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The potential of chitosan as alternative biopesticide for postharvest plants

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Abstract

There are some troubles in postharvest plants. It is especially caused by fungi or microorganism that grows in that plant. The problem that appears caused by fungi and microorganism is the decrease of quality and quantity of harvest plant which is produced. One of the solutions of this problem now is by using pesticide. But it has negative effect that can make the plant hazardous and if human consume it, it will affect the health of humans. Chitosan is one of the alternative solutions to solve this problem. Chitosan is component from chitinase that is produced by chitinolytic microorganisms. Chitinase is used to decompose chitin of shell Arthropode or Crustaceae. Chitosan can inhibit the growth of postharvest fungi. It has direct effect like can inhibit the growth of fungi through inhibit the germination of spore, change the morphology of the microorganism, induce enzyme that can use for defense. Chitosan can be spread to the postharvest fruit, vegetables, etc. and it is coated all the outer. They can survive till 14 days after the storage. The objective of this paper is to know the potential of chitosan as alternative biopesticide that save for humans.

Keywords : Chitosan, Biopesticide, Postharvest Plants.

Introduction

The term disease applied to a plant expresses abnormal state of the whole or a part of the plant due to the influence of the environment. Parasitic diseases, in contrast to physiological diseases which are caused by physical factors, are caused by the aggression of an organism which is both parasite as well as pathogen. The tropical environment, when its hot and humid seasons, which may be more or less prolonged depending on the regions, is favourable for the development of parasites, especially fungi and bacteria. These organisms go into the resting stage in various resistant forms (chlamydospores, oospores, cysts, etc.) during dry periods. When the conditions become favourable again, the parasite resumes its activity and sporulates profusely (Renard, 2001).

Food safety has been crucial issue, thus impact for human life become importance to be concerned. Many efforts have been done to improve food safety, especially for fruits and vegetables. Those agricultural products should be maintained for the safety before being consumed by the peoples. The growth of microbial which is caused by fungi on storage can be decrease the quality and food safety of fruits and vegetables itself.

The interaction between the needs of agriculture, environmental protection and concerns for human health is complex. Human health implications cannot be simply regarded as negative and restricted to the potential risks associated with the presence of pesticide residues in foods (Wilson, 2003).

Pesticides, in addition to controlling pests, damage a wide variety of beneficial microorganisms as they persist in the ecosystem (Padhy, 1985). Consequently, marketing of decay-free fruit, especially to long distance markets, can be problematic without postharvest fungicide treatments. Decay fungi are primarily wound pathogens. Thus, postharvest decays mainly develop from injuries that occur before and, most importantly, during or after harvest. Once fungal spores are deposited into these wounds, rapid fruit decay can occur (Adaskaveg et al., 2000)

The BioPesticides Manual (2002) describes chitosan as a 'crustacean-derived plant defence booster'. It is a polysaccharide called 2-Amino-2-deoxy-beta-D-glucosamine. Chitosan is a modified natural carbohydrate polymer derived from chitin, which occurs principally in animals of the phylum Arthropoda. The primary unit in the chitin polymer is 2-deoxy-2-(acetylamino) glucose. The units are combined by 1,4 glycosidic linkages, forming a long chain linear polymer. Removal of most of the acetyl groups of chitin by treatment with strong alkalis yields chitosan (Peniston and Johnson, 1980). This paper would describe about the potency of chitosan as a crustacean-derived which can be used as alternative biopesticide for postharvest plants.

Objectives

This paper has some objectives for:

- Introduce the potency of chitosan as alternative biopesticide for postharvest plants
- Describe how important the role of chitosan to support sustainable organic agriculture.

Materials and Methods

This paper has written using descriptive method. Descriptive method was a method to solve problems that we have faced now days, done by collected data, literary study, and analysis and then made a conclusion for a better recommendation.

Results and Discussion

Postharvest problems

Post-harvest rots from several fungi cause considerable losses, in almost all fruits, vegetables and cut flowers in many countries during storage or transportation (Hide, 1981; Sommer, 1982; Opgenorth, 1983; Ceponis et al, 1987; Sive and Resnizky, 1987; Abdel-Rahim, 1988; Adicaram, 1988; Singh and Prashar, 1989; Snowdon, 1990; Agbor-Egbe and Richard, 1991; Böttcher and Pohle, 1991; Shaul et al, 1992; Niklis, 1994).

Susllow (2000) reported the inherent quality of produce cannot be improved after harvest, only maintained for the expected window of time (shelf life) characteristic of the commodity. Part of what makes for successful postharvest handling is an accurate knowledge of what this window of opportunity is under your specific conditions of production, season, method of handling, and distance to market. Under organic production, growers harvest and market their produce at or near peak ripeness more commonly than in many conventional systems. However, organic production often includes more specialty varieties whose shelf lives and shipping traits are reduced or even inherently poor.

Characteristic of chitosan

Chitosans are polysaccharides produced from chitin, for instance from crab shells, which can be made soluble through alkalic or enzymatic deacetylation. Chitosan is reported to influence the production of substances related to stress response, such as phytoalexins (Walker-Simmons et al. 1983) and chitinases (Dörnenburg and Knoor 1994, O'Herlihy et al. 2003).

