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Cork and Sustainability: Discussing the Sustainable Use of the Material from a Design Perspective

ANA CARINA Pereira[1,2*], *HAN Brezet*[1], *HELENA Pereira*[2], *JOOST Vogtländer*[1]
(1. Design for Sustainability, Faculty Industrial Design Engineering, Delft University of Technology, 2628 CE Delft, The Netherlands; 2. Forest Research Centre, School of Agronomy, Technical University of Lisbon, Lisbon 1349-017, Portugal)

Abstract: There is the challenge to use materials in a more sustainable way. Even though cork has an interesting eco-profile as a material, other aspects contributing to an enhanced sustainable use of the resource are discussed: addressing the life-span of products, materials substitution, and the trend of materials development identified.
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0 Introduction

There is the challenge to use materials in a more sustainable way, namely by using less and cleaner materials, and to recycle them. As designers, we have been mainly selecting materials, and the end goal is application. It is proposed that taking the perspective of the materials instead, enables the identification of ways to contribute to a more sustainable use and balance of the resources in the long term. This is explored with cork, the bark of the cork oak tree.

From the above, there is a research question — how to use cork in a more sustainable way?

1 Problematic — Design, Materials and Sustainability

It is already generally acknowledged that the use of materials is not sustainable[1-2]. Large amounts of materials are used, mainly since the last century, and there has been a shift from renewable to non-renewable ones[3],[4]8. In a general way it is acknowledged that renewable resources and materials have a significant contribution towards sustainability[5-6]. On the other hand, since circa 1900 the number of materials available proliferated; the number of existing materials is unlimited, as are also the possible combinations of them in composite materials[7]42. A more profound, intense and precise manipulation of matter is observed; although, the materials produced as such are more difficult to reintegrate in the natural cycles, in the end of their useful life, and composites are combined in an extremely difficult way to dissociate[7]49.

There are some proposals on how to use materials in a more sustainable way, such as cradle to cradle (C2C)[8], but these are not straightforward or universal solutions; exemplifying, while C2C may be interesting for a local context, if applied in a global market emissions can double. Additionally, with regard to recycling, even though it can be technically feasible for many materials, recycling rates are relatively low even for common polymers such as polyethylene (PE) and polypropylene (PP) (w(PE) = 7.5%—9.5%, and w(PP) = 5.1%—6.0%)[4]. Recycling needs to be economically feasible, and which requires scale[4]73-76,[9]233-234. How can this be accomplished if the number of materials continues to proliferate?

Considering that the purpose of the activity of designers is application, there is established knowledge in materials selection, and more recently including environmental aspects[4]; although, the materials perspective, and the effects of choices and developments in these resources are generally not acknowledged. Exemplifying, new materials proliferate and enable more specific applications, but then there are many more materials and it's more difficult to foster recycling, which needs scale for economical feasibility.

From this problematic, it is proposed to look at materials from a resource perspective, trying to identify the aspects contributing to the long term sustainable balance, and how to use them in a more sustainable way (by enhancing the long term balance of the resource).

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∗**E-mail:** a.c.dasilvapereira@tudelft.nl

2 Cork Applications and Sustainability — Characterizing the Case

2.1 Cork Oak Forest Systems — Origin of the Material Resource

Cork is a renewable resource, the outer bark of the cork oak tree, and can be removed periodically from the tree stem without endangering vitality. The cork oak forests occur in the Mediterranean region and provide multiple important functions, such as preventing soil erosion and the protection of biodiversity[10-11].

The cork oak can be found in two kinds of forest systems: ① a multifunctional system, where the forest areas are combined with some agriculture and cattle raising, designated "montado de sobro" in Portugal, and where it represents 70% of cork oak forests; ② a mono-functional system, focused on the forest use, and characterized by higher forest density. In our days, cork oaks are explored for the production of cork[10]17-19. The multifunctional ecosystem was developed since the end of the nineteenth century, and due to the increasing valorisation of cork and socio-economical changes, these became one of the richest in biodiversity, and with economical sustainability[10]30-33.

