PACKAGING SYSTEM FOR BANANAS WITH BIOCHAR-BASED ETHYLENE ADSORBER

Technical Field

The present utility model concerns packaging systems, particularly to a packaging system for bananas incorporating a biochar-based ethylene adsorber to delay ripening during storage and transport.

Background of the Utility Model

Banana is a high value commodity in the Philippines that is being exported in countries and regions such as Japan, Australia, United States of America and Middle East. According to the Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development — Department of Science and Technology (PCAARD-DOST), there are three major varieties of banana grown in the country, Cavendish, Lakatan, and Saba, with Cavendish comprising 50% of the total banana production. When fruits are detached from its tree, metabolic activities still proceed leading to ripening and eventual decay after extended days of storage. Bananas are exported to distant regions by sea that usually takes days to a maximum of 30 days to reach destination. Proper packaging and storage are required to control fruit ripening since importing countries require that bananas arrive at the country in its mature, green, unripe form. Signs of premature ripening could be a basis of rejection at the importation port.

Ethylene (C_2H_4) is a ripening inducing gas to fresh fruits and vegetables. Bananas are highly sensitive to ethylene and exposure to even just minimal concentration could lead to premature ripening and deterioration. Traditionally, ethylene gas is removed by use of ethylene absorbers in sachet form and inserted into packages. These ethylene absorbers are mainly composed of potassium permanganate ($KMnO_4$). Potassium permanganate is a strong oxidizing chemical that breaks down ethylene to carbon dioxide (CO_2) and water (H_2O). It is a hazardous and controlled chemical due to its potential toxicity, special disposal, and sometimes it removes desirable aroma from fruits. It should be packaged properly when used as ethylene absorbers to food to avoid contamination. Alternative materials are needed that have the same function but with less risk of being a safety and environmental hazard.

Biochar is a solid substance produced from burning biomass in an oxygen-deprived environment. It can be classified into three: carbonized biomass, activated carbon, and carbon quantum dots. It is typically used in agricultural applications such as energy storage, sequestration and soil remediation, or as a sorbent for water, wastewater, or fluent gas treatment. The adsorption capacity of biochar is due to its structure geometry and pore size distribution, surface charge, organic content of biochar, ash content and other dissociable functional groups. As ethylene adsorber, the chemical ethylene is physically adhered to the surface and is deposited in the pores of biochar via weak intermolecular forces.

PL246403B1 discloses a sachet-shaped ethylene absorber with a torrefied biomass bed, characterized in that it contains a biocarbon insert obtained in the anaerobic pyrolysis of wheat straw, the process comprising preparing a lignocellulosic raw material for torrefaction, torrefaction of the raw material, and placing the torrefied raw material in a sachet.

CN120209437A discloses a porous in-situ microfiber active preservative film and a preparation method thereof comprising the following steps: loading an ethylene elimination agent and/or an antibacterial agent as active substances on a porous framework material to obtain an active substance-porous framework material; the preparation method comprises the following steps: preparing an active substance-porous framework material, blending the active substance-porous framework material and a polymer as a fiber phase, mixing the fiber phase and a matrix phase, carrying out micro-nano lamination co-extrusion to form a composite material, and etching the matrix phase in the composite material with a good solvent to obtain the porous in-situ microfiber active preservative film.

Summary of the Utility Model

The present utility model provides a packaging system for bananas incorporating a biochar-based ethylene adsorber to delay fruit ripening during storage and transport. The system comprises a banana product, a primary polypropylene packaging, and an ethylene adsorber containing a biochar material selected from carbonized rice hull or activated carbon. The ethylene adsorber is enclosed in a perforated polypropylene sachet with specified thickness, perforation size, and perforation count to allow ethylene diffusion and adsorption. The carbonized rice hull and activated carbon possess defined bulk densities, moisture contents, and particle sizes to optimize ethylene adsorption capacity. When the sachet is placed inside the primary packaging with the bananas, ethylene gas generated during storage is adsorbed, reducing its concentration in the package headspace. This slows peel yellowing, maintains fruit firmness, and extends storage life without the need for chemical ethylene scavengers.

Brief Description of the Drawings

The accompanying drawings, which are included to provide a further understanding of the present utility model, are incorporated herein to illustrate embodiments of the present utility model. Along with the description, they also explain the principle of the present utility model and are not intended to be limiting.

FIG. 1 shows internal ethylene concentration of packed bananas.

Detailed Description of the Utility Model

Alternative ethylene adsorbers were prepared from biochar materials namely, carbonized rice hull and activated carbon individually packed in polypropylene sachets. These materials were used as inserts in a packaged banana to delay ripening during storage.

Rice hull was carbonized using a commercial carbonizer. In detail, rice hulls were placed on top of the steel layering component of the carbonizer, with an open flame underneath. As the metal surface is heated, the rice hulls set aflame. Rice hulls were occasionally mixed and scattered until completely charred. The carbonized rice hulls (CRH) were deposited into a metal container, sealed to prevent further aeration, and left to cool for 24 hours. After cooling, 50g of carbonized rice hull was transferred to a 130mm x 75mm perforated polypropylene (25-micron thickness; 1mm average perforation diameter) and sealed to make a sachet. The sachet has average total perforations of 1,064.

In an embodiment, the carbonized rice hull has a bulk density in the range of 0.15 to 0.19 g/ml, a moisture content of about 3.3 to 3.8%, and a mesh size of about 149 microns.

Activated carbon was purchased from a commercial activated carbon producer. Fifty grams (50g) activated carbon was placed to a 130 mm x 75 mm perforated polypropylene (25-micron thickness; 1 mm average perforation diameter) and sealed to make a sachet. The sachet has average total perforation of 1,064.

In an embodiment, the activated carbon has a bulk density in the range of 0.60 to 0.66 g/ml, a moisture content of 5.9 to 6.3% and a mesh size of about 12 microns.

Green, unripe cavendish banana were washed with potable water, sanitized with 10 ppm sodium hypochlorite for 5 minutes, and air-dried for one hour at 30±2°C. Each bunch or 'piling' of bananas (approximately 1 kg) was individually packed in a 20-micron thickness 380mm x 260mm polypropylene bag. The prepared biochar sachets (carbonized rice hull and activated carbon) were separately placed inside the package before sealing. Packed banana without biochar sachet and with $KMnO_4$ ethylene adsorber were prepared for comparison. This is to determine the effect of the presence of biochar on banana ripening.

Banana samples were stored at 13°C chamber for 27 days. Monitoring of internal ethylene concentration and banana peel color was conducted every 3 days. Figure 1 presents the measured ethylene concentration of individual banana packages with different biochar sachets. Control samples or banana without inserted sachets recorded the highest level of internal ethylene gas concentration throughout the duration of storage. Conversely, banana samples packed with biochar sachets (including activated carbon and carbonized rice hull) exhibited lower detected gas levels compared to the control, indicating the effectiveness of biochar in ethylene adsorption. $KMnO_4$ ethylene absorbers consistently recorded the lowest ethylene levels.

The effect of the presence of biochar sachets and commercial $KMnO_4$ ethylene absorber in packed banana is analyzed. Peel color change from green to yellow was already evident on banana without biochar sachets (control) on day 21 whereas banana with biochar sachets and $KMnO_4$ remained green. This could be explained by the adsorption of ethylene to biochar particles preventing accumulation into the headspace of the package and furthermore delaying fruit ripening. Additionally, there were no observed contamination of biochar materials to the banana.