bottled” (Transformer 15). During the Covid-19 pandemic, it was impossible for businesses to meet new clients in person in order “to pass a trust image toward natural cork and sustainable communication (green product)” (Transformer 4).

Winemakers

Amongst the winemakers, the biggest issue was the presence of TCA, which can wine taint and ruin the wine, eventually

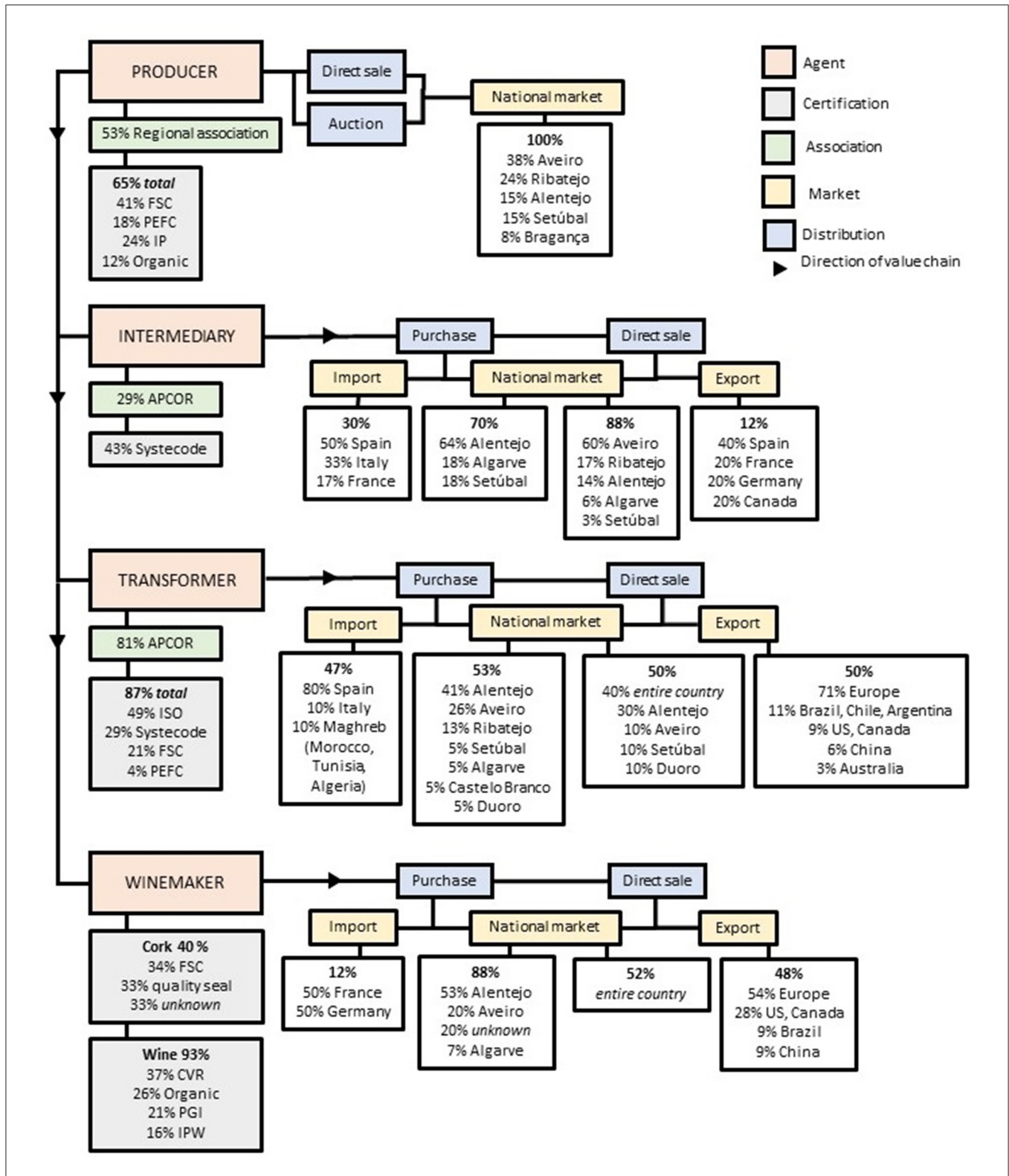


FIGURE 7 | Flow chart displaying the cork value chain including agents and sub-actors (certification bodies and associations) and distribution and marketing channels. Abbreviations are described in the main text. Association and certification: The proportions indicate the total members amongst our respondents. Purchase and sale: Proportions in bold represent the division of market type. The proportions below represent the frequency of place names of the respective receiver location mentioned by respondents.

