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### **Application of Chitosan as Preservatives on Organic Fruits**

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#### **Abstract**

Chitosan is deacetylated derivatives of chitin, which is one of the naturally most abundant mucopolysaccharides and supporting materials of crustaceans and insects. Generally, the shell of crustaceans is waste product, but research has shown that chitosan, which can be extracted from the shell of crustaceans has many beneficial uses. One of these benefits is that chitosan can form physical and chemical barriers against invading pathogens. Organic foods are often consumed as part of healthy lifestyle. Most of people assume that consuming organic foods, especially fruits and vegetables, can reduce possibility of accumulative effect of unwanted chemical substances in their body. Some fruits are often stored for quite long period before consumption. However, during the storage, fruits can be damaged by microbes and affect the respiration of the fruit itself. Application of synthetic preservatives for the extension of the shelf-life of organic fruits must be avoided as the main purpose for people consuming organic fruits is the gaining nutrition in the fruits without any risk of dangerous chemical additives. Chitosan is a natural biopolymer, therefore it has a low potential to be harmful and environmentally safe. It is also a known as antimicrobial agent. Furthermore; coating fruits with chitosan solutions can reduce respiration rate and ethylene production and internal O<sub>2</sub> increased internal CO<sub>2</sub> concentrations and therefore the fruit are firmer with less decayed. The aim of this paper was to observe the effects of chitosan as a preservative in storage of organic fruits.

**Keywords:** chitosan;preservatives;organic fruits

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## Introduction

Chitosan is a high molecular weight and a linear polymer that is composed of  $\beta$ -1,4-linked glucosamine (GlcN) with various quantities of N-acetylated GlcN residues. It is normally obtained by the alkaline deacetylation of chitin extracted from an abundant source of shellfish exoskeletons or the cell walls of some microorganisms and fungi (Po-Jung, C., Fuu S., Hung-Ren L., 2007). This biodegradable cationic polysaccharide has antimicrobial activity and excellent film forming ability. This makes it particularly suitable for the formulation of edible coatings, which have proved to be effective at extending the shelf-life of fruits and vegetables (<sup>1</sup>Vargas, M., Albors, A., Chiralt, A., González-Martínez, C., 2009).

Several mechanisms were proposed for the antimicrobial activity by chitosan. In one mechanism, the polycationic nature of chitosan interferes with the negatively charged residues of macromolecules at the surface. Chitosan interacts with the membrane of the cell to alter cell permeability. The other mechanism involves the binding of chitosan with DNA to inhibit RNA synthesis (Xiao, F.L., Yun, L.G., Dong, Z.Y., Zhi, L., Kang, D.Y., 2001).

Chitin, chitosan and their derivatives have been used as food wraps, due to their filmforming properties. The chitosan film controls moisture movement between food and surrounding environment, thus decreasing the rate of metabolism, respiration, and rendering high impermeability to certain substances such as fats and oils, in addition to temperature. These would lead to a delay in ripening of fruits (Shahidi *et al.*, 1999)

The coating of fruits with chitosan delays the rate of ripening and the occurrence of decay in tomato, bell pepper and cucumber, and strawberries (El-Ghaouth, A., Rathy, J.A., Boulet, P.M., 1991). The control of disease in fruit by chitosan could account for the antifungal activity of chitosan and its capacity to provoke defense and enzymes and phytoalexins in plant tissue or a combination of both.

Meanwhile, organic foods, including organic fruits, are required in a number of alternative treatments, including several alternative cancer therapies. It is widely assumed that any benefit derived from organic foods is due to an absence of pesticide residues. However, prior to the widespread use of pesticides, those in the health care community who advocated organic foods claimed that these foods contained a better arrangement of nutrients as a result of the superior soil management and fertilization practices used by organic farmers.

In this paper, we discussed about application of chitosan as antimicrobial edible coating on organic fruits.

## Results and Discussion

### Effect of edible coating on respiration rate and deterioration index of organic fruits

According to <sup>2</sup>Vargas, M., Albors, A., Chiralt, A., González-Martínez, C. (2009), at the beginning of the storage, the respiration rate of coated carrot samples was not significantly different from that found for uncoated ones. However, during 1 d storage until 12 d storage, internal CO<sup>2</sup> produced by coated carrots was higher than the uncoated carrots (Simões, A. D. N., Tudela, J.A., Allende, A., Puschmann, R., Gil, M.I., 2009). The lower respiration rate was also showed by Huanghua pears coated by carboxymethylated chitosan (CMC) compared with the uncoated pears (Zhou, R., Mo, Y., Li Y., Zhao Y., Zhang G., Hu, Y., 2008).

