RESEARCH ON OBTAINING NUTRITIONAL SUBSTRATES FROM PROTEIN BIOCOMPOSITES

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Organic biocomposites are a source of raw materials for agriculture, as their composition provides enough elements to improve physical-chemical properties of degraded soils and plant growth. Using biocomposites obtained from compounding collagen hydrolysates from pelt waste with various biodegradable polymers stimulates enzymatic substances in the plant, favours development of the root system and increases germination capacity of seeds, favouring rootlet development. The paper presents the development of nutritional substrates with protein biocomposites from pelt waste by means of an experimental facility of manufacturing biodegradable nutritional substrates. The advantages of using these nutritional substrates derive from the fact that, in comparison with currently used plastic substrates, they are biodegradable.

Keywords: leather waste, biocomposites, nutritional substrate.

INTRODUCTION

The application of innovative biotechnologies to valorize pelt waste from tanneries leads to the development of biodegradable nutritional substrate.

As Figure 1 shows, processing 1000 Kg raw hide (raw material) results in 750 Kg leather waste of which 592 kg is pelt waste, which can be further processed into fertilizers for agriculture (Zainescu *et al.*, 2014).

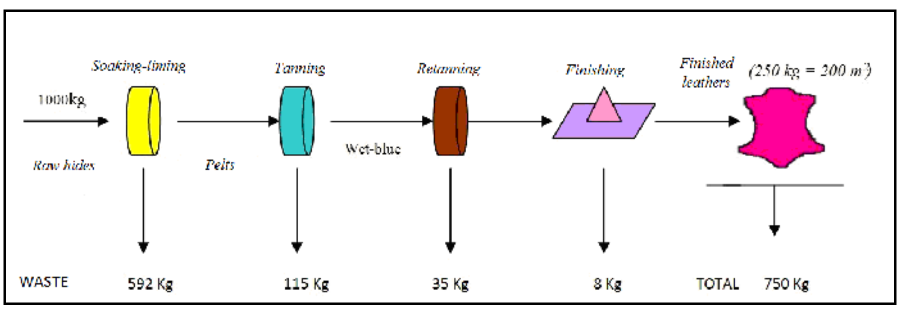

Figure 1. Balance of materials from processing 1000 kg raw hides

The composition of biocomposites obtained from collagen hydrolysate comprises macroeluents - nitrogen, phosphorus, potassium and a wide range of microelements essential for plant metabolism. Therefore, they are chelate complexes containing Fe, Cu, Zn, Mo, B, Mg, Mn, S, as well as organic protein substances made up of proteins and protein hydrolysates (Pillai and Archana, 2012; Bajza and Vrucek, 2001). Biocomposites can be diversified depending on vegetation phases of plants and on the type of crops, being able to correct nutritional deficiencies and scarcity of nutrient compounds of the soil (due to the technological factor or climatic stress) (Thanikaivelan *et al.*, 2004; Zainescu *et al.*, 2013).

The advantages of using these nutritional substrates derive from the fact that, in comparison with currently used plastic substrates, they are biodegradable and contain fertilizers with long-term action.

Biodegradable nutritional substrates belong to a new generation of transplant substrates and are designed so as to perform two distinct functions: substrate for the seedling for a variable time period depending on the plant; and active biological material, which provides biostimulating effects by gradual degradation in the soil (Zainescu *et al.*, 2011).

EXPERIMENTAL

In this study pelt waste from fleshing and trimming bovine hides (weighing 35 kg) were used, from SC Pielorex Jilava tannery, Ilfov County. Raw hide contains 50-68% proteins, 0.6-9% fat, 15-50% ash and less than 5% water, reported to dry weight.

An innovative process was proposed for the treatment of pelt waste by hydrolysis of protein waste in acid medium, resulting in a protein biopolymer which, combined with other polymers (polyvinyl alcohol, corn starch, polyacrylamide, maleic anhydride, celullose, etc.) will be used in agriculture (for remediation of degraded/eroded soils and plant growth in greenhouse or in the field).

Figure 2. Technological process of obtaining biocomposites from pelt waste

Hydrolysis of raw hides is applied, especially in medicine, to obtain natural collagen which is a natural polymer formed by polymerization of 20 amino acids arranged in specific sequences for the collagen molecule, which has a unique triple helix conformational structure. Thus, in the collagen composition, the glycine amino acid (Gly) is about 33%, and the proline (Pro) and hydroxyproline (Hyp) amino acids are about 22%.

The polypeptides in the collagen hydrolysate form chelate complexes with metal ions, especially Fe, Ca, Mg, Cu, Zn by means of reactive carboxyl, hydroxyl and nitrogen groups such as NH-pyrrolidine and -CO-NH- peptide bond. The lower the average molecular weight of the hydrolysate or the lower the metal ion concentration, the more stable the chelates formed (Gu and Lee, 2009).

