Qatari *Pulicaria* Natural Fibers:

Promising Antioxidant and Antimicrobial Materials for Biomedical Applications

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Over the past few decades, people worldwide have become increasingly aware of environmental pollution. As a result, more people are choosing natural fibrous materials over synthetic ones. The main issue with synthetic fibrous materials is their persistence in the environment, leading to long-term complications and pollution. On the contrary, plant fibrous materials are cost-effective, abundantly available, and have unique features such as biocompatibility, biodegradability, and mechanical strength.

Local plant resources offer numerous benefits, positioning them as key contributors to the bio-based economy. Researchers are increasingly exploring the potential of plant-based resources to develop eco-friendly alternatives. Qatar is home to approximately 400 plant species, one-third of which are reported to have medicinal value. As an industrialized country with limited agricultural land, Qatar does not cultivate fibrous crops such as bamboo, hemp, flax, and cotton, which are commonly used in textiles and industrial applications. Given the importance of self-sufficiency in natural resources and the goal of a more sustainable future, there is a pressing need to explore and identify new fibers from local plants with unique properties. At the Agricultural Research Station (ARS) at Qatar University, the focus is on exploring Qatar's natural resources and their potential for bioprospecting. As part of a flagship research initiative, studies are conducted to identify local medicinal plants that produce fibers that could be used for therapeutic purposes.

Based on preliminary observations regarding fiber richness, natural fibers were extracted and characterized in the present research, particularly from two medicinally important aromatic plant species, *Pulicaria undulata* and *Pulicaria gnaphalodes* (Figure 1). *P. undulata* (locally known as "Jithjath") is widely distributed followed by *P. gnaphalodes* (local name "Nufaij") among three reported *Pulicaria* species in Qatar. Traditionally, these species have been used by locals as herbal tea and medicine. In other Arabian countries, these species have a long history of use as an insect repellent, anti-inflammatory, wound healing, and anti-gastritis agent. Before this study, these species had been investigated for their bioactive phytochemicals and essential oils, but not for their fiber content and utility. Considering this research gap, the research focused on the bio-functional properties of these fibers, including their chemistry.

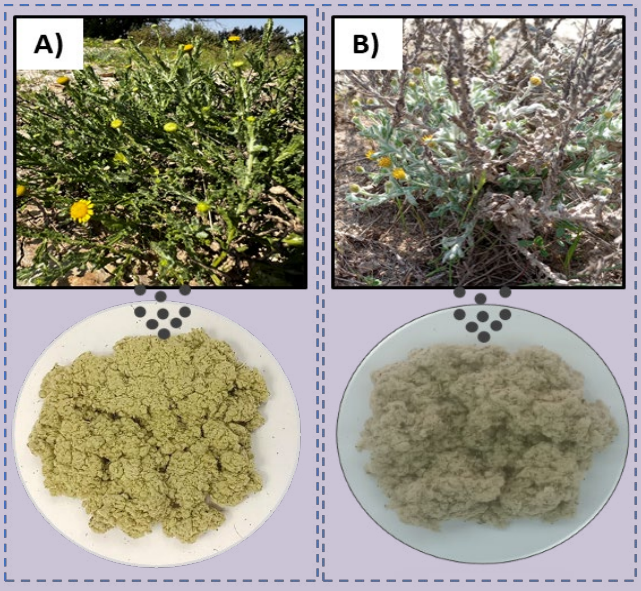

Figure 1: A) *Pulicaria undulata* and B) *Pulicaria gnaphalodes* and their respective extracted fibers.

In this study, natural fibers were extracted from *Pulicaria* species for the first time. The raw fiber yields obtained were 28.1% for *P. undulata* and 18.1% for *P. gnaphalodes*. Previous studies have shown that raw fibers can be used in various applications, including biomedicine, due to their high moisture absorption, low durability, poor thermal stability, and strength. Therefore, various physical, chemical, and biological treatments are applied to crude fibers to improve their structural and surface properties. However, the effect of these treatments on fiber quality, more precisely on their intrinsic bio-functional properties, is not yet clearly known. Therefore, the effect of commonly used treatments, specifically alkali treatment, on the physiological and bio-functional properties of *Pulicaria* fibers was also investigated.

The results of the physicochemical analysis revealed that raw *Pulicaria* fibers are lignocellulosic in nature (Materials that are primarily composed of lignin, cellulose, and hemicellulose). However, alkali treatment removed a significant portion of the hemicellulose, lignin, and bioactive extractives from the raw fiber. This treatment increased the fibers' crystallinity and hydrophobicity but also led to a decrease in their

bio-functional properties. A comparative scanning electron microscope image of the raw and alkali-treated *P. undulata* fibers is shown in Figure 2.