These coatings treatments also lowered the deterioration index of organic fruits. The deterioration index of uncoated grape fruits was higher than those treated with chitosan when stored for 16 d at 20°C or 42 d at 0°C, respectively (Meng, X., Li B., Liu J., Tian S., 2006). Chitosan coating treatments were also effective in preventing deterioration of papaya cubes (González-Aguilar, G.A., Valenzuela-Soto, E., Lizardi-Mendoza, J., Goycoolea, F., Martínez-Téllez, M.A., Villegas-Ochoa, M.A., Monroy-García, I.A., Ayala-Zavala, J.F., 2009). A comparison of the decay of both untreated and chitosan-treated fruit indicated that decay in citrus fruit coated with chitosan was significantly reduced (Chien, P.J., Sheu, F., Lin, H.R., 2007). It can be seen that all treatments with chitosan markedly decreased deterioration index of fruits.

The respiration rate and deterioration index is a good index for the quality of organic fruits during storage. Edible coatings lead to high carbon dioxide and low oxygen internal gas concentrations in coated fruits by lowering respiration rates and deterioration index, which contributes to longer shelf-life of fruits (Hagenmaier, R.D., 2005). High levels of carbon dioxide in fruits restrict succinic dehydrogenase activity and induce the accumulation of succinic acid, which finally leads to the inhibition of the Krebs cycle (Deng, Y., Wu, Y., Li, Y.F., 2006). Additionally, low levels of oxygen suppress cytochrome oxidase activity and play a role in the inhibition of the activities of oxidases such as ascorbic acid oxidase, polyphenol oxidase, and glycolic acid oxidase (Özden, Ç. and Bayindirli, L., 2002). Clearly, these coating treatments contribute to the reduction of vital activities, thus maintaining the quality of organic fruits during storage.

#### **Effect of edible coating on sensory quality of organic fruits**

According to Chien, P.J., Sheu, F., Yang, F.H. (2007), both the control and the chitosan-coated sliced mango fruit were still commercially satisfactory after they had been stored for three days. However, after being stored for seven days, the control became unacceptable for the market whereas the good quality of the chitosan-coated sliced fruit was retained. Dong, H., Cheng, L., Tan, J., Zheng, K., Jiang, Y. (2004) also reported that chitosan coating improved the quality and extended the shelf life of peeled litchi fruit.

Whiteness and consequently overall visual quality of carrot sticks were strongly affected by the edible coating. White surface discoloration was significantly controlled by the edible coating and thus, the overall visual quality of coated carrot sticks was higher than that of uncoated carrot (Simões, A. D. N., Tudela, J.A., Allende, A., Puschmann, R., Gil, M.I., 2009). The taste score of coated Huanghua pears were also generally higher than the uncoated pears (Zhou, R., Mo, Y., Li Y., Zhao Y., Zhang G., Hu, Y., 2008). Both the taste and the color scores of red pitaya pulp also declined quickly during storage. After 7 days, the control became unacceptable, while the chitosan-coated fruit retained acceptable quality (Chien, P.J., Sheu, F., Lin, H.R., 2007).

Chitosan coating on organic fruits delayed the decrease in sensory quality and extended the shelf-life. However, some authors have described that the use of edible coatings such as chitosan negatively affected the flavour and aroma of fruit (Devlieghere, F., Vermeulen, A., Debevere, J., 2004). These contradictory results could be due to the use of different formulations including different ingredients and concentrations as well as a high sugar content of the product, which may favour the development of off-flavours.

#### **Effect of edible coating on weight loss of organic fruits**

A chitosan coating retarded the weight loss of sliced mango fruit. After seven days of storage, the weight losses of the control and 2% chitosan-coated sliced mango were 19.86% (highest)

and 10.27% (lowest), respectively (Chien, P.J., Sheu, F., Yang, F.H., 2007). The weight losses of chitosan-coated and uncoated citrus fruit increased continuously. However, the weight loss associated with coating treatments was slower than that of the uncoated citrus fruit (Chien, P.J., Sheu, F., Lin, H.R., 2007). Compared with the control samples, the coated pears also showed a significantly reduced weight loss during storage (Zhou, R., Mo, Y., Li Y., Zhao Y., Zhang G., Hu, Y., 2008).

