Effect of Plasma Treatments and Low Temperature to Some Physical and Some Physiology of Fresh Fig Fruit (*Ficus carica* L.) cv. Black Jack

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Abstract—**The aim of this research was to study the effect of plasma treatments and low temperature on some physical and some physiology of fresh fig fruit (*Ficus carica* L.) cv. Black Jack during postharvest cold storage. We investigated the effects of different time plasma treatments including 2, 5, and 10 hours compared with the control (untreated) fruit during storage at 4°C. The results are found that plasma treatments reduced the metabolism of fresh fig including weight loss, respiration, and ethylene production during storage. The decreasing of firmness was reduced by plasma treatment, especially 2 hours plasma treated. Moreover, plasma treatments remarkably inhibited fungal incidents which prolong the storage life of fresh figs under storage at 4°C. However, these treatments did not affect the color change in this fruit. These findings suggest that plasma treatment combined with storage at low temperature has commercial potential and useful to reduce postharvest decay, maintain the quality and prolong the storage life of fresh fig fruit cv. Black Jack. More studies should be accomplished on this technique for other fig cultivars and nutritional properties after treatments.**

Index Terms—**Fig Fruit, Postharvest Quality, Plasma Technology, *Ficus carica***

I. Introduction

The fig (*Ficus carica* L.) Musaceae family is a traditional fruit believed to be originated from western Asia and to have been distributed by humans throughout the Mediterranean. There are four distinct types based on the flowering characteristics of figs including Caprifig, Smyrna, San Pedro, and Common fig. Caprifig is uneatable, only male flowers are observed, use for the pollen for pollination. Smyrna consists of only of female flowers that require the pollen from Caprifig for development. San Petro produces female flowers, bearing two fig crops, one borne on leafless wood without pollination, the other with pollination, borne on new wood. Common fig produces parthenocarpy; do not require pollination to develop and mature fruit. The Common fig is a nutritious fruit, high in fiber, potassium, calcium, iron, and is free of sodium, cholesterol, and fat [1]. Additionally, figs are a source and abundant of vitamins, amino acids, and antioxidants. Fig varieties with dark skin (i.e. Mission, Checchik, Black Jack, Brown Turkey, and Bursa) contains higher levels of polyphenols, anthocyanins, and flavonoids and higher antioxidant activities than lighter skin figs (i.e. Brunswick, Kadota, Sierra, Tina, UCR200-43, and Panachee) [2].

Fresh fig is a kind of perishable fruit with is very short durability period (3-5 days) at room temperature. Fungal decay of figs can result in extensive losses for the farmer.

Fig. 1. Fungal decay incidence of fresh figs during storage and on shelf life.

Recently, the fig is becoming a popular and high potential crop in Thailand. Fig cultivation in the greenhouse is practical, growers could control the environmental factor conditions and other risks from pests and plant diseases, an increase of productivity and in quantity, and commercial opportunity. Black Jack is one of the most popular cultivars grown in Thailand, because easy to grown and high productivity. The fruit of Black Jack is purplish-brown to purplish-black and the pulp is amber with rose tones. The skin is thin and spoilage sensitive. Moreover, it can be cultivated both in a greenhouse and open field conditions depend on preference, cost and type of the growers want to be [3].

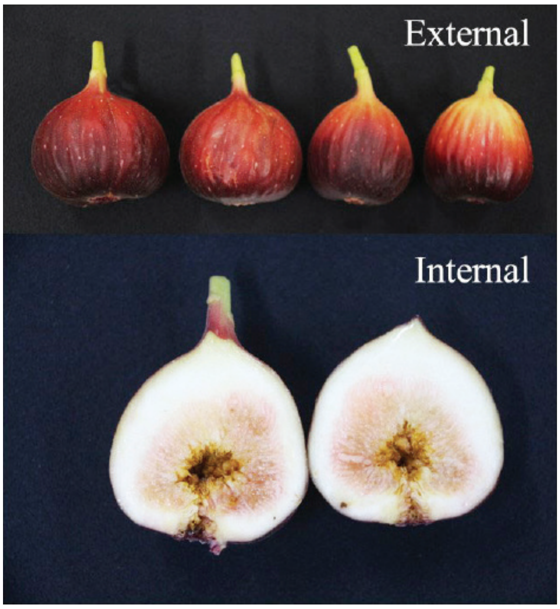

Fig. 2. External and internal of fresh figs cv. Black Jack

Different sizes of viols which are made of propylene (PP) were used for packaging fresh figs. The optimum and reasonable for consumers were 4 fruits capacity (Fig. 3).


Fig.3. Packaging of fresh figs put in the market and modern trade.