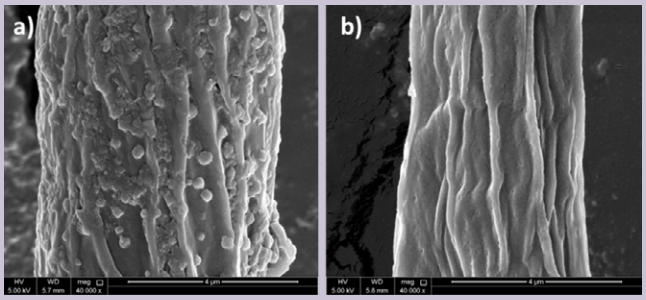

Figure 2: a) Representative scanning electron microscope image of the raw and b) alkali-treated *P. undulata* fibers, showing the loss of hemicellulose, lignin, and bioactive extractives from the raw fibers after alkali treatment.

The bioactivity evaluation revealed that the raw fibers from both species displayed promising radical scavenging and reducing power properties. Furthermore, *P. undulata* fibers demonstrated remarkable antifungal activity against *Candida albicans*, a major contributor to candidiasis. Together, these findings highlight the potential of these fibers, particularly *P. undulata* as powerful biomaterials for wound healing and other medical and cosmetic applications. Representative results of the antioxidant activity of raw and alkali-treated *P. undulata* fibers using a novel assay approach, including antifungal activity, are shown in Figure 3.

However, in this study, it has also been found that alkali treatment significantly reduces these bio-functional properties, suggesting the need for further research on extracting fiber extractives and incorporating them into other natural fibers. This could facilitate the development of advanced natural fibers for biomedical applications.

In conclusion, this article provides an overview of our published work on the natural fibers of *Pulicaria* species, focusing on their physicochemical and biofunctional properties, including the impact of alkali treatment. The findings highlight the unique characteristics of these fibers, demonstrating their potential for use in various biomedical applications, particularly in wound healing and cosmetics. The promising properties of these fibers, combined with further research, could lead to innovative, sustainable solutions in the healthcare and cosmetic industries.

The work presented in this article is a summary of our research, published in the journals *Carbohydrate Polymer Technologies and Applications* (December 2024, DOI: https://doi.org/10.1016/j.carpta.2024.100542) and *Frontiers in Chemistry* (August 2024, DOI: https://doi.org/10.3389/fchem.2024.1437277). The research was conducted in collaboration with the Center for Advanced Materials (CAM) and the Environmental Science Center (ESC) at Qatar University, under the guidance and support of Dr. Mohammed Alsafran, Director of ARS.

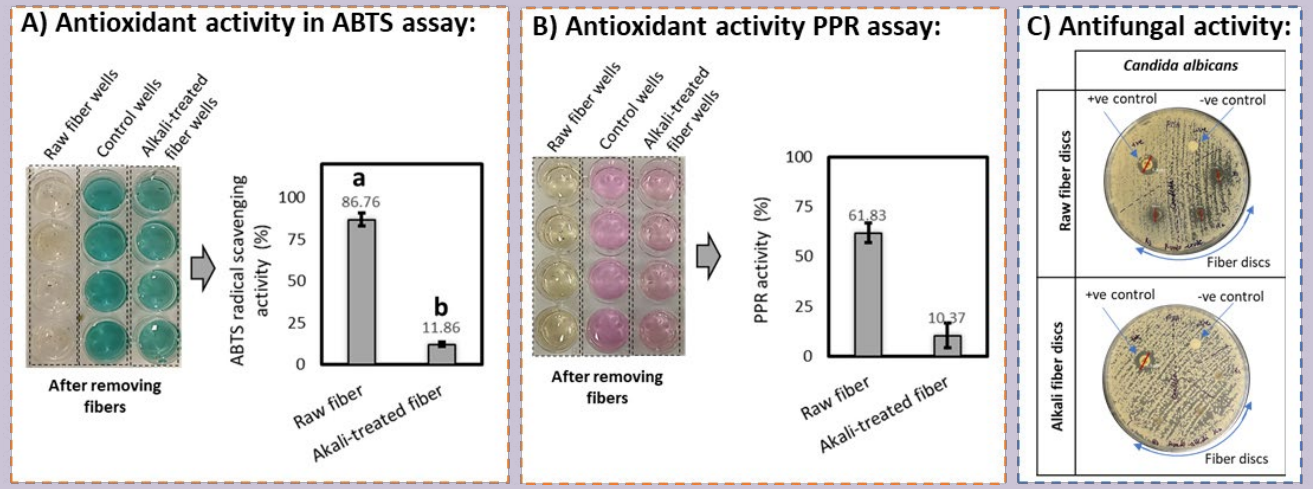

Figure 3: Antioxidant activity of raw and alkali-treated *P. undulata* fibers in A) ABTS and B) PPR assays, along with their C) antifungal activity.