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## SUSTAINABLE FOOD PACKAGING: A STUDY OF COMPOSITION, FUNCTIONAL PROPERTIES AND ENVIRONMENTAL IMPACT

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### **Introduction**

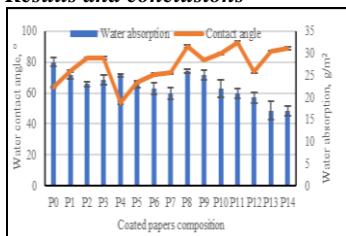
Cellulose-based packaging is recognized as the most eco-friendly option available, offering inherent advantages over existing packaging materials. Generally, food packaging paper is surface coated to enhance its barrier properties against water, oxygen, moisture, grease, or oils. However, these coatings often result in low recyclability and biodegradability, especially when derived from non-renewable resources. This paper analyzes the biodegradability and recyclability of food packaging papers coated with biopolymer hemicelluloses in various formulations. These innovative coatings offer sustainable alternatives to petroleum-based options and could enhance the overall sustainability of food packaging.

### **Materials and methods**

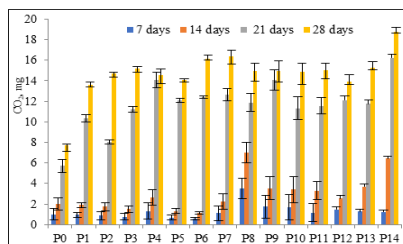
The paper coated with aqueous dispersions based on native xylan, xylan derivatives, chitosan, nanocrystalline cellulose, and ZnO nanoparticles, in different ratio (P1-P14), were applied in single and double layer on paper surface (about 4,5 – 5 g/m<sup>2</sup> on both sides of paper) using an automatic film applicator. After drying (10 min in air at 23°C and 10 min at 60°C in oven), the coated papers were kept in conditioned atmosphere at 23°C and 50% RH, and then were tested regarding the functional properties, specific for food packaging papers. To evaluate the environmental impact, the biodegradability and recyclability capacity of coated samples was analysed. The functional characteristics as barrier to water (water contact angle, water absorptiveness), water vapours and gases (water vapours transmission rate – WVTR, air permeability), oil and greases (oil absorption and KIT rate) as well as resistance against fungus and bacteria were performed using standardised methods and foods contact regulations. The samples of coated papers were subjected to recycling tests and soil biodegradation according to ASTM D5988 (2012) method. The biodegradation rate was assessed by measuring weight losses of the paper samples at four different time intervals: 7, 14, 28, and 42 days. CO<sub>2</sub> production was also monitored as an indicator of microbial activity and the degradation process over the same time intervals. Recyclability tests were performed by repulping of coated

samples after their utilisation as food packaging at 2% consistency (similar with industrial papermaking process) and evaluation of repulping process comparing with uncoated papers (as duration, number of revolutions and dehydration capacity). After repulping, the paper sheets formed on Buchner funnel were evaluated by optical microscopy.

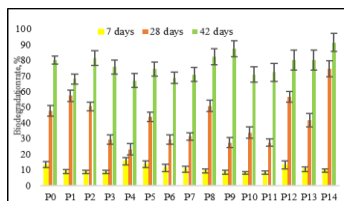
### Results and conclusions



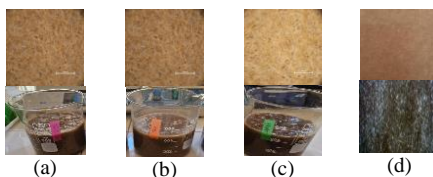
**Figure 1.** Biodegradation rate of hemicellulose coated papers



**Figure 2.** CO<sub>2</sub> production from the biodegradation of hemicellulose coated papers



**Figure 3.** Water barrier properties of hemicellulose coated papers



**Figure 4.** Recycled pulp from: (a) radish packaging paper; (b) butter packaging paper; (c) knorr stock cubes packaging paper; (d) uncoated paper

The coated papers utilizing xylan hemicellulose, chitosan, nanocrystalline cellulose, and ZnO nanoparticles provide excellent barrier properties suitable for food packaging (Figure 1), while also being environmentally friendly. Their high biodegradation rate in soil (70-80% within 28 to 42 days) and minimal CO<sub>2</sub> production (14 – 16 mg CO<sub>2</sub>) during degradation, indicates that the materials break down effectively under natural conditions, minimizing environmental impact (Figures 2 and 3). After their use as food packaging, these coated papers can be easily recycled under conditions similar to uncoated papers that make them a sustainable choice for packaging applications (Figure 4). This combination of functional performance and environmental benefits addresses the growing demand for eco-friendly packaging solutions.

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