Antimicrobial Activity of Oak Wood Against Nosocomial *Acinetobacter Baumannii* of Human and Animal Origin: A One Health Approach

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Abstract Wood, being an organic and renewable resource, is the most commonly used sustainable material for the construction of surfaces in hygienically sensitive places and has been proven to improve the psychological health and well-being of inhabitants. Still, there exists a misconception regarding the organic and porous nature of this material, which is blamed for the retention of microbes. The aim of this investigation was to study the in vitro hygienic properties of wood against nosocomial pathogens of human and animal origins. The round discs having a diameter of 9 mm with 2.5 mm thickness were prepared from the outer heartwood part of oak wood. These discs were conditioned in a climatic chamber and then packed and gamma sterilized. The four isolates of *Acinetobacter baumannii*, of animal and human origin (zoonotic and nosocomial), were pre-cultured. The method of direct antibiogram testing was employed. The bacterial suspension at 0.5 McFarland was inoculated on Mueller–Hinton agar plates by swab streaking method. Later, the wooden discs were directly placed on inoculated agar. After incubation for 24 h at 37 °C, the zone of inhibition on agar around the discs was noted manually. All the tests were performed in triplicates. The results showed that t wood has antimicrobial properties against nosocomial *A. baumannii* bacteria. Additionally, the direct antibiogram method can be used to quickly screen the antibacterial nature of wood. These properties can counter the growth of pathogens originated from multiple sources, including humans, animals, and indoor environment.

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1 Introduction

Wood is the major renewable material used for eco-friendly constructions. It has stress relieving and restorative health effects on inhabitants when used as indoor building environment [1]. Moreover, it is used as contact surface in hygienically important places [2], for example, as food contact surface for cutting, preparation, packaging, and fermentation. However, the porosity of this material is always questioned regarding the hygienic safety. Interestingly, some studies have reported that the porosity and the chemical composition of wood equips it with antimicrobial properties, making it a superior choice as a hygienic material [3, 4].

The test methods for antimicrobial properties of wood are mostly extractive dependent. However, this method is undesirable for the quick screening protocols because of the involvement of an extra step of extraction which requires chemical handling and experienced labor. Moreover, this method only isolates the chemical part of the wood and does not provide any information on the role of physical structure of wood to counter he microbial growth. Recently, a novel method has been developed to directly use the solid wood piece and test its antimicrobial behavior via direct agar diffusion method [5].

Wood could be a hygienic solution for the preparation of organic and safe surfaces for hygienically important places. However, research on this issue remains scarce because microbiologists in wood industry extensively study the interaction of this material with wood degrading organisms and the role of human and animal pathogens remains hidden. The application of multidisciplinary research approaches such as one health collaboration helps to overcome such limitations. Therefore, this study was performed to study the antimicrobial properties of wood against hygienically important nosocomial pathogens of animal and human origin, via a direct agar diffusion method.

2 Materials and Methods

The European oak wood (*Quercus* spp.) was collected from Nantes, France. After natural drying of wood, as performed in industrial settings, cutting was done via an electric saw (Altendorf-F45, Minden, Germany) into 2.5 mm sheets in transversal (RT) and tangential (LT) directions. These veneers of wood were used to prepare 9 mm wooden circular discs using a laser cutting machine (Trotec-SP500 C60, Wels, Austria). The samples were conditioned in a climatic chamber to achieve a moisture content of 12% which is similar to wood used in construction. Further, the samples were sterilized by gamma irradiation at 25 kGy.

The *Acinetobacter baumannii* isolates were selected for this study owing to their importance in nosocomial infections related to interior environment of human and veterinary hospitals. The bacteria were taken from the collection of bacteriology laboratory of Central University Hospital (CHU) of Angers. The origin of two isolates [Acineto SAN (AS) and Acineto Mucoide (AM)] was infected human patients and of two other [Acineto Animal Nantes OXA-23 (AAN) and Acineto Sensitive Species of Animal (ASSA)] were infected animals.

The direct disc diffusion method was used to determine the antimicrobial activity of wood. The bacterial suspensions were prepared with 0.5 McFarland turbidity and inoculated by streaking on Mueller–Hinton agar plates (BioRad, Marnes La Coquette, France), according to the joint recommendations of the Antibiogram Committee of the European Committee on Antimicrobial Susceptibility Testing (EUCAST) and French Society of Microbiology (CASFM). The sterilized discs were placed directly on agar plates. The antibiotic discs (6 mm) of Meropenem and Ciprofloxacin were used as controls. The plates were incubated at 37 °C for 24 h and then the inhibition zones were interpreted according to the recommendation of CASFM and EUCAST. The experiments were performed in triplicates.

3 Results

The results of antibiogram are given in Table 1. Both wood cuttings showed antimicrobial activity against all the tested isolates. The sensitivity pattern among all tested isolates was ASSA > AS > AM > AAN. The RT cuts showed higher activity than LT ones. All the tested isolates were resistant to ciprofloxacin except ASSA and only AAN was resistant to meropenem antibiotic.

Table 1 Antibiogram zone of inhibition (mean ± SD mm)* on agar induced by different species wood discs tangential (LT) and transversal (RT) cut against *Acinetobacter baumannii* isolates

Bacteria	Wood		Antibiotic	
	RT	LT	Meropenem 10 μg	Ciprofloxacin 5 μg
AS	15 ± 2.4	12 ± 1.6	28 ± 00	6 ± 00
AM	13 ± 2.2	12 ± 2.5	28 ± 0.5	6 ± 00
AAN	13 ± 1.7	11 ± 1	6 ± 00	6 ± 00
ASSA	19 ± 3.1	17 ± 2.6	12 ± 0.7	28 ± 1.6

*The diameters of wood discs were 9 mm and 6 mm for antibiotics

4 Discussion

All the bacterial isolates were susceptible against the diffused chemicals of wood, confirming the antimicrobial activity of oak wood against the *A. baumannii* bacteria. Interestingly, oak showed antimicrobial activity against Acineto animal Nantes (OXA-23), even the tested antibiotics were inefficient in this case. The isolation of these chemicals from oak wood may give some potent compounds which can be used as antibiotics or antiseptics. Apart from the chemical composition of wood, the natural acidic pH of oak (3.5–4) may also have played a role in the antimicrobial behavior, as the *A. baumannii* has been reported to be sensitive to acidic pH of surfaces [6]. Earlier, this bacterium has been reported to survive for longer times on dry glass surfaces [7] and it was difficult to decontaminate porous material (scrub) as compared to metal (steel) [8]. In this regard, the porous wood surface with acidic pH and natural antimicrobial potential is an important material to be further explored.

The transversal section of wood showed higher antimicrobial activity than the longitudinal section. This difference can be attributed to the difference of anatomical structures of wood and direction of diffusion due to fibers orientation. Similar findings were reported in earlier studies [3, 5].

The results of these findings clearly show that this method of antimicrobial testing can be adapted as a screening test. However, there is variability among the activity of wooden samples within the triplicates, which should be considered when performing more sensitive studies. Further investigation is needed to standardize this method.

This study was a successful collaboration of human, animal, and environmental health researchers. Similar studies of "one health approach" can efficiently apply the competencies of multidisciplinary scientists and turn out fruitful results.

5 Conclusion

From this study, we can conclude that the oak wood has antimicrobial activity against *A. baumannii* isolates. In addition, the direct agar diffusion method can be used to test and screen the antimicrobial activity of wood against bacteria. Finally, the results obtained via one health approach can benefit all the collaborative scientists, as it can fill multiple gaps of knowledge on a specific topic.

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