The treatments also considerably delayed the weight loss of papaya cubes (González-Aguilar, G.A., Valenzuela-Soto, E., Lizardi-Mendoza, J., Goycoolea, F., Martínez-Téllez, M.A., Villegas-Ochoa, M.A., Monroy-García, I.A., Ayala-Zavala, J.F., 2009). These results can be compared with those obtained by El-Ghaouth, A., Rathy, J.A., Boulet, P.M. (1991), where weight loss of bell peppers and cucumbers coated with chitosan was lower compared to uncoated fruits. Meng, X., Li B., Liu J., Tian S. (2006) showed that the rate of weight loss of grape fruit increased with the storage time at 20 °C and postharvest chitosan coating treatment significantly decreased weight loss.

Weight loss is caused by respiratory weight loss and evaporation of water from the fruit (Amarante, C., Banks, N.H., Ganesh, S., 2001). The main mechanism contributing to weight loss is the evaporation of water activated by a gradient of water vapor pressure at different locations in fruit (Yaman, Ö., Bayındırlı, L., 2002). Water diffuses preferentially through a liquid aqueous phase in the cuticle, where water conductance is considerably higher, rather than through pores (Amarante, C., Banks, N.H., Ganesh, S., 2001). Water loss can cause flesh softening, fruit ripening, and senescence by ethylene production and other metabolic reactions (Bai, J., Baldwin, E.A., Hagenmaier, R.H., 2002). Clearly, relatively lower weight loss in chitosan-coated organic fruits contributed to maintaining better quality of fruit during cold storage.

### **Effect of edible coating on microbial quality of organic fruits**

Chitosan has been demonstrated to be able to inhibit the growth of some fungi (El Ghaouth, A., Smilanick, J. L., Wilson, C. L., 2000). The application of chitosan coating delayed the acceleration of the decay of stored Murcott tangor, indicating that the chitosan coating reduced pathogen growth in some way. Furthermore, chitosan coating markedly inhibited the growth of *P. digitatum*, *P. italicum*, *B. lecanidion* and *B. cinerea* in citrus fruit (Chien, P.J., Sheu, F., Lin, H.R., 2007). Also, the results of the microbiological analysis of chitosan-coated and uncoated sliced mango fruits showed that the chitosan coating on the sliced mango effectively inhibited the growth of microorganisms (Chien, P.J., Sheu, F., Yang, F.H., 2007).

Sudharshan, N.R., Hoover, D.G., Knorr, D. (1992) observed the antimicrobial effect of different water-soluble chitosans on different bacteria, finding that the tested chitosans were effective in inactivating Gram positive and Gram negative bacteria for short times. González-Aguilar, G.A., Valenzuela-Soto, E., Lizardi-Mendoza, J., Goycoolea, F., Martínez-Téllez, M.A., Villegas-Ochoa, M.A., Monroy-García, I.A., Ayala-Zavala, J.F. (2009) showed that the chitosan treatments were more effective compared to the control in inhibiting the growth of molds and yeast on fresh-cut papaya stored for 14 days at 5 °C. Romanazzi, G., Gabler, F.M., Smilanick, J.L. (2006) also reported that fungal deterioration of grapes could be inhibited if the grapes were coated with chitosan.

It is believed that the chitosan joins the electronegatively charged sites of bacterial surfaces, causing agglutination (Shahidi, F., Arachchi, J.K.V., Jeon, Y.J., 1999). This was also proposed by Helander, I.M., Nurmiäho-Lassila, E.L., Ahvenainen, R., Rhoades, J., Roller, S. (2001) with chemical analysis and electrophoresis of supernatant free from chitosan-treated cells were the interactions between chitosan, *Escherichia coli* and *Salmonella* spp. show the non-liberation of lipopolysaccharide in other lipids from the membrane. Electron microscopy showed that chitosan caused exterior alterations in cellular surface and covered the outermost surface with

vesicular structures. Chitosan seems to join the outermost membrane, explaining the loss of barrier function of this organelle (Helander, I.M., Nurmiäho-Lassila, E.L., Ahvenainen, R., Rhoades, J., Roller, S., 2001). Therefore, chitosan coatings can effectively inhibit the microbial growth on organic fruits.

### Conclusion

Due to their filmogenicity, chitosan are satisfactorily used as fruit coating film. The coating of organic fruits with chitosan modify the internal atmosphere, decrease transpiration, and delay ripening of fruits. Besides that chitosan also have antimicrobial activity that inhibit the growth of moulds and yeasts.

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