

SOUTHERN REGION SMALL FRUIT CONSORTIUM RESEARCH PROJECT

Progress report for 2003 grant

EDIBLE CHITOSAN COATINGS AS NOVEL EFFECTIVE BIOPESTICIDE

Svetlana Zivanovic¹, John R. Mount¹, Frances A. Draughon¹, Carl E. Sams²

¹ Department of Food Science and Technology, University of Tennessee, Food Safety and Processing Building, 2605 River Drive, Knoxville, TN 37996; ² Department of Plant Sciences and Landscape Systems, University of Tennessee, Ellington Plant Sciences Building, 2431 Center Drive, Knoxville, TN 37996

OBJECTIVE

The overall goal of our project is to investigate the feasibility of novel, completely natural biodegradable coatings in extending shelf-life of fresh produce. Specific objective of this project was to determine the effect of chitosan and chitosan-essential oil coatings on post-harvest quality of strawberries, blueberries, and grapes.

JUSTIFICATION

In many food products microbial growth is predominant at the surface and, consequently, surface application of various antimicrobials has been intensively studied. However, rapid migration of active component into the interior of the product significantly reduces its concentration, and thus its effectiveness at the targeted area. One of the possible solutions to overcome this problem is incorporation of antimicrobial agents in edible films and coatings. In this way, active ingredients would be trapped in a film matrix ensuring high concentration of preservative only at the targeted surface zone. Focusing antimicrobials only at the area where microbial growth is expected can prolong their effectiveness and reduce total concentration of preservative in the entire product. Furthermore, coatings can be engineered to form semipermeable barriers that can reduce moisture loss and form a modified atmosphere packaging on a single fruit. Application of chitosan and essential oils in the form of edible coatings on fresh berry fruits may be the effective and affordable commercial treatment to extend shelf-life and enhance quality and safety of the produce.

METHODOLOGIES

Strawberries, blueberries, and grapes were used to examine the feasibility of chitosan coatings. The fruits were purchased in local grocery store and treated immediately upon arrival in the laboratory. To evaluate antimicrobial properties of the proposed coatings, each berry was inoculated with *Botrytis cinerea*, dried under aseptic conditions, and dipped in an appropriate solution for 30 seconds. The coating-forming solutions were prepared either with 1 % chitosan or with 1 % chitosan and 4 % anise essential oil. Non-dipped berries served as controls. Berries were dried, packed in polyethylene bags, and stored at 4 °C. Samples were taken in 3-day intervals and mold count was assessed using Rose Bengal agar with antibacterial supplement.

To evaluate whether chitosan coatings, alone or enriched with essential oils, can alter plant metabolism, non-inoculated berries were dipped in chitosan and chitosan-essential oil solutions and

dried in laminar hood. Berries were packed in glass jars and stored at room temperature. Headspace was analyzed for ethylene accumulation using gas chromatography. All microbiological and chemical analyses were performed with three replications.

RESULTS AND CONCLUSIONS

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 non-coated berries had high microbial counts from the moment they were inoculated and throughout the experiment. For example, after 9-day storage, the mold counts were 4.40, 2.90, and 0 cfu/mL for nontreated, chitosan, and chitosan-essential oil coated strawberries, respectively. The mold growth on chitosan-coated strawberries increased after 18 days to 3.87 cfu/mL, but was still lower than in nontreated control (4.33 cfu/mL). Although all the berries were equally inoculated, the outer layer of blueberries and grapes appeared to protect against mold growth more than strawberries since their plate counts were generally lower. Thus, after 15 days of storage, the mold counts were 2.68, 1.49, and 0 cfu/mL for nontreated, chitosan, and chitosan-essential oil coated blueberries, respectively, while the equivalent counts on grapes after 12 days were 3.25, 2.73, and 0 cfu/mL.

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. The synthesis in blueberries decreased from 0.022 $\mu\text{L/kg}\cdot\text{hr}$ in non-coated samples to 0.013 $\mu\text{L/kg}\cdot\text{hr}$ in coated berries regardless on type of the coating. However, in strawberries, the initial value of 0.187 $\mu\text{L/kg}\cdot\text{hr}$ decreased to 0.028 and 0.012 $\mu\text{L/kg}\cdot\text{hr}$ in chitosan and chitosan-anise essential oil treated fruits. Additional research is needed to address these findings and differentiate affects of chitosan and essential oils on ethylene metabolism in strawberries, blueberries, and grapes.

The results of this project showed that natural, biodegradable chitosan-essential oil coatings have excellent potential to be used on fresh produce to maintain quality and extend shelf life. We are planning to continue with optimizing the coating procedure to develop a feasible system that can be used both by producers and food industry. The next phase will include (a) evaluation of coatings formed by spraying (instead dipping into the solution); (b) determination of the minimum concentration of essential oil that can provide inhibition of fungal growth; (c) evaluation of chitosan coatings under commercial packaging conditions.

IMPACT STATEMENT

Results of this project provide important knowledge in the development of novel strategies in extension of shelf-life and enhanced quality of stored fruits. Ready-to-eat products with improved protection from spoilage microflora will enhance the value and competitiveness of U.S. products. Furthermore, these completely natural coatings may be attractive to consumers as well as to growers and processors interested in products with "green" labels.

PUBLICATIONS AND PRESENTATIONS

Sams, T., S. Zivanovic, A. F. Draughon, J. Mount, C. Sams. 2004. Extension of fresh produce shelf-life with novel chitosan coatings. To be presented at IFT meeting in Las Vegas, NE on July 12-16, 2004.