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STUDY ON THE EFFECTS OF LONGAN FRUIT DIPPING IN CHLORINE DIOXIDE ON PERICARP BROWNING AND QUALITY DURING COLD STORAGE

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ABSTRACT: Pericarp browning is the main factor to reduce the storage life and marketability of longan fruit. In the present study evaluated chlorine dioxide (ClO_2) dipping on reducing pericarp browning. Fresh longan fruit was dipped in 1%, 1.25% and 1.5% ClO_2 for 5 min and stored at 5±2 ºC, 85±5% RH for 42 days, investigated every 7 days. Evaluation by browning index (BI) as pericarp browning, outer pericarp color by a chromameter expressed as L*and b* value and hue angle, disease incidence, ClO_2 residue and sensory acceptance was determined. The result showed that dipping in 1%, 1.25% and 1.5% ClO_2 could reduce pericarp browning (lower BI, higher L* and b* value and hue angle). However, they showed no significant differences with commercial SO_2 fumigation but they were significant differences with untreated fruit. ClO_2 treatments could reduce disease incidence and low ClO_2 residue in flesh. The sensory acceptance such as outer pericarp color, flesh and flavor treated with 1.5% ClO_2 had shown great potential. The results suggested that 1.5% ClO_2 dipping could reduce pericarp browning of longan fruit as same as the commercial SO_2 fumigation.

Keywords: Longan fruit, Chlorine dioxide, Pericarp browning, and *Sulfur dioxide*

1. INTRODUCTION

Longan (*Dimocarpus longan* Lour.) is non-climacteric fruit, widely cultivated in many countries especially in China, Vietnam and Thailand. In Thailand cv. Daw is an important economic exported fruit. It was very short postharvest life for 3-4 days under ambient temperatures. The main factors reduce storage life and marketability of longan fruit are pericarp browning, fungal and microbial decay [1], [2]. Sulfur dioxide (SO_2) fumigation is commercially to extend shelf life of fresh longan at least 45 days at low temperature [3]. It is the most popular commercial means for prevention of fruit decay and browning because it was effective and inexpensive [1]. However, SO_2 fumigation leaves SO_2 residues and toxic ingredients that may have adverse effects on human health. Therefore, a replacement of SO_2 or improve process with the safer for consumer are required.

Acidified sodium chlorite (ASC) is a sanitizing agent approved by Food and Drug Administration (FDA) for dip or spray treatment of food items, including fresh and fresh-cut fruits and vegetables, and has shown a strong ability to control pathogen [4]. ASC is mixture of sodium chlorite (SC) and an acid. Sodium chlorite, the major component of ASC, also had strong anti-microbial ability against human pathogenic bacteria. SC was strongly inhibited enzymatic browning on fresh-cut apples. Because of its dual role in browning inhibition and pathogen inactivation, the anti-browning property of SC could be attributed to two modes of action, i.e., direct inactivation of polyphenol oxidase (PPO) activity and oxidative degradation of the phenolic substrates [5] It could be combined with a substance for improving better good quality that hydrochloric acid (HCl) mixed with SC produced chlorine dioxide (ClO_2). It is one of the disinfectants has been used to control microbial contamination. ClO_2 solution offers several advantages for food sanitizing, especially for processing vegetables and fruits. The used of ClO_2 to reduce microorganism have been reported in apple, carrot, lettuce, cabbage, tomato and blueberries [6]-[8]. In addition to the studies of ClO_2 has been used to reduce enzymatic and maintain quality such as fresh-cut lotus roots, flesh-cut asparagus lettuce and litchi fruit [9]-[11]. In longan, the use of gaseous ClO_2 concentration 10 mg/L for 10 min. was effective to reduce pericarp browning during storage at 25 ˚C for 7 days [12]. Although gaseous form has greater penetration ability and leave behind less residue [13] but the aqueous ClO_2 form to reduce pericarp browning in longan had still lack enough data. Therefore the objective of this study was the effects of fruit dipping in various concentration of ClO_2 solution on pericarp browning control and fruit quality of longan fruit during cold storage.

