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RESEARCH ARTICLE

Effectiveness of Chitosan-Based Edible Coating on Wax Jambu (*Syzygium samarangense*)

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Abstract

Chitosan is a biodegradable material derived from chitin. It is used in agriculture industry. It has an antifungal property. Cinnamic acid is known as the agent of antimicrobial. Cinnamic acid is rarely used in single coating but tend to be used in combination coating. Coating is used to protect the food and conserve their shelf life. Wax jambu (*Syzygium samarangense*) fruits have a thin red skin and are delicate; they need to be picked by hand twice a week and handled with care. The fruits of *S. samarangense* are also having several medicinal properties they are highly perishable under post-harvest condition. This problem is an obstacle to the production of wax jambu for export. Objective of this study focused on the effectiveness of chitosan-based as edible coating on wax jambu (*Syzygium samarangense*) to extend its product's shelf life. Results showed that wax jambu (*Syzygium samarangense)* was coated by 1.5% chitosan and 3.5 mM cinnamid acid which were appropriated to extend its shelf life for 10 days under ambient condition. Chitosan coatings can be used for storage of highly perishable fruits as it had showed increase in the shelf life of wax jambu. Chitosan ensures to slow down senescence by preventing respiration and transpiration.

Keywords: *Chitosan, Cinnamid acid, Coating, Shelf life, Syzygium samarangense.*

Introduction

The wax jambu *(Syzygium samarangense)* is a tropical fruit which belongs to the genus *Syzygium* in the family Myrtaceae [1, 2]. It *is* a fruit plant native to Mekong delta, Vietnam. The fruit is oblong, pear shaped and 5-12 cm in length, with four fleshy calyx lobes and 1- 4 seeds (1-2 cm in diameter). Fruits of wax jambu prefer warm temperatures for normal growth and development. Low temperatures impede fruit growth and red color development, while high temperatures accelerate fruit growth and ripening yet inhibit red color development [1, 2].The ripe fruit is thirst quenching and juicy. This plants extracts have potent free radical scavenging, antioxidation, antimutation and anticancer activities [3]. The wax jambu leaves contain ellagitannins, flavanones, flavonol glycosides, proanthocyanidins, anthocyanidins, triterpenoids, chalcones and volatile terpenoids. The fruit pulp of wax jambu is a rich source of phenols, flavonoids and several antioxidant compounds and as a result it is believed to have great potential benefits for human health and used in traditional medicine to cure diabetes [1, 2]. The flavonoids, isolated from wax apple, were reported to possess antihyperglycemic activity, spasmolytic and immunomodulatory activity [4, 2, 5].After harvesting its shelf life is very short under ambient temperature due to its thin skin and soft texture when ripe. This results in the loss of water and a vulnerability to infections from disease. Low temperature is always used to extend the shelf life of wax jambu but it necessitates high cost, whereas covering the skin with a coating substance like chitosan has been shown to reduce water loss, disease infection and weight loss in many other fruits [6]. Without any preformed injuries, the sound fruit shows a good keeping quality at 2 to 5°C and at 2 to 10°C wax apple produce very low

ethylene. However, chilling injury is a problem at these temperatures. Storage at 12 to 14°C (54 to 57°F) with 90 to 95% RH would result in a shelf-life of 10 to 14 days [1, 2]. The wax jambu fruit should be consumed or preserved within a few days from harvest. Chitin is a biodegradable, long, linear chain polymer found naturally abundantly in the marine and terrestrial environments [7]. Chitosan is a linear amino polysaccharide consisting of glucosamine and N-acetylglucosamine units, which can be extracted from the exoskeleton of crustaceans. Chitosan is a nontoxic, odorless, and biodegradable polysaccharide with good film formation and broad-spectrum antimicrobial properties. It can be used as a preservative for the postharvest preservation of fruits and vegetables [8, 10]. Cinnamaldehyde is a well-known food flavor additive that has been approved as a safe and effective active antimicrobial substance in food packaging [11]. Several studies have shown the effectiveness of chitosan when used to coat fruits. The effect of chitosan on respiration, ethylene production, and quality attributes of tomato (*Lycopersicon esculentum* Mill.) fruit stored at 2°C was investigated [12].The effectiveness of pre- and postharvest treatments with chitosan (0.1, 0.5, and 1.0%) to control *Botrytis cinerea* on table grapes was investigated [13].