The cork oak is a slow growing tree, and with a high longevity, up to 250—300 years. The economical exploration of the tree occurs between 40 and 150—200 years, corresponding to approximately 12—14 consecutive removals of cork, every 9 years. Yearly cork growth thickness varies between 2 and 5 mm, more intensely in the first years, and for most regions of Portugal, cork thickness reaches 3.5 to 4.0 cm after 9-year cycle[10]26-27.

Costa et al.[12] assessed the cork oak landscape dynamics, in an area considered representative of the "montado" in Portugal, for the period 1958—2005. While some land use changes were observed, overall, the cork oak woodlands were stable during the 47-year study period, regarding area and dynamics. The authors considered this to be indicative of the basic sustainability of the "montado" system.

2.2 General Cork Context and Applications

Portugal is the main cork producing country, with 52.5% — over 150 thousand tonnes per year, and about 90% of the cork transformed is exported. This represents 0.7% of the gross domestic product (GDP), and 2.3% of the exports. Portugal is also the major importer of cork. About 40% of cork is used for the production of stoppers, and these account for 69% of the sales[13]21-26,31. At the moment the market for cork stoppers is unstable due to substitution by alternative sealants[13-14]. Succinctly, this originated on the quality and technical performance of some stoppers, concerning the appearance of trichloroanisole (TCA) in some wines, and which triggered the initial development of substitutes. During the last decade the problem was generally corrected by the cork industry, but the expansion of substitutes allowed more competitive prices.

Besides use as a sealant, cork is also found in a variety of applications: floating devices, shock absorbers, insulation and aeronautic. And among several properties, cork is light, rather impermeable, resistant to wear, and has high friction[15-16]. More recently there has been research in using cork for pharmaceuticals, and its properties are still considered interesting and with potential for new applications[16-17]. Also in design several cork products have been developed in the last years, e.g. by Daniel Michalik, and one recent project, Design Cork, was organized by Mestre in 2008[18].

Concluding, cork is an important resource for Portugal, relevant to export, and besides its use in stoppers there are already several applications, and others are being explored. With regard to the substitution of stoppers, taking into account that other substitutions of cork have also happened in the past — inner layer of capsules for pharmaceutical industry[16], it seems important to acknowledge aspects that have an influence in the market, such as quality.

2.3 Life Cycle Assessment — The Environmental Impact of Cork Products

In general, life cycle assessment (LCA) studies of cork products are scarce. Two detailed studies have been performed on stoppers: one comparing cork and alternative sealants[19], in which the cork stoppers were found to have in general a lower environmental burden; the other study covered the entire life cycle of a natural cork stopper[20]. A few other examples of LCA or other cork environmental related information were identified in the construction sector, for flooring and insulation, e.g. Ref. [21]. In Ref. [22] the eco-costs value ratio (EVR) model is applied to assess and improve several cork products, recently developed within the Design Cork project[18], but detail on environmental information is not available yet. Concluding, even though a comprehensive overview is not presented, this is already indicative of the need to perform more LCA studies.

3 Specific Aspects Identified as Relevant in the Cork Context

Considering the importance of using materials in a more sustainable way, and the specific cork context, some issues were identified which may enhance the sustainable use of this resource.

3.1 Identifying Cork Applications with Higher Benefits, by Exploring Material Alternatives in Substitution

From a materials substitution perspective, and considering that cork is a relatively clean material, an important observation emerged acknowledging that the benefits of using cork are not just in using it — they depend on where and how the material is used. In other

words, those different applications can have differentiated environmental benefits, by taking the alternative materials avoided into account. This could be investigated by exploring alternatives in substitution, and is relevant for sustainability, since knowledge and development focus in the applications with higher benefits would enable to enhance or optimize the positive impact of using the material.