leading to a use of alternative materials. Acquiring guaranteed TCA-free bottle stoppers was difficult (*Winemaker 10*), although some suppliers were able to guarantee 0.3% chance of presence (*Winemaker 13*). The high chance of occurrence in natural stoppers could be a challenge for the wine business (*Winemaker 6*) and a respondent added that “*microgranulate stoppers allow for a deeper cleaning which allows less TCA.*” The low quality of cork increases the prices for the top-quality material which again raises the basic price per bottle, leading to unpopularity with wine distributors (*Winemaker 1*). Eventually, some respondents reported challenges linked to dissatisfaction amongst consumers not knowing how to handle cork bottle stoppers such as “*clients not knowing the proper way of unscrewing a cork and having it break and then complain that it was faulty...*” (*Winemaker 13*). Nonetheless, natural stoppers could be used as a competitive advantage in an otherwise saturated wine market (*Winemaker 2*).

DISCUSSION

We set out to test how a value chain approach can inform the connections between the actors involved in the production, handling, and consumption of landscape products *sensu* García-Martín et al. (2020) and the landscape of origin. We found that the top challenge between all value chain agents was the poor quality of cork. The poor quality of material stems from mismanagement and abandonment of the montado, old trees and a lack of rejuvenation. Low quality is enhanced by extended periods of drought and the increase of pests and diseases. The consequences are seen as unstable market prices and strong competition for the little high-quality material available, which is often exclusively accessible by large sector companies with high purchase capacity. The poor quality of material thus contributes to competition with alternative materials at the consumer end because these are more affordable and reliable for the final product. The lack in profitability of small-scale production closes the circle by leading to increased abandonment of the montado, or at least the management of the cork oak trees. If the montado is to survive as the rich ecosystem is has historically been, innovative approaches are necessary in order to ensure a stable quality of cork that makes for an overall profitable landscape.

Phytosanitary Health of the Montado Affects the Quality of Cork

As we observed amongst cork producers, the main challenges result from the threat of climate change and the consequences thereof, to a large extent based on the lack of water and the increase in diseases. Especially the root decay fungus *Phytophthora cinnamomi* Rands thrives in dry soils, prohibiting root growth especially for young trees (Moreira et al., 2006; Pereira et al., 2009). This contributes to the decline in overall montado health, which includes phytosanitary aspects and poor soil quality. The concern for cattle grazing was very low amongst our respondents, a point that contradicts the great concern made by researchers that too heavy grazing pressure is affecting soil properties and water retention capacities, and thus further inhibiting cork oak rejuvenation (Berrahmouni et al.,

2007; Bugalho et al., 2011). Since livestock is the second most common source of income amongst our respondents, it might be worth looking into the precise relationship between and the attitudes toward these contrasting land-uses, as also suggested by Angelstam et al. (2019).

Another direct factor affecting the quality of cork are insect pests, such as the Flathead Oak Borer or *cobrilha* (*Coraebus undatus* Fabricius) and the Oak Pinhole Borer or *plátipo*, (*Platypus cylindrus* Dejean). The *cobrilha* is spreading rapidly and is a major problem as the insect galleries reduce the amount of high-quality cork that can be extracted from the harvest (Sousa and Inácio, 2005; Gallardo et al., 2012). The poor-quality cork, as well as scraps from the production of natural stoppers, go to the production of technical stoppers or other products (Pereira, 2007b). Connecting this to the winemakers' concern that the prime product becomes unaffordable, this could force them to go with alternative closure materials, such as technical stoppers or synthetics (Silva Pereira et al., 2000). Both alternatives would also relieve the concern that presence of TCA cause tainted wine, although, controlling the regular changing of boiling water at the intermediary preparation stage, handling of the final product, and cleaning of wine bottling and storage facilities has improved (Silva Pereira et al., 2000). However, the bad name of TCA linked to cork might be cleared if further attention were paid to the various phenolic biocides used in agriculture and the paper industry, leaving traces in both terrestrial and aquatic environments (Pereira, 2007c).