2. MATERIAL AND METHOD

2.1 Plant Material and ClO_2 Treatment

Mature longan fruits (Daw) for export were transported from packing house in Lamphun province, Thailand. They were placed in 11.5 kg commercial perforated plastic basket, 15 baskets (9 baskets for ClO_2 treated, 3 baskets SO_2 fumigated and 3 baskets not treated) were transferred to laboratory 1 day before testing and stored overnight at 5ºC with 80-90% relative humidity (RH). Next day, longan fruits were selected with uniformity shape, color size and without disease or insect infected and divided into 3 treatments for dipping in ClO_2 solution. Before treating each basket were cleaned with tap water, after that each treatment (3 basket/treatment) were dipped in ClO_2 solutions at different concentration of 1%, 1.25% and 1.5% for 5 min which tested in only a fume hood for safer and allowed to air dry for 2 h and then stored at 5ºC with 80-90% (RH) for 42 days. The samples were taken every 7 days for quality evaluation as browning index, pericarp color, disease incidence, sensory evaluation and ClO_2 residue and storage life until day 42.

2.2 Fruit Quality Evaluation

2.2.1 Browning index (BI)

Browning index was assessed visually the total of brown area on fruit surface by following scale: 1= no browning, 2= slight browning, 3= less than 25% browning of the total surface, 4= 25-50% browning and 5= >50% browning. The browning index was calculated by Σ(browning scale × percentage of fruit in each scale). A browning index scale over 3.0 was considered as unacceptable marketability [14].

2.2.2 Pericarp color

Pericarp color was measured by chromameter (Model CR400, Minolta Japan). The results were expressed as L*, b* value and hue angle. L* value indicated lightness of color wheel, ranged from black = 0 to white = 100, b* value = (-) blue to yellow (+) and hue angle was true color. Two spots on opposite sides of the fruit were measured and the mean of the two measurements considered as one reading. The results were expressed as a mean value from three replications of the 5 measured samples.

2.2.3 Flesh discoloration

The following scale was used: 1 = normal (excellent quality); 2 = slight flesh discolored; 3 = less than 25% discolored of the total surface; 4 = 25-50% discolored; and 5 = 50% discolored (poor quality). A flesh discoloration index was calculated using the following formula:
∑ (discolor scale x number of fruit in each class)/Total fruit. Fruits flesh having a discolor score above 3.0 were rated as unacceptable.

2.2.4 Disease incidence (DI)

Disease incidence was visually assessed by counting the fruits that showed lesions of mycelium or rot on the fruit surface.

2.2.5 Sensory evaluation

Sensory evaluation was evaluated during cold storage every 7 days. The in-house trained panel consisting of 10 members assessed the samples. The acceptability of pericarp color, flesh quality, taste and overall quality using a five-point hedonic scale where 5 = like extremely, 3 = neither like nor dislike and 1 = dislike extremely.

2.2.6 Chlorine dioxide residues

ClO_2 residues was evaluated by using DPD method [15].The samples (100 g) of whole fruit (ClO_2 residue on pericarp) and just a flesh (ClO_2 residue on flesh) were rinsed with 100 ml distilled water shaken at 160 rpm for 10 min. Ten milliliters of rinsed water were collected for analyze ClO_2 residues [12]. The ClO_2 residue in fruits was expressed as mg/kg.

2.2.7 Storage life

Storage life was determined from 3 parameters as browning index below 3.0 score, disease incidence (%) below 25% and sensory evaluation above 3.0 [14], [16], [17].
Analysis of variance (ANOVA) and the test of mean comparison according to least significant difference (LSD) were applied with a significance level of 0.05.

3. RESULTS AND DISCUSSION

3.1 Pericarp Browning, Pericarp Color and Flesh discoloration

In preliminary test was studied the effect of different ASC (HCl+$NaClO_2$) concentration on longan pericarp browning and extended shelf life. It was found that fruits were dipped in HCl or $NaClO_2$ alone did not reduced pericarp browning, the used of HCl 9% combined with $NaClO_2$ 7.5% could produced ClO_2 2% (maximum concentration) was the effective treatment to reduce pericarp browning and had storage life for 35 day at 5ºC. In this study was investigated in the effect of difference concentration of ClO_2 (1.0%, 1.25% and 1.5%) on reducing pericarp browning. Pericarp browning was shown as browning index (BI) and pericarp color. Fruits dipping in all ClO_2 concentration at 1.0%, 1.25% and 1.5% for 5 min could prevent pericarp browning for 28 day (BI below 3.0) at 5 ºC (Fig. 1). Whereas untreated fruit, pericarp became browning by 7 days at 5ºC which indicated by BI above 3.0 due to chilling injury occurrence. For flesh discoloration, all treatment was increased with storage time increased but scores showed less than limit of acceptance (less than 3.0) throughout period of time (Fig.2). BI was corresponded with pericarp color as shown in L*, b* value and hue angle, all treatment of ClO_2 were higher than the control after treated and were maintained color for during 42 day storage (Fig. 3a-c). This study was found that high ClO_2 concentration from 1 to 1.5% increased high bleaching effects in controlling pericarp browning which was contrasted that of Wu et al.[8] who found that litchi were dipped in ClO_2 at low concentration of 120 mg/l was significantly lower BI than the control after 5 day of harvest and the same as Saengnil Chumyama Faiyuec and Uthaibutra [12] who use 10 and 25 mg/l ClO_2 fumigation on longan fruit found that they were maintained marketing quality of fruit at room temperature for 5 day and delayed the decrease in L* and b* value and hue angle. This could be explained that pericarp browning of longan fruit is primarily attributed to oxidation of phenolic compounds by PPO and POD [12],[18],[19] and possible that ClO_2 might discolor longan pericarp by oxidation of lignin as lignin oxidation in pulp bleaching [20]. ClO_2 treatment significantly delayed the decrease in total phenolic content which was accompanied with a decrease in activity of PPO and POD, leading to a lower BI of longan pericarp [12].

