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Review Article

Novel postharvest technologies for prolonging fruit shelf life in Japan

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ABSTRACT

In order to prolong the shelf life of highly perishable fruits and vegetables, new technologies should be introduced during storage and transportation. Temperature control is surely important for keeping freshness and quality higher. In addition, both humidity and microbial controls are also playing important role for avoiding the wilting, discoloration, microbial growth, etc. The nano-sized mist is generated by Lenard effect with high speed impact of water droplet to metal mesh. The peak diameter of mist is approximately 80 nm, which is roughly several times smaller than that of the normal mist for humidity control of fresh produces generated by ultrasonication. The nano-sized mist has the advantage for preventing over-wetting which results in the collapse of cardboard even with high relative humidity environment, whereas no considerable effects on the physiological responses of fresh produces were found.Infrared/Ultaviolet treatment was applied to the decontamination process of microbes infecting the surface of fresh produces. A 1-1.5 logs reduction of surface microbe of fruits was obtained by infrared or ultraviolet treatment individually. In addition, another 1-2 logs reduction were enhanced by their combination without negative effects on surface color, hardness, and respiration.

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Introduction

Recently, Japanese fruits and vegetables are evaluated as commodities with high safety and good quality, and the amount of fresh produce exporting to all over the world is getting increaseingly larger year after year. According to the statistical data in 2012, about 2.7 billion USD of agricultural commodities were exported.

In Fukuoka prefecture, Kyushu Island, the home town of Kyushu University is famous for the production of delicious fruits, such as strawberry 'Amaou', persimmon 'Fuyu', fig 'Toyomitsu-hime', etc., and prefectural government is supporting the exporting business of such fresh fruits. However, such Japanese fruits is highly perishable because their surface skin is really soft and easily wounded and injured during the treatment. Moreover, such unwanted injury often induces serious microbial growth and quality loss during transportation from Fukuoka. In consequence, the shelf life of these products become shorter than the expected period of time. Further technical improvement is urgently required for extending the shelf-life of highly perishable produce while ensuring the microbial safety.

In general, most of humidity-control mist for fresh produces is generated by ultrasonic treatment with around 10 µm of droplet diameter. Such large size mist is fine for preventing the water loss of fresh produces. However, over-wetting of produce surface, inner wall of storage container, and cardboard box are oftern induced the softing, microbial growth, and then the load collapsing resulted in the strength reduction. On the other hand, the nano-sized mist with 80 nm of peak diameter has effect of water-loss prevention without overwetting, and it is expected for prolonging the shelf life of fresh produces.

Both Infrared (IR) and Ultraviolet (UV) are electromagnetic wave with the wavelength from 780 nm to 1mm and from 100 to 380 nm, respectively. Especially, 1.5-5 µm of IR (middle-IR) is used for material heating, and C region (200-280 nm) UV is well-known for microbial disinfection.

In this talk, I would like to introduce our study about the trials of the application of nano-mist humidity control and IR/UV treatment for prolonging shelf life of some fresh produces. Actually, these technologies have been installed in some postharvest processing facilities in Fukuoka prefecture, and expected to become popular domestically and internationally.

Prolong of the produce shelf life by nano-sized mist humidification

The schematic diagram of nano-sized generator is shown in Figure1 (Hung *et al*., 2010). Water in chamber is taken up by motor, then, released and crashed into metal mesh screen with high speed. Various size of mists are generated by the high speed impact with screen, and transferred to mist chamber by a fan wind. Larger sized droplets are dropped back to water chamber due to its own weight, however, smaller sized particles are climbed up and released out to the produce storage container. Finally, the internal humidity level is kept at around 94% RH without over wetting of materialsurface. Figure 2 shows the difference of weight losses of various produce under differenthumidifications of nano-sized mist and ultrasonic mist generators at 6°C.

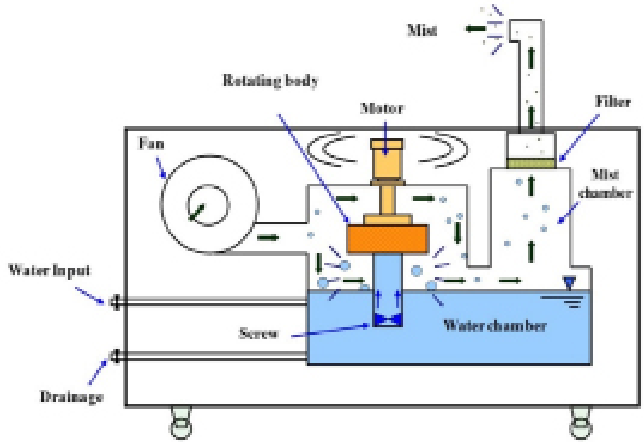

Figure 1 Schematic diagram of nano-sized mist humidifier.

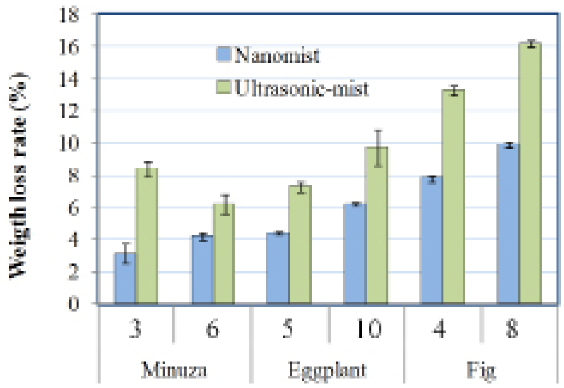

Figure 2 Weight loss of three fresh produces stored at 6°C for several days under nano-sized mist or ultrasonic mist humidity conditions.