Chitosan 0.1% reduced growth of problematic post-harvest pathogenic fungi by up to 50%. It also controlled gray mould and blue mould caused by *Botylis cinerea* and *Penicillium expansum* in tomatoes stored at 25 °C and 2 °C [14]. Effects of hydro cooling and chitosan coating on browning and physiological changes in fresh-cut rose apple were examined [15]. Chitosan 2% reduced the weight loss of longan fruit [16] and it has been used to treat papaya fruit (Ali, A. et al., 2011). The effect of chitosan treatment on the quality of rose apples cv. Tabtim Chan stored at an ambient temperature of 30 °C was investigated [6]. The effectiveness of a chitosan-coating treatment on the physical and chemical, nutraceutical, and sensorial traits of three sweet cherry cultivar was evaluated [17].The effect of two coatings was evaluated, a control (chitosan, 1%) and a treatment (chitosan, 1%; containing propolisethanolic extract, 5%), on the microbiological and physicochemical properties of papaya fruits [18]. Ma et al [19].Also reported that the chitosan-based coating with cinnamon oil could improve the microbiological safety and keep the quality of cantaloupe. The effect of combined coatings of chitosan (Ch) and cinnamic acid (CA) in extending the tomato shelf life was observed. Cinnamic acid helped chitosan in improving coating ability by serving better barrier from pathogen and oxidative gas penetration to prevent earlier spoilage problem [20]. In another report, 0.5% cinnamid acid-chitosan and 1.0% cinnamid acid-chitosan might be good formulations for maintaining the quality of mandarin fruit cv. Ponkan during room-temperature storage [21].Wax jambu (*Syzygium samarangense*) has a short shelf life. Therefore, objective of this study focused on the effectiveness of chitosan-based as edible coating on wax jambu (*Syzygium samarangense*) to extend its product's shelf life.

Materials and Method

Material

Wax jambu (*Syzygium samarangense*) fruits were collected from Can Tho city, Vietnam. After collecting, they must be conveyed to laboratory within 8 hours for experiments. They were blowed by fan to remove foreign matters. Besides wax jambu (*Syzygium samarangense*). Commercial chitosan and acetic acid were purchased from Sigma-Aldrich. Lab utensils and equipments included digital weight balance, penetrometer, refractometer.

Figure 1: Wax jambu (*Syzygium samarangense*)

Researching Procedure

Chitosan was prepared by dissolving the respected amount in 1.0% (v/v) acetic acid. Raw wax jambu (*Syzygium samarangense*) fruits were coated with different chitosan concentrations (0.5%, 1.0%, 1.5%, 2.0%) by dipping in 15 seconds. Then these fruits will then be dipped into cinnamid acid solution (2.5 mM, 3.0mM, 3.5 mM, 4.0 mM) layer by layer in 2 minutes and then dried at ambient temperature. The treated fruits were monitored weight loss (%), firmness (N), total soluble solid (^{o}Brix) during the 0^{th}, 2^{nd}, 4^{th}, 6^{th}, 8^{th}, 10^{th} observational days.

Physico-chemical and Sensory Analysis

Weight loss (%) was estimated by comparing the initial weight and final weight of the coated samples. Firmness (N) was measured by penetrometer. Total soluble solid (^{o}Brix) was determined by hand refractometer.

Statistical Analysis

The experiments were run in triplicate with three different lots of samples. Data were subjected to analysis of variance (ANOVA) and mean comparison was carried out using Duncan's multiple range test (DMRT). Statistical analysis was performed by the Stat graphics Centurion XVI.

Result & Discussion

Effect of Chitosan: cinnamid Acid Coating on Weight Loss (%) of wax Jambu

Chitosan coating is beneficial to maintaining the storage quality and prolonging the shelf life of postharvest fruits and vegetables, which is always used as the carrier film for the antimicrobial agents [22]. Raw wax jambu (*Syzygium samarangense*) fruits were coated with different chitosan concentrations (0.5%, 1.0%, 1.5%, 2.0%) by dipping in 15 seconds. Then these fruits will then be dipped into cinnamid acid solution (2.5 mM, 3.0mM, 3.5 mM, 4.0 mM) layer by layer in 2 minutes and then dried at ambient temperature. The treated fruits were monitored weight loss (%) during the 0^{th}, 2^{nd}, 4^{th}, 6^{th}, 8^{th}, 10^{th} observational days. Results were depicted in Table 1.