3.2 Disease Incidence (%)

In this study found that the treated treatment with 1.25% and 1.5% of ClO_2 showed no sign of disease developed during 42 day storage as same as SO_2 treatment but ClO_2 1.0% treated found disease incidence (DI) at 6.7% at 42 day. Whereas the untreated fruit had DI over than 25% in 28 days of storage at 5 ºC (Fig. 4) due to fruit rotting from many diseases. The result found that high ClO_2 concentration more than 1.25% increased high efficiency in preventing DI because ClO_2 act as oxidizing agent could kill many pathogens. This result was likely of Wu Li Hu Liu and Chen [11] who observed dipped litchi in ClO_2 solution concentration at 80 mg/l and 120 mg/l were significantly to reduce postharvest disease. On the other ClO_2 treatment were reduced microflora in mulberry fruit [21]. Saengnil Chumyama Faiyuec and Uthaibutra [12] was fumigated longan with 10 and 25 mg/l ClO_2 could delay and reduced disease. Due to ClO_2 is the strong oxidizing and sanitizing agents possible to kill endospores, virus, algae, fungi and some common bacillus [22]. Furthermore the various observations indicated that the increase BI is associated with DI development [11],[23] and also susceptible to various pathogen [2].

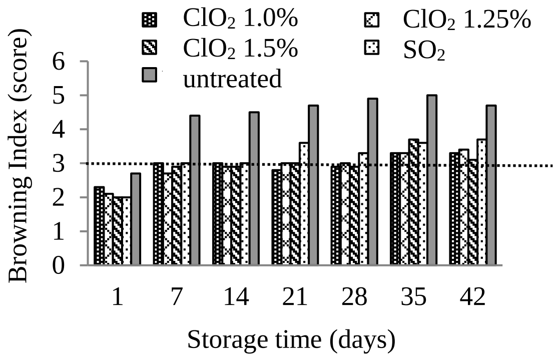

Fig.1 Effect of ClO_2 dipping on browning index of longan pericarp during store at 5ºC for 42 days (Dot line represents limit of acceptance).

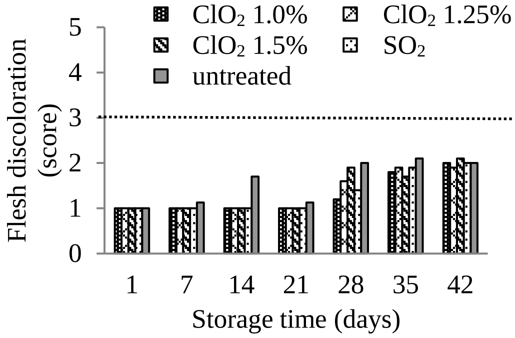

Fig.2 Effect of ClO_2 dipping on flesh discoloration of longan during store at 5ºC for 42 days (Dot line represents limit of acceptance).

