Extraction of Mucilage from Prickly Pear Waste as an Additive in Bio-Mortar

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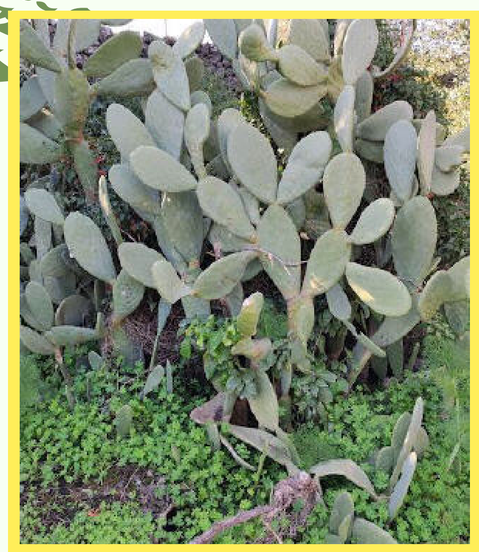
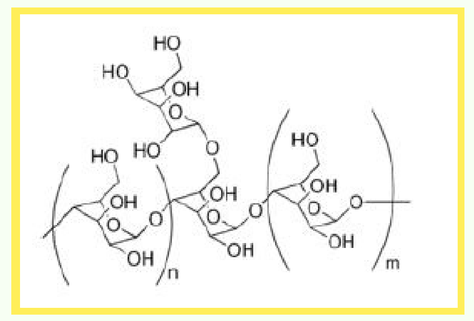


A Abstract:

This research project examines the extraction and utilization of by-products derived from the processing of prickly pear cacti and their fruits, with a specific focus on mucilage. Proteins have been utilized in the past, with evidence suggesting their use in the Middle Ages for adhering materials in mosaic art. Mortars containing proteins, likely egg whites, were employed for this purpose. The use of plant additives in mortars, such as prickly pear mucilage, has also been attested at some pre-Columbian and Mexican archaeological sites. The practice of utilizing mucilage as an additive in mortars is still observed by Mexican restorers to enhance mortar characteristics, including plasticity, setting time, ductility, and durability. The incorporation of mucilage facilitates the retention of moisture over an extended period, thereby promoting a slower setting process and a more uniform carbonation. The addition of mucilage facilitates the increased solubility of calcium hydroxide, thereby enabling the homogeneous and compact crystallization of calcium carbonate. Mucilage has been demonstrated to facilitate the carbonation reaction of calcium hydroxide. Moreover, it is employed as a waterproofing agent and as a fixative for mural paintings, due to its adhesive and cohesive properties.

I Introduction:

The prickly pear (Opuntia ficus-indica) is a cactus-like plant belonging to the Cactaceae family, which also includes other succulent plants. It is native to Central America but has become naturalized throughout the Mediterranean basin, especially in Italy, due to its extraordinary ease of propagation. In recent times, with the advent of the bioeconomy, the prickly pear has emerged as a compelling case study in the principles of a circular economy. The fruits are esteemed for their fiber, sugar, and pectin content, in addition to the presence of minor constituents such as proteins, vitamins, and minerals. The pulp contains a notable quantity of ascorbic acid and vitamin E. Additionally, the antioxidant profile is characterized by the presence of flavonoids and betalains. The interest in the extraction and use of this bio-product arises from the fact that prickly pear cladodes represent pruning waste. For example, in Italy, during pruning for the production of later fruits, approximately 6-10 tons per hectare of material must be disposed of by the farmer, as a result of the pruning process. Mucilage is obtained through the extraction and purification of the cladodes, or prickly pear pads, and is employed in a variety of fields, including pharmacy, medicine, the food industry, and the cosmetic industry, for a range of purposes, including the emulsification of oily substances, the suspension of insoluble powders, and the agglomeration of powders. Plant preparations containing mucilage are employed for their protective effects on mucous membranes and skin. Additionally, they possess laxative, hypoglycemic, and hypolipidemic properties.



M Materials, Methods, and Experiments:

Materials

- Prickly pear cladodes, Calcium Carbonate, Calcium Oxide, Activated Carbons
- Blender, Extractor, Filters

Methods

The process of extracting the mucilage is as follows:
The maceration method of extraction involves soaking the parenchyma of cladodes, which have been cut into small pieces, in water for 72 hours at room temperature. The ratio of water to cladode is typically 1:1 (kg/L or g/ml). The maceration process is based on the principle of passive diffusion. When plant matrix fragments are immersed in distilled water, the mucilaginous cells, being in a hypotonic solution, swell by absorbing water until they burst and release their contents. Subsequently, the plant matrix is separated from the water employing a coarse mesh filter, thus allowing it to drain for the requisite time to collect the mucilage.