Plasma is the fourth state of matter and is an ionized gas, a gas into which sufficient energy is provided to free electrons from atoms or molecules and to allow both species, ions, and electrons, to coexist. Depend on the sources of plasma generated from, high or low temperatures. Plasma was devised into 2 types as thermal and cold plasma, respectively [4]. The cold plasma contains energetic reactive species including, electrons, positive and negative species, ultraviolet (UV), free radicals and exited or non-excited molecules and atoms. On strawberries, decay during postharvest storage is mainly caused by the fungus. Cold plasma has been used on strawberries to prevent decay from microbial during storage [5]. Moreover, it has been reported that plasma treatment successfully inactivated microorganisms in liquid media [6] and on fresh produce [7]. Previous studies found that cold plasma is an efficient technique used for fruit and vegetable surface decontamination [8]. This technique is high potential and suitable for substantial applications, especially for maintained phytochemicals and quality of agricultural produces [9], [10].

Very little research has been showing the effectiveness of storage temperatures lower than 5°C in reducing the metabolic activity affected on the quality maintaining of fresh fig [11]. In present, there are no reported about plasma treatment on postharvest quality of fresh figs and there is very little research in figs postharvest physiology.

The objective of this research was to investigate the effect of plasma treatments on the quality and storage life of fresh figs at cold storage.

II. Materials and Methods

Experiments were performed on (*Ficus carica* L. cv. Black Jack) at commercial-stage purchased from a local farm in Chiang Mai Province. The fruits were harvested and immediately packed in the boxes and transported to the laboratory of Quality Assurance, the King Mongkut's University of Technology Thonburi in Bangkhuntien Campus. Fruits were selected based on uniformity of size, color, and without defects. Selected fruits sample were placed in a sealed plastic chamber at 25°C. Using a plasma generator (PG), the fruits were treated for 2, 5, and 10 hours, respectively. After treatments, all fruits were transferred to an observation room under 4°C. The study was done following a completely randomized design (CRD) experiment using 4 replications.

A. Weight Measurements

After treatment, the fresh weight of the fruits was measured at room temperature (25°C) every 2 days.

B. Color Measurement

The Surface color was evaluated with a colorimeter (Minolta, model CR -300, Osaka, Japan). The L* and hue angle values in five positions of the fruit were measured.

C. Quantification of Ethylene Production and Respiration

Individual fruits were placed in 450-mL plastic boxes sealed with lids fitted with a silicone rubber injection port. The boxes were sealed for 1 hr at 25°C, and l-ml gas samples were collected from the headspace to determine ethylene concentration by gas chromatography with a flame ionization detector (model GC-15 A, Shimadzu, Kyoto, Japan) using an activated alumina column (2.0 m×3.0 mm I.D., Shinwa Chemical Industries Ltd. Kyoto, Japan). The respiration rate was determined by gas chromatography (model GC2014, Shimadzu, Kyoto, Japan) with a thermal conductivity detector using a Porapak Q column (1.0 m×3.0 mm I.D., Shinwa Chemical Industries Ltd. Kyoto, Japan).

D. Firmness

The firmness of the fruit (resistance to compression & penetration) was determined using an automatic penetrometer. The force required to induce 3 mm of deformation at a rate of 0.2 mm/s in five fresh fig fruits was recorded using an Intron texture analyzer (Instron 4302 Universal Testing Machine, Canton, MA, USA) with a 3.5 mm flat diameter cylindrical probe. Data were analyzed using Intron series software IX for Windows. This test measures the firmness of the fruit based on the resistance of the flesh to deformation by the probe [12].

III. Results and Discussion

A. Weight Loss under Cold Room Storage

During storage, weight loss of fresh fig cv. Black Jack gradually increased. The weight of figs pronounced loss in the control fruit, highest throughout the experiment period. Fresh figs treated with plasma at 2, 5, and 10 hours were not different among the treatments (Fig. 4).

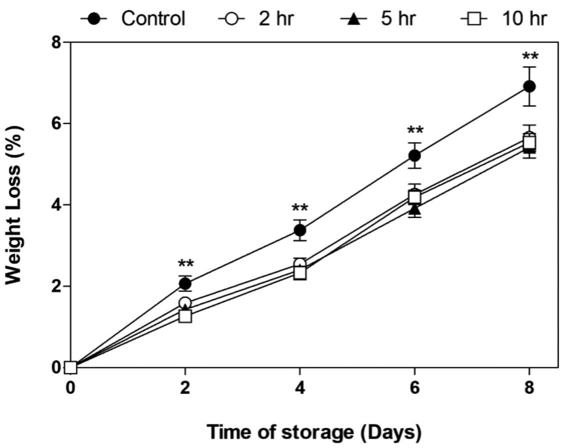

Fig. 4. Weight loss of fresh fig 'Black Jack' after treated with plasma for 2, 5, and 10 hours, respectively.