Raising Awareness Throughout the Value Chain

We created an overview of the cork value chain in order to see which agents and sub-actors are involved (Kaplinsky and Morris, 2000; Bockel and Tallec, 2005). Our study shows the potential for delving deeper into a global value chain analysis *sensu* Gereffi et al. (2005) as our results reveals power dynamics hinting at a monopolism of the sector from large national companies. Our results highlighted the inequality of access to raw material which may depend on purchasing power as well as the resources for the subsequent industrial transformation and marketing (Parejo-Moruno et al., 2021). The general reduction in the number of buyers and an increase of the main national producers that handle all processes from production to finalisation of products, will eventually reduce the chance for small-scale producers to compete in the market since it is not desirable for intermediaries to buy only small quantities of the high-quality cork that is demanded. This may eventually lead to unstable prices and thus an unstable income for small-scale producers, leading to a stagnation in cork production (Parejo-Moruno et al., 2021), i.e., decreasing cork oak maintenance and eventually abandonment.

We observed a clustering of agents to the north of Portugal, which according to Lopes and Branco (2013) has a historical reason, although no clear advantages in modern day business. Agents at intermediary and transformation stages showed a high awareness and concern about the montado, which, from a landscape sustainability perspective, was a positive outcome as it indicated little disconnection toward the landscape of origin

throughout the value chain. However, the winemakers showed as consumers no or little concern directly for the landscape of origin but instead had a stronger focus toward the quality of the product they received. Since the winemakers were concerned about their customers' desires of acquiring a natural product of high quality, it would be crucial that this agent in the value chain utilise the potential of added value and branding that natural bottle stoppers already are associated with, in order to normalise the awareness of the landscape of origin (Holt, 2006).

The Role of Associations and Certification

Our study shows that associations and certification bodies are of great importance for disseminating information about cork throughout the chain. Considering that these sub-actors connect producers and enterprises with final consumers of goods and services (Nang'ole et al., 2011), several agents received assistance in training of personnel and how to communicate the value of cork. As the main centre for combining interests from all over the cork sector, APCOR assures that members adhere to "the highest standards of production of cork bottle stoppers, in order to ensure that the wine industry and the clients in the sector are provided with products of the highest quality" (APCOR, 2021c). Together with C.E. Liège, they contribute to research on the global cork market as well as the development of cork processing and setting production quality standards in the International Code of Cork Stopper Manufacturing Practise, represented in the label Systecode (C.E. Liège, 2021b). Besides production standards, some respondents adhered to the International Organisation for Standardisation (ISO), monitoring the quality of business and environmental management, as well as quality in food systems and value chains (ISO, 2021). All of these associations and standards show a tight connection and an interest in guaranteeing the highest quality product to the end consumer. However, we observed a gap between agents when it came to certifying sustainable resource management at the place of origin, namely amongst the intermediaries. As a non-timber forest product (NTFP), cork is better represented through forest management programmes such as FSC or PEFC (Moussouris and Regato, 2002; Costa and Oliveira, 2015). These types of certification include well-developed mechanisms for tracing the product from origin to final product i.e., by auditing the chain of custody (Forrer and Mo, 2013; Masiero, 2018). Moreover, their focus is on introducing and maintaining sustainable forestry practises that could eventually contribute to the high-quality product in demand (Berrahmouni et al., 2007; Bugalho and Silva, 2014).

In addition to stressing the focus on sustainable forest management, transmitting storeys of the origin landscape through labelling connects the landscape with the consumer by creating values and relations (Holt, 2006; García-Martín et al., 2020). Narrative labels (*sensu* Slow Food), PGIs and specific landscape product labels, such as Mountain Partnership Products Initiative, transmit storeys and values of the people and the landscape of origin (MPPI, 2021; Slow Food, 2021). However, their focus lies on food products, and they most commonly represent the reality of the producer and not of the whole value chain. With an additional landscape label *sensu* Mann

and Plieninger (2017), the attention toward to the montado as a holistic entity could reach further across geographical scales and add value to the product, either as part of a food product such as wine, or as a novel usage (Gil, 2015). Attempting to minimise the dependency on the wine market, cork is currently being promoted as a 100% natural and renewable material that is durable and reusable throughout its whole life-cycle, placing it favourably on the global environmental awareness agenda (Duarte and Bordado, 2015).