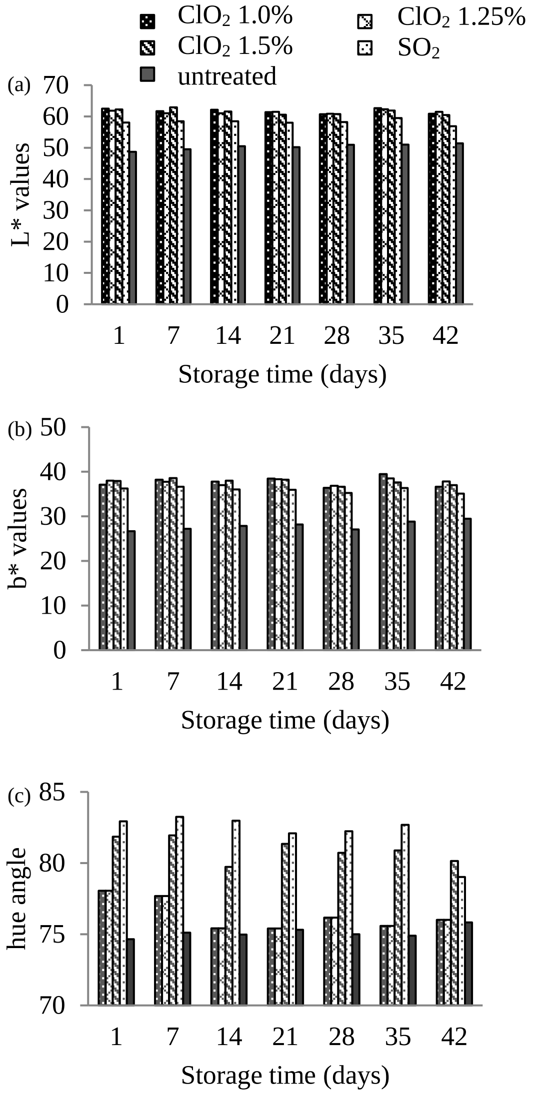

Fig.3 Effect of ClO_2 dipping on L*(a), b*(b) value and hue angle (c) of longan pericarp during store at 5ºC for 42 days.

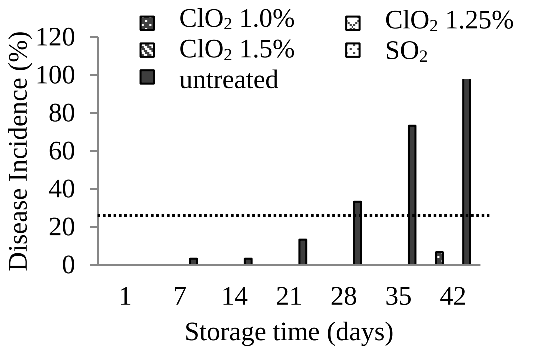

Fig.4 Effect of ClO_2 dipping on disease incidence (%) of longan during store at 5ºC for 42 days (Dot line represents limit of acceptance).

3.3 Sensory Evaluation

Pericarp color acceptance of longan fruit were treated with 1.0%, 1.25% and 1.5% ClO_2 were acceptable for 42 days during storage. Whereas untreated fruit was accepted for 1 day (Fig. 5a). Flesh color and tasty acceptance, treated with ClO_2 were accepted for 35 days showed no significant difference with SO_2, but untreated fruit was accepted at 21 days and 35 days, respectively (fig. 5b,c). The overall acceptance, dipped in 1.0%, 1.25%, 1.5% ClO_2 and SO_2 fumigation were high acceptance as compared with untreated fruit at 42 day, whereas untreated fruit acceptable at 28 day (fig. 5c). The result of this study are relate with Saengnil Chumyama Faiyuec and Uthaibutra [12] which longan fruit treated with 2.5-10 mg/l ClO_2 10 min maintained higher sensory quality scores than those of the control. Furthermore sensory quality evaluation just likely an overall visual quality (OVQ) of Du Fu and Wang [9] study found that 100 mg/l ClO_2 treatment on fresh-cut lotus root for 10 min generated high OVQ values during storage time.

3.4 Chlorine Dioxide Residues

ClO_2 can participate in series of oxidation reactions and subsequently degrade to chlorite, chlorate and chloride, they are the principal residues from chlorine dioxide gas interaction with food [6], [15]. The Environmental Protection Agency (EPA) and The National Institute for occupational Safety and Health have established residual acceptance levels as 0.8 mg/L for chlorine dioxide and 1.0 mg/L for chlorite in drinking water [24]. Although it is well known that a major benefit of ClO_2 for disinfecting drinking water is the lack of organo-chlorine compounds, the residues from the direct treatment of fruits and vegetables have not been well established [15]. In this study ClO_2 residues on longan pericarp was detected every 7 days during storage time after treated with 1.0%, 1.25% and 1.5% ClO_2 solution, the levels of ClO_2 residues was in ranking 0-0.12 mg/kg, 0.07-0.22 mg/kg and 0.04-0.17mg/kg, respectively. Furthermore, ClO_2 residues on fruit flesh was evaluated as pericarp, there were 0-0.02 mg/kg, 0-0.02 mg/kg and 0-0.03 mg/kg, respectively (data not shown). The levels of ClO_2 residues on pericarp and flesh of all treatment were very low. The results are consistent with Saengnil Chumyama Faiyuec and Uthaibutra [12] who reported that ClO_2 residues on longan fruit were less than 0.014 mg/kg and not detected in flesh. For this study is indicating that the physiological of pericarp is different, ClO_2 solution can absorbed into flesh easily, but ClO_2 residues level on flesh was very low and less than 3 mg/kg that limitation imposed by the FDA [25].