B. Color

Fruit color is a major quality factor that needs to be discussed after treated with plasma. Consumers are attracting by the black-red of fig cv. Black Jack. A Previous study reported that plasma treatment did not affect color change and the firmness of strawberries and cherry tomatoes contained in the package, significantly [5]. In this research, the lightness parameter (L*) of plasma treatments and control figs were gradually decreased throughout the experiment, and no significant difference among the treatments. The redness value (a*) of treated fresh figs were constantly during storage and not significant differences among the treatments (Fig. 5).

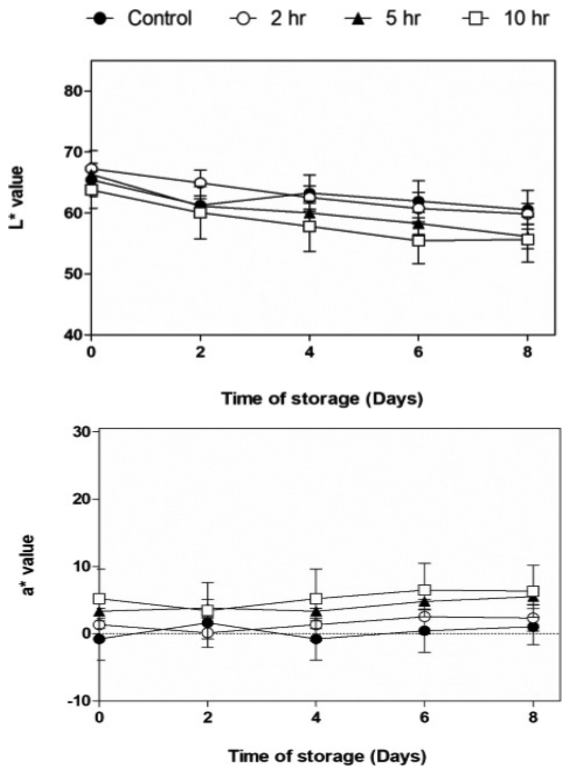

Fig. 5. Lightness (L*) and redness (a) of fresh fig 'Black Jack' after treated with plasma for 2, 5 and 10 hours, respectively.

C. Ethylene Production and Respiration Rat

It is well-known that the deterioration rate of agricultural produces after harvested is generally related to the respiration rate [13]. After treated with plasma, the respiration rate in all treatments was decreased on the first 2 days of storage, lowest (10.86 mg CO_2/ kg×hr) on 5 hours plasma treatment (Fig. 6). Thereafter, the respiration rate was constant in both treated and untreated figs throughout the experimental period.

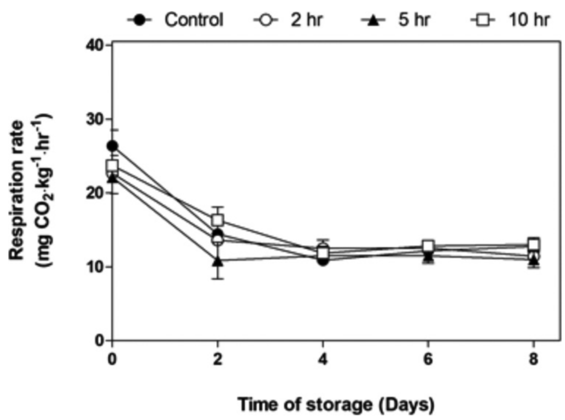

Fig. 6. Respiration rate of fresh fig 'Black Jack' after treated with plasma for 2, 5, and 10 hours, respectively.

In general, the ethylene production rate increases with harvest maturity and with physical injury, disease attack, elevated storage temperatures up to 30°C, and water stress. On the other hand, the ethylene production rate of fresh horticultural crops is reduced by storage at low temperature, reduced oxygen content (less than 8%) and increased carbon dioxide content (more than 2%) around the agricultural produces [10]. Ethylene production of fresh figs after treated with plasma was gradually increased from day 2 to day 6 during storage in plasma treatment for 2, 10 hours and control. Fresh figs treated with plasma for 5 hours were shown constantly ethylene production rate between 0.392 and 0.484 µl C_2H_4/ kg×hr (Fig. 7).

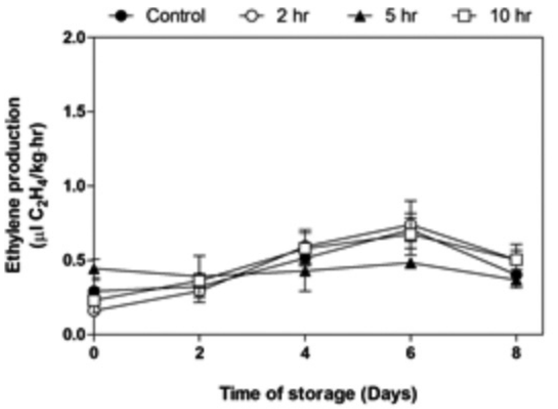

Fig. 7. Ethylene production of fresh fig 'Black Jack' after treated with plasma for 2, 5, and 10 hours, respectively.