Multifunctionality Is Necessary for Landscape Sustainability

The montado can be defined as a socio-ecological system (Gauquelin et al., 2018) associated with various values ranging from financial market value to relational and aesthetic values (Chan et al., 2012). Numerous studies have confirmed that the various activities taking place in the montado are out of balance (Costa et al., 2009; Bugalho et al., 2011; Pinto-Correia and Godinho, 2013; Costa and Oliveira, 2015). The fact that the cork sector is private and regulated by the market, and other montado related activities are supported by public funds such as the CAP, makes it necessary to look at how these complement or contradict each other. Our results show that livestock rearing is the second most important source of income apart from cork, and it is amongst most of our respondents supported by the CAP. As mentioned previously, a too heavy grazing pressure is inhibiting the regrowth of cork oak trees, and thus if both are going to thrive side by side, it is necessary to reduce the grazing pressure (Arosa et al., 2017). However, there is no need to compromise on the total production within the montado system. By increasing the awareness and promoting other sources of income from montado related activities such as tourism or education, and products such as olives or wild harvested aromatic plants, this could bring about the shift necessary to restore a socio-economic and ecological balance (Costa and Oliveira, 2015). There are already channels in place that could motivate cork producers to market other niche products e.g., vegetables or high quality olive oil to local restaurants following "Kilometre Zero" principles (Tulla et al., 2014), or longer value chains associated to wild harvested products e.g., FairWild (Brinckmann et al., 2014). Initiatives for supporting such activities are already in place in the second pillar of the CAP, such as support for integrated production or mosaic agroforestry. Including these multifunctional practises would increase the contribution of ecosystem services such as provisioning and regulating services through montado products, improvement of water retention, and biological pest control (Bugalho et al., 2011).

Limitations to Our Study

Our sample represents a small selection of agents from the cork sector. As this study set out to explore and test a landscape product approach, we are well aware of the fact that making a generalising statement about the state of the entire cork sector would require a much larger study, including more participants across the sector. Associations such as APCOR publish reports on the cork market on a regular basis (APCOR, 2020), thus it would make sense to collaborate with them. However, as

the wine sector is not usually included in these reports, we recommend collaborating with the regional wine commissions, which a large part of our winemaker respondents were members of. The various interests represented in the montado as well as the socio-economic differences amongst actors have been scrutinised in research by Pinto-Correia et al. (2019) and Muñoz-Rojas et al. (2019). Inferring a general typology of cork sector agents would again require a larger study, potentially expanding the cork sector to include other products than bottle stoppers, as well as conduct a full life-cycle analysis of cork products. Regarding value chains as adaptive systems would require a take on landscape products that would be an addition to the scope of this study.

CONCLUSION

We explored the cork sector from a landscape product point of view. Cork stems from a highly unique landscape, the montado, and is a globally important product intimately connected with the wine sector. By interviewing agents from the cork value chain, we gathered perspectives on the actors and connexions involved, and from this we were able to discuss potential leverage points for sustainability in the landscape of origin, which could eventually bring a positive trickle-effect of benefits for the whole sector. From a landscape approach perspective, the integration of cultural as well and socio-economic aspects is necessary for making suggestions that will benefit the entire industry of bottle stoppers in a sustainably manner. As this is an explorative study, we recommend further in-depth studies involving collaborations between agents and sub-actors, who provide strong network and communication channels within the industry. Lastly, there is a great potential in making cork consumers sensitive toward the multifunctionality necessary to uphold a bioculturally diverse socio-ecological system such as the montado. As the cork sector is closely connected to the wine sector, winemakers have an important role to play in order to promote the montado. They are meeting their customers face-to-face at wine fairs and wine tasting events, and they are very aware and concerned about the customers' wishes. As tourism is increasing in central and southern Portugal, there is a great potential for cork producers and winemakers to collaborate in promoting the montado for their common benefit.

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DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

AUTHOR CONTRIBUTIONS

The questionnaires for this study were jointly developed IS, MT, CQ-S, JM-R, and TP. Data analysis and writing of the manuscript was done by IS under supervision by MT, CQ-S, JM-R, and TP. All authors contributed to the article and approved the submitted version.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fsufs.2021.787045/full#supplementary-material>

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