To obtain nutritional substrates in the form of pots it was necessary to design and implement an experimental facility for manufacturing biodegradable nutritional substrates.

Thus, an experimental model facility was developed with a high degree of flexibility, the principle of which consists in forming and dewatering biodegradable nutritional substrates on a media die-punch system using a vacuum. We opted for a single post mold and mold shape and size have been determined based on the following criteria: geometry, technology, possibility of mechanization, packaging, transportation, economic efficiency and productivity. The mold facility has the advantage of using high consistency and enables the possibility to obtain finished products with the desired size and shape without requiring other operations and finishing materials. The optimum solution selected in order to develop the mold for nutritional substrates was the cone, which has the advantage of better stability of the substrate and has a high degree of flexibility regarding the operating parameters, allowing different compositional variants for biodegradable nutritional substrates.

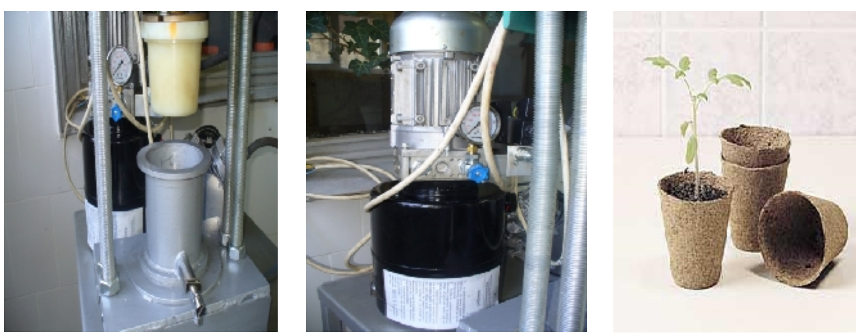

Figure 3. Experimental facility for obtaining nutritional substrates

The experimental facility for obtaining nutritional substrates is composed of the following elements: stainless steel laboratory table which supports the facility, vacuum pump and the tapered single-post (nest) mold (equipped with sieve) in which the material is introduced, the mobile die-punch mounted on a fixed steel support (for centering) is connected to a power press (100 atm).

The advantages of using these nutritional substrates derive from the fact that, compared to currently used plastic substrates, they are biodegradable, as they are made of protein biocomposites from leather waste. Biodegradable nutritional substrates belong to a new generation of culture media and are designed so as to perform two distinct functions:

- substrate for the seedling for a variable time period depending on the plant;
- active biological material, which provides biostimulating effects by gradual degradation in the soil.

RESULTS AND DISCUSSIONS

Research has shown that the hydrolysis of protein waste leads to new products acting as state-of-the-art organo-mineral protein fertilizers, designed to transport nutrients to and into the plant, resulting in metabolism stimulation, speeding the production phase, stimulation of the plant defense system and optimization of mechanisms responsible for the health of the fruit.

The technology for developing biodegradable nutritional substrates is based on key properties that these materials must meet in the process of growth and development of seedlings, namely:

- to form a reservoir of mineral nutrients (biologically active material);
- to completely degrade physically during a life cycle of the plants transplanted into the soil;
- to ensure availability of water transfer to plants;
- to provide support to the plant;
- to allow exchange of gaseous compounds (oxygen, CO_2);
- the products resulting after degradation of the composite structure (protein hydrolyzate, polymers, additives) should not be toxic to the soil;
- to be biodegradable and contribute to soil bioremediation.

The composition of nutritional substrates consists of:

- protein hydrolysate from pelt waste mixed with different soils (clay, peat). The type of soil must ensure a controlled porosity in the substrate structure so that the physicochemical processes of mineralization, upon contact with the soil, would lead to regulating the duration of biodegradability;
- auxiliaries with the role of regulating the biodegradation capacity of the nutritional substrate, controlling tensile strength, establishing an optimal balance of nutrients and providing plant prophylaxis; they are obtained by die-punch molding and dehydration.

Application of the protein biocomposite from pelt waste corrects micronutrient deficiencies, prevents and corrects weak fruiting and leaf malformations. It also significantly increases phosphorus uptake, improves vegetative development and cell wall formation, increasing pollen fertility and plant resistance to low temperatures.

CONCLUSIONS

The established technology provides a cost-effective and environmental solution for protein waste recovery from the leather industry in the form of composite materials that can be used in the development of biodegradable nutritional substrates.

Biodegradable nutritional substrates based on protein biocomposites from leather waste and peat, with addition of protective and stimulating materials constitute a superior form of transportation used in current technologies for producing plant seedlings; therefore these nutritional substrates have the following advantages:

- they allow direct transfer of the plants into the soil without disturbing the roots;
- when using this type of transplant no solid waste is generated as in the case of using plastic or ceramic substrates;
- they are biodegradable, being made of natural compounds;

- they have a good permeability to water and air;
- due to their porous structure, they present an increased capacity of being penetrated by plant roots.

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