Storage periods for Mizuna, Eggplant and Fig fruit were 6, 10 and 8 days, respectively, and weight loss assessments were made at 0, 3, 6 days for Mizuna, 0, 5, 10 days for Eggplant, and 0, 4, 8 days for Fig fruit. Even under same relative humidity at around 95%, nano-sized mist fumidificaiton had significat advantages for prevention of weight loss (Hung *et al*., 2011). These advantage of nano-mist humidification might be resulted from the difference of stomatal opening of produces (Hung *et al*., 2011). The opening level of stoma under nano-mist humidification were smaller than that of unltasonic-mist environment as shown in Figure 3. The lower levels of stomatal opening could cause the prevention of water vapor release from produces under nano-sized mist environment. However, no obvious advantages were obtained by nano-sized mist storage comparing with ultrasonic mist in points of microbiological damage.

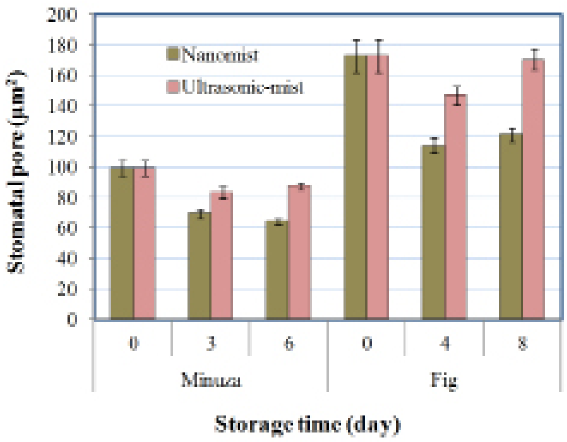

Figure 3 Stomatal opening of Mizuna leaf and Fig fruitstored at 6°C for several days under nano-sized mist or ultrasonic mist humidity conditions.

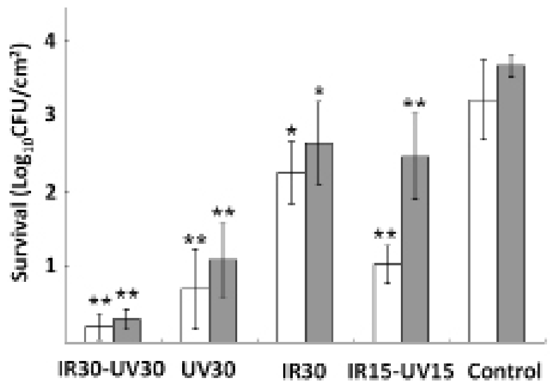

Figure 4 Fungi survival on fig fruit surface following single and sequential treatments of IR heating and UV irradiation. Error bars denote the standard deviation (n=3). Asterisks (*, **) denote the significant differences between control and treated sample by Student's t-test ($P < 0.05$, <0.01). The numbers shown with IR or UV on the horizontal axis are the treatment periods in seconds. □: day zero, ■: 2 days in storage

Decontamination of produce surface by IR heating and UV irradaition

In generally, most of microbes infecting fresh fruits and vegetables are only on the surface unless the plants were infected at their growth stage. Therefore, the applicable technology for the surface decontamination is required to treat the surface layer of produce without denaturation of internal quality. Decontamination process by Infrared radiation (IR) heating is recognized as microbicidal action by thermal treatment. However, the transfer process of thermal energy is heat radiation from source to the target material. Actually, thermal decontamination processes by conductive and convective heating need long time to reach the target temperature since huge thermal energy is dissipated. Such long heating period by conduction and convection could result in the undesirable denaturation of internal quality. On the other hand, IR heating can transfer huge energy directly to material surface without any heating media, and immediately converted to thermal energy. This heating process by IR can increase the temperature of target microbe to lethal level in short time. Therefore, IR heating is expecting to kill microbes on the surface of fresh produces effectively (Hamanaka and Tanaka, 2010).

In our previous investigation, IR heating is effective in the inactivation of *Bacillus* spores (Hamanaka *et al*., 2003), and the effectiveness of spore inactivation was affected by the environmental relative humidity and wavelength radiating from heat source (Hamanaka *et al*., 2005, 2006). In addition, we reported that the combination of UV-C irradiation with IR heating had synergistic effect on the microbial inactivation (Hamanaka *et al*., 2010). Figure 4 shows the survival of microbes on fig fruit surface after IR heating with/without UV irradiation. Approximately 3 logs reduction was obtained by the combining treatment of 30 sec of IR heaitng with 30 sec of UV irradiation. This low contamination level was maintained for more 2 days in storage at 15°C. For the quality and physiological response of fig fruit, no negative effects were obtained by the combining treatments (Hamanaka *et al*., 2010).

Conclusion

For prolonging the shelf life of fresh produces, it is surely suggested that the combination of various technologies is important. Control of surrounding conditions such as temperature and humidity are critically important for keeping freshness and quality high. And, microbial decontamination by physical process are also required for preventing food accidents without any residue of chemical components.In our study, the shelf life extention of some fresh produces has been achieved by nano-mist humidification and IR/UV decontamination with/without combination. In order to obtain further improvement of shelf life extention, adequate combination of other technologies in physically, chemically and biologically considering the property of each fresh produces should be applied to the actually postharvest processing.

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