Experiments:

Method 1:

An amount of 200 grams of fresh parenchyma was soaked in distilled water for 72 hours in the dark at approximately 25 degrees Celsius, using the following water volumes: 200 milliliters for the 1:1 ratio, 600 milliliters for the 1:3 ratio, 1,000 milliliters for the 1:5 ratio, 1,400 milliliters for the 1:7 ratio, and 1,800 milliliters for the 1:9 ratio. The results indicated that higher dilution ratios, with the same soaking time, yielded superior outcomes compared to the 1:1 solution. From a sustainability standpoint, the maceration extraction method presents significant challenges for industrial applications, primarily due to its prolonged processing time and the considerable volumes of water required.

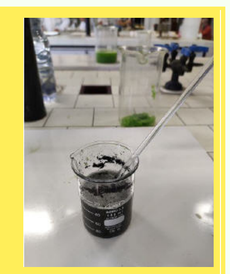
Method 2:

An alternative extraction method is cold extraction. The cladodes, which have been cut into small cubes, are placed in an extractor that separates the liquid from the fibrous portion. One disadvantage of mechanical extraction is the presence of chlorophyll, which imparts a green color and may affect the suitability of the material for certain applications, such as use as an additive in restoration. The fiber is separated from the mucilage by filtration. To decolorize the green-colored filtrate, activated carbon was employed, yielding satisfactory results.

An aerial mortar was prepared with marble powder and lime in a 1:1 ratio, with the addition of prickly pear mucilage as a further ingredient. For mortar application, mucilage obtained through maceration in water was utilized, as it contains only water-soluble components and is free from chlorophyll. However, approximately fifteen days later, the formation of mold was observed on the surface of the sample. It was therefore proposed that a biocide be added to the mixture. A review of the literature revealed the potential use of capsaicin derived from chili peppers as an antimicrobial agent to deter biological contamination.

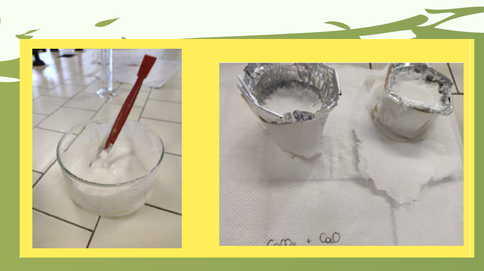
R Results and Discussion:

A study on the prickly pear supply chain, which has the potential to provide bioproducts with a high "natural" connotation, would be incomplete without an assessment of possible critical issues.
In particular, the aspects considered include the formation of mold and the control of bio-receptivity in a manner that does not risk the promotion of the biological attack of biodeteriogenic species. It would be beneficial to extend the study to evaluate the longevity and efficacy of mucilage for stone materials in the presence of natural biocides, such as capsaicin. Furthermore, it would be beneficial to ascertain the chemical and physical properties of the extract and confirm its stability.



C Conclusions:

The prickly pear cactus has the potential to become a significant economic sector in Italian agriculture, and it could even become the leading sector in Europe. The diversification of its use from human consumption to animal feed, from dietary supplements to pharmaceutical and cosmetic products, as well as the utilization of mucilage in environmental chemistry as an additive for restoration mortars and as an agent capable of forming complexes to sequester heavy metals in polluted waters, could provide a source of income for farmers.
The utilization of mucilage in a range of sectors, including nutraceuticals and cosmetics, contributes to the field of sustainability through the development of natural products for restoration. The potential for employing natural extracts derived from cladodes offers the advantage of reducing the reliance on synthetic substances, which can sometimes be toxic.



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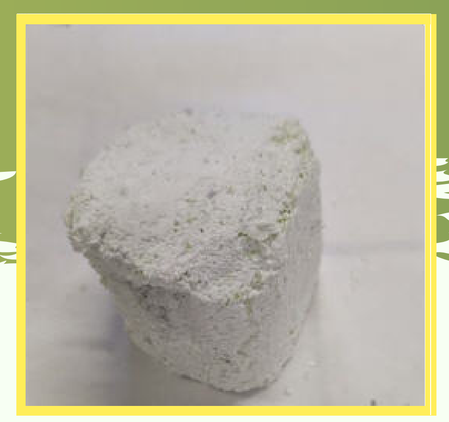

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