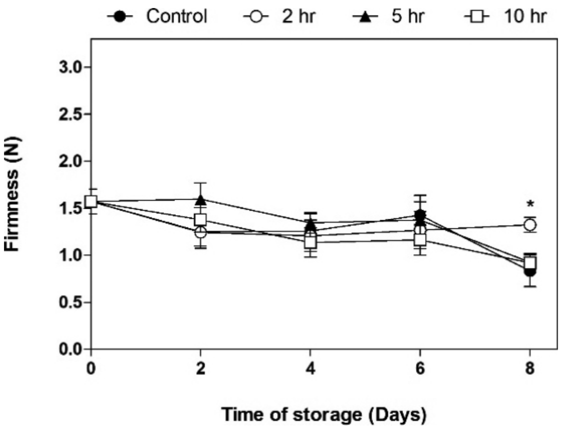

Fig. 8. Firmness change of fresh fig 'Black Jack' after treated with plasma for 2, 5, and 10 hours, respectively.

D. Firmness

The firmness of fresh figs in control and treated with plasma for 2, 5, and 10 hours are shown in Fig. 8. The Firmness of fresh fig slightly decreased from an initial value of about 1.5 N to below 1.0 N on 8 days of storage, indicating that the fruit increasingly softened with storage time.

Common figs, naturally, are soft fruits and very highly susceptible to loss of firmness, especially in the mature stage. In this research, plasma treatment did not influence firmness loss, although, on day 8 of storage, fresh figs treated with plasma for 2 hours had higher than fresh figs in control and other treatments significantly. This is related to with the finding of Misra et al., [5] in strawberries.

Fig. 9. Ostiole-end splitting and fungal damage appearance in control fresh fig (A) compared with Plasma treated fresh fig (B)

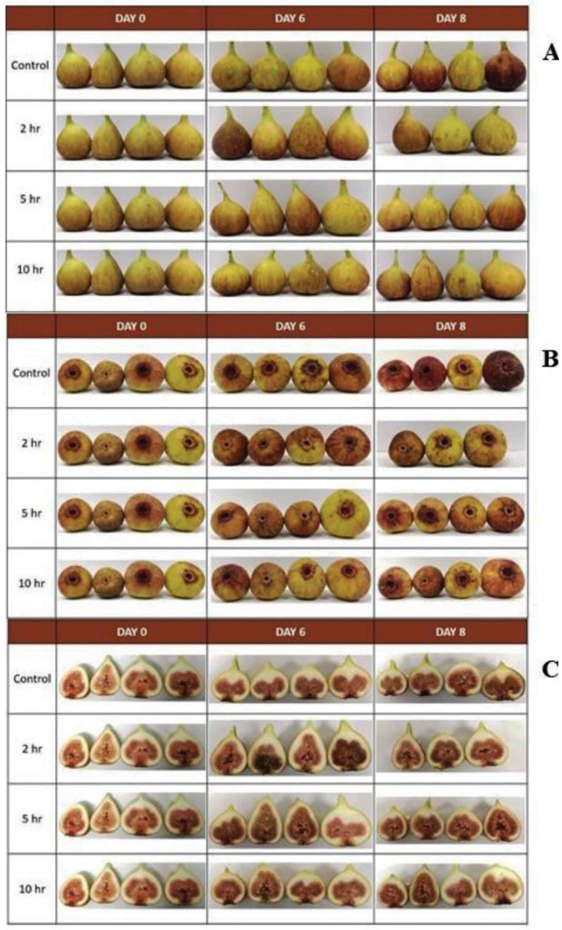

Fig. 10. External (A) ostiole-end (B) and internal (C) appearance of fresh fig cv. Black Jack after treated with plasma and stored at 4 °C

The fungal incident was inhibited by plasma treatment for 5 hours, while in control figs surface show fungal appearance (Fig. 9). It has been reviewed that the major mechanism for inactivation effect of plasma is reactive oxygen species (ROS)-induced oxidative damage [14]. Low temperatures application is one of the most significant factors in maintaining the quality and controlling spoilage of fresh figs [15].

IV. Conclusion

In conclusion, the result suggests that the common fig cv. Black Jack is being considered as proper crops with high commercial value. Plasma treatments remarkably reduced weight loss and prolong the storage life of Black Jack, but had no marked effect on color and fruit firmness. In addition, fungal incidents are absent in fresh figs treated with plasma. However, treatment duration is one of the most important factors affecting the efficiency of plasma treatment. Further studies should be conducted, especially in nutrition and antioxidant activities after treatment.

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