Chitosan hydrolysate can be prepared by acid hydrolysis (Hwang et al. 2002) or by enzyme hydrolysis (Kim et. al., 2000; Sashiwa et. al., 1989). The enzymatic method can be used under mild conditions, does not create environmental problems (Mekkriengkra et. al., 2001), and has a minimal effect on the chemical nature of the reaction product, since there are minimal side reactions. There are several reports of the use of different enzymes, such as lipase, lysozyme, chitinase and chitosanase (Aiba et. al., 1994).

The action of chitosan as plant defense booster

Chitosan's antifungal and antimicrobial activities are believed to originate from its polycationic nature (Roller et. al., 2000). Binding with anionic sites in proteins results in selective antimicrobial activities against fungi or bacteria (Jung et. al., 1999). Chitosan contains three types of reactive functional groups, an amino group, a primary hydroxyl group, and a secondary hydroxyl group, at the C-2, C-3, and C-6 positions of the glucosamine residue, respectively (Furusaki et. al., 1996). Chemical modifications of these groups have provided numerous useful materials in different fields of application (Kurita, et al., 1986; Sugimoto et. al., 1998). Ocarboxymethylated (O-CM) chitosan is thought to play an important role in the antimicrobial activity of chitosan because of the substitution of the hydroxyl group in the C-6 position of chitosan with the acetyl group, which enhances the protonation of the amine group

in the C-2 position in the presence of the new carboxyl ion (Liu et. al., 2001). Moreover, since O-CM chitosan can be dissolved in water over a wide pH range (Park et. al., 1986), it has a much broader application as an antimicrobial agent than chitosan does.

Walker paper described, the mode of action of chitosan is to stimulate natural defence response systems in treated plants. Poly-D-glucosamine binds to fungal receptor sites, mimicking an attack by fungal spores. This in turn results in signals being sent to the nuclei of the plant and triggering signals which elicit multiple genetic and biological responses, including the production of phytoalexins (anti-microbial compounds produced in plants), aimed at inhibiting infections (BioPesticides Manual, 2002). It has been suggested that when plants are induced to become resistant, in particular in the absence of pest pressure, there is often a plant fitness cost associated with the response. When plants are induced to become resistant, many physiological, biochemical and ultra-structural changes take place, suggesting possible alterations in the allocation of plant resources (Louws et al., 2001). In particular, plants appear to favour induced host resistance above constitutive processes under low nitrogen levels. It has been proposed that the use of plant activators under crop stress conditions may induce plants to divert energy and plant resources to mount defence responses at the expense of constitutive growth requirements resulting in phytotoxicity (Louws et al., 2001).

Effect of chitosan coating to decrease postharvest diseases

Permeability of coating can be showed by resistance to the gases such as O₂, CO₂ and the respiration level. Permeability of polysaccharides coating increasing with the rising of temperature but reverse with the humidity (Baldwin et al. 1999). El-Ghaouth et al. (1992) explained, rapid of respiration in tomato which coated by chitosan had lower than no coated, it caused by the O₂ diffusion to the internal of tomato obstructed.

Based on Zivanovic researched, coatings of strawberries, blueberries, and grapes with chitosan and chitosan-essential oils resulted in lower fungal counts during 18 days of storage at 4 °C compared with equally inoculated but non-treated berries. All the fruits treated with chitosan-anise essential oil coating showed complete microbial reduction with no mold growth up to 18 days; pure chitosan coating prevented mold growth for 9, 6, and 0 days for grapes, blueberries and strawberries, respectively, while all noncoated berries had high microbial counts from the moment they were inoculated and throughout the experiment. Ethylene analyses showed decrease in ethylene synthesis due to chitosan coatings. Addition of essential oil into the coatings did not have additional effect on ethylene accumulation in blueberries but considerably affected ethylene synthesis in strawberries.

Hewajulige et al. (2006) reported that chitosan at a concentration of 1.0% showed improved fruit firmness after ripening, and improved the keeping quality reaching 70-80% marketability throughout the storage period of 14 days at 13.5°C and 95% relative humidity followed by two days at ambient temperature (28 °C±2).

Cheah et al. (1996) found that 2% or 4% chitosan coating reduced the incidence of *Sclerotinia* rot caused by *Sclerotinia sclerotiorum* from 80% to about 20% and also reduced the extent of the rot on a carrot. Du et. al. (1997) reported that chitosan significantly inhibited the growth of the *B. cinerea* cultured on artificial media. After 3-day culture the diameter of colony of this pathogen in Potato Dextrose Agar containing 0%, 0.05%, and 0.20% chitosan were 77.4 mm, 65.4 mm and 25.6 mm respectively. El Ghaouth et al. (1992) explained that 0.6% chitosan inhibited radial growth of *B. cinerea* and *Rhizopus stolonifer* by 95.5% and 71.5%. El Ghaouth (1991) also reported that chitosan coating reduced water loss of cucumber and bell pepper.

Conclusions

Chitosan as an abundant by product of the crab and shrimp processing industries give beneficial to support sustainable organic agriculture. The role of chitosan not only as the coating in the outer of fruits and vegetables but also as plants defense booster. Because of that reason chitosan has a potential role to be developed as alternative biopesticide for postharvest plants.

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