Table 1: Effect of chitosan: cinnamid acid coating on weight loss (%) of wax jambu

CH:CA	0^{th}	2^{nd}	4^{th}	6^{th}	8^{th}	10^{th}
0.5%:2.5 mM	0	3.85±0.06^{a}	5.73±0.04^{a}	7.89±0.05^{a}	9.33±0.02^{a}	13.78±0.04^{a}
0.5%:3.0 mM	0	3.74±0.03^{ab}	5.68±0.07^{ab}	7.58±0.03^{ab}	9.21±0.07^{ab}	13.61±0.02^{ab}
0.5%:3.5 mM	0	3.64±0.07^{bc}	5.53±0.01^{bc}	7.44±0.02^{bc}	9.12±0.04^{bc}	13.24±0.05^{bc}
0.5%:4.0 mM	0	3.41±0.04^{d}	5.31±0.04^{d}	7.23±0.06^{d}	8.95±0.05^{cd}	13.04±0.08^{de}
1.0%:2.5 mM	0	3.66±0.05^{b}	5.61±0.03^{b}	7.52±0.07^{b}	9.17±0.04^{b}	13.55±0.05^{b}
1.0%:3.0 mM	0	3.49±0.04^{c}	5.44±0.06^{c}	7.34±0.04^{c}	9.01±0.05^{c}	13.24±0.03^{bc}
1.0%:3.5 mM	0	3.31±0.05^{de}	5.29±0.05^{e}	7.17±0.05^{e}	8.90±0.04^{d}	13.07±0.05^{d}
1.0%:4.0 mM	0	3.18±0.06^{f}	5.15±0.04^{g}	7.03±0.06^{ef}	8.73±0.05^{e}	12.91±0.02^{f}
1.5%:2.5 mM	0	3.47±0.04^{cd}	5.40±0.05^{cd}	7.30±0.05^{cd}	8.95±0.06^{cd}	13.20±0.03^{c}
1.5%:3.0 mM	0	3.30±0.03^{e}	5.28±0.04^{ef}	7.17±0.03^{e}	8.83±0.04^{de}	13.02±0.05^{e}
1.5%:3.5 mM	0	3.18±0.05^{f}	5.19±0.05^{fg}	7.02±0.04^{ef}	8.70±0.05^{ef}	12.87±0.04^{fg}
1.5%:4.0 mM	0	3.02±0.04^{g}	5.03±0.04^{h}	6.88±0.03^{fg}	8.58±0.04^{fg}	12.71±0.06^{gh}
2.0%:2.5 mM	0	3.40±0.05^{d}	5.32±0.03^{de}	7.24±0.06^{de}	8.90±0.05^{d}	13.14±0.04^{cd}
2.0%:3.0 mM	0	3.28±0.03^{ef}	5.25±0.05^{f}	7.14±0.03^{e}	8.80±0.04^{de}	12.99±0.05^{ef}
2.0%:3.5 mM	0	3.16±0.07^{fg}	5.14±0.02^{gh}	6.99±0.05^{f}	8.66±0.05^{f}	12.85±0.05^{g}
2.0%:4.0 mM	0	3.00±0.03^{g}	4.99±0.06^{h}	6.84±0.06^{g}	8.52±0.05^{g}	12.68±0.07^{h}

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α=5%)

Ripening process allows respiration of wax jambu which reduced the weight. Losing weight cause changes to firmness alteration. Edible coating helps in facilitating surface feature by avoiding shrivelling and moisture loss. The effect of chitosan treatment on the quality of rose apples cv. Tabtim Chan stored at an ambient temperature of 30 ºC was investigated. The results demonstrated that at day 5 of storage, the fruit coated with 2 % chitosan had a weight loss of 12.82 % and a disease incidence of 14 % which were significantly less than those of the control (22.12 %, 24 % respectively). [6]. Xing et al [23].Demonstrated that the chitosan-based coating with cinnamon oil reduced the weight loss and decay of jujube fruits.

Effect of Chitosan: cinnamid Acid Coating on Firmness (N) of Wax Jambu

Chitosan coating is one of the promising techniques because of its excellent properties including the property to form the thin film on the fruit's surface, the property to avoid the loss of moisture and aromas, the inhibition of the oxygen penetration to the

plant tissue or microbial growth, and the safety for using on the food [24, 25, 26, 27, 8, 28]. Xing et al [29].Reported that the applications of chitosan coating with cinnamon oil as the antimicrobials could provide better effect on the quality and decay of sweet peppers. In our current research, raw wax jambu (*Syzygium samarangense*) fruits were coated with different chitosan concentrations (0.5%, 1.0%, 1.5%, 2.0%) by dipping in 15 seconds. Then these fruits will then be dipped into cinnamid acid solution (2.5 mM, 3.0mM, 3.5 mM, 4.0 mM) layer by layer in 2 minutes and then dried at ambient temperature. The treated fruits were monitored firmness (N) during the 0^{th}, 2^{nd}, 4^{th}, 6^{th}, 8^{th}, 10^{th} observational days. Results were noted in Table 2.