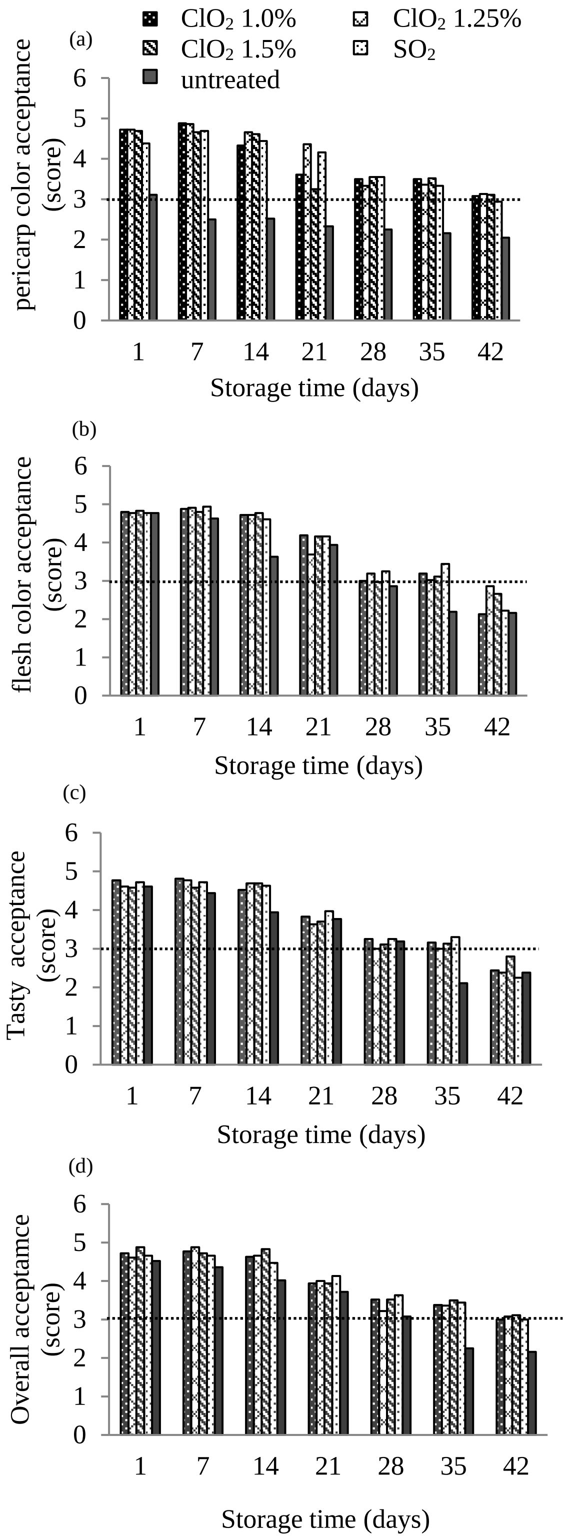

Fig.5 Effect of ClO_2 dipping on sensory evaluation (a) pericarp color, (b) flesh color, (c) tasty and (d) overall quality acceptance of longan pericarp during store at 5ºC for 42 days (Dot line represents limit of acceptance).

3.5 Storage life

From the results of 3 parameters (BI, DI and sensory evaluation) found that longan fruit were treated with 1.0%, 1.25% and 1.5% ClO_2 had storage life for 28 days. Whereas storage life of SO_2 fumigation and untreated fruit were stopped at 21 and 7 day, respectively (Fig.1, fig.4, and Fig.5d).

4. CONCLUSION

The results showed that dipping in 1.0%, 1.25% and 1.5% ClO_2 for 5 min were effective to reduce pericarp browning, postharvest decay and extended storage time for 42 days at 5ºC. Therefore, dipping in 1.5% ClO_2 solution could be used to reduce pericarp browning and further study more. It will be one of alternative to replace SO_2 in the future.

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