3.2 Trend in the Development of Cork Materials

A trend has been identified concerning the development of cork materials: cork is not just one material, there is already a portfolio of cork materials, and more are being developed. Among the materials are: white agglomerates, black agglomerates, rubber-cork, cork gel, cork polymer composite (CPC), cork wool, cork paper, cork textile/ skin[16-18,23]. This trend is consistent with general developments on materials, and cork is namely being mixed with others to form composites. This pattern is similar to developments in wood[24].

On this issue a dilemma is noticed: in one hand, this development enables new and diversified applications; but on the other, these cork materials become more complex, more distant from the natural material, and eventually more difficult to recycle and less environmentally friendly. Therefore, it seems relevant to further understand and characterize this trend in materials, and additional environmental information is necessary to clarify the dilemma.

3.3 Life-Span of Cork Products

Long life-span products are generally acknowledged as environmentally desirable[5,25]. In the case of cork, this appears as a key issue to address for several reasons. The resource itself is limited — there is slow growth only in a specific region; as such, long life-span products contribute to the conservation of the resource. Considering the localized production and transformation of cork, there is an economical interest in exporting the products. It is already generally known that the transport of materials or products over long distances can significantly contribute to increase the environmental impact of products, as mentioned in Ref. [26]. If the products have a long life-span, this impact is diluted or distributed through the years. On the other hand, products with a long life are also associated with high quality, which is relevant to users, and may be regarded as enhancing the overall value and use of the material. From the above, it is relevant to investigate their longevity, influencing aspects, and how to extend it.

3.4 Systems Thinking Approach — Exploring Influences and Repercussions of Use in the Forests

The use of the material in products can have important repercussions in the forest systems — the lack of quality in stoppers reduced the value of the material in market, endangering the forests. As such, a specific study of these influences would be useful from a systems thinking approach.

As observed in Ref. [10], since cork oak monofunctional systems presented higher cork productivity, development policy and incentives have been mainly addressing these; but this may compromise the traditional "montado", which offers higher ecological and social values. At the moment it is important to increase the value of the material, which has been affected by substitution in stoppers. Additionally, it is proposed in Ref. [27] that the reduced production diversity of cork products (a contraction stimulated by the emergence of agglomerated cork) reflected by the specialization on stoppers, does not favors the preservation of cork oak trees. From the above, we may suggest that a more representative and diversified portfolio of cork applications could contribute to an increased sustenance of the ecosystem.

3.5 "Appropriate Use" of the Material — A Concept for Sustainability

Taking the aspects mentioned above into account, it is proposed that an "appropriate use" of the material is a way to accomplish more sustainable solutions. Succinctly, the concept of "appropriate use" could be characterized as an utilization in which the properties of the material suit naturally (without much transformation — trend), in which the material in product withstands use through time (enabling long life-spans), and in which the products are appreciated and valued by users (technically and aesthetically). Additionally, applications in which these aspects are more clearly distinguished from solutions accomplished with other materials, and including environmental information about the products, could be regarded as offering a higher positive differentiation (substitution — benefits).

4 Conclusion

The utilization of materials has a substantial burden on the environment, and there are several possibilities on how to use them in a more sustainable way; their effectiveness may vary from case to case. It is proposed that as designers, a broadening or shift of thinking from exclusively the applications as the end goal towards the material, by addressing the repercussions of use from a resource perspective, may contribute to enhance our understanding on how to use materials in a more sustainable way.

As a resource, cork can be considered to have in general an eco-profile; although, few LCA studies can be found to clarify how this is reflected in products. Cork has interesting properties, multiple applications are possible, and it seems important to address aspects such as quality.

From the specific cork context, several aspects were identified with potential to contribute to a more sustainable use of the resource (research question — how to use cork in a more sustainable way?): identifying the applications with higher benefits by exploring alternatives in substitution; investigating the trend concerning the development of cork materials; addressing the lifespan of cork products; exploring the influences and repercussions of use in the forests through systems thinking; and, focus on applications enabling an "appropriate use" of the material.

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