Table 2: Effect of chitosan (CH): cinnamid acid (CA) coating on firmness (N) of wax jambu

CH:CA	0^{th}	2^{nd}	4^{th}	6^{th}	8^{th}	10^{th}
0.5%:2.5 mM	6.75±0.04^{a}	6.14±0.03^{d}	5.39±0.04^{d}	4.58±0.05^{e}	3.25±0.06^{e}	2.87±0.05^{f}
0.5%:3.0 mM	6.75±0.04^{a}	6.18±0.05^{cd}	5.42±0.06^{cd}	4.63±0.07^{de}	3.29±0.07^{de}	2.94±0.03^{e}
0.5%:3.5 mM	6.75±0.04^{a}	6.23±0.06^{bc}	5.45±0.02^{c}	4.67±0.04^{cd}	3.33±0.05^{cd}	2.98±0.05^{d}
0.5%:4.0 mM	6.75±0.04^{a}	6.25±0.01^{b}	5.48±0.05^{bc}	4.70±0.03^{c}	3.37±0.01^{bc}	3.02±0.02^{c}
1.0%:2.5 mM	6.75±0.04^{a}	6.17±0.04^{cd}	5.41±0.03^{cd}	4.60±0.02^{e}	3.27±0.03^{e}	2.90±0.02^{ef}
1.0%:3.0 mM	6.75±0.04^{a}	6.20±0.03^{c}	5.44±0.03^{c}	4.65±0.05^{d}	3.31±0.03^{d}	2.96±0.04^{de}
1.0%:3.5 mM	6.75±0.04^{a}	6.25±0.04^{b}	5.47±0.04^{bc}	4.69±0.02^{c}	3.35±0.03^{c}	3.01±0.03^{c}
1.0%:4.0 mM	6.75±0.04^{a}	6.28±0.03^{ab}	5.50±0.02^{b}	4.72±0.04^{b}	3.39±0.02^{b}	3.05±0.05^{b}
1.5%:2.5 mM	6.75±0.04^{a}	6.19±0.04^{c}	5.42±0.03^{cd}	4.63±0.01^{de}	3.30±0.03^{de}	2.93±0.04^{de}
1.5%:3.0 mM	6.75±0.04^{a}	6.23±0.02^{bc}	5.46±0.02^{bc}	4.69±0.04^{c}	3.34±0.02^{cd}	2.99±0.03^{cd}
1.5%:3.5 mM	6.75±0.04^{a}	6.27±0.02^{ab}	5.49±0.04^{b}	4.71±0.03^{bc}	3.37±0.05^{bc}	3.04±0.05^{bc}
1.5%:4.0 mM	6.75±0.04^{a}	6.30±0.03^{ab}	5.54±0.07^{ab}	4.76±0.02^{ab}	3.41±0.02^{ab}	3.09±0.02^{ab}
2.0%:2.5 mM	6.75±0.04^{a}	6.22±0.04^{bc}	5.44±0.05^{c}	4.67±0.05^{cd}	3.33±0.04^{cd}	2.96±0.05^{d}
2.0%:3.0 mM	6.75±0.04^{a}	6.25±0.03^{b}	5.47±0.03^{bc}	4.71±0.02^{bc}	3.36±0.03^{bc}	2.97±0.04^{d}
2.0%:3.5 mM	6.75±0.04^{a}	6.29±0.05^{ab}	5.50±0.07^{b}	4.73±0.02^{b}	3.40±0.02^{ab}	3.06±0.04^{b}
2.0%:4.0 mM	6.75±0.04^{a}	6.33±0.02^{a}	5.57±0.04^{a}	4.79±0.01^{a}	3.45±0.02^{a}	3.11±0.03^{a}

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α=5%)

Effect of Chitosan: cinnamid Acid Coating on Total Soluble Solid (^{o}Brix) of Wax Jambu

Permeability is one important property of chitosan-based coating that could control the diffusion of antimicrobial agents, such as cinnamon oil, through a carrier film to the packages, with a driving force due to the different concentrations of substances between the two sides of coating film. Ojagh et al [30].Also demonstrated that the effect of cinnamon oil on chitosan film might decrease its elongation at break. This might be due to the strong interaction between the polymer and cinnamon oil, which could produce a cross-linker effect and decrease the molecular mobility and the free volume of chitosan polymer. The arrangement of stacking layers of cinnamon in chitosan film indicated that the formed compact structure could induce the increase in the tensile strength and the decrease in elongation at break. Degradation of cell wall and sugar accumulation happen during ripening (Hossain *et al.*, 2014). Coating combination inhibits respiration process by minimising starch conversion into sugar, resulting in lower sugar (total soluble solid) content. Slower ripening process delayed the carbohydrate hydrolysis into sugar (Elsabee and Abdou, 2013). The effect of chitosan treatment on the quality of rose apples cv. Tabtim Chan stored at an ambient temperature of 30 ºC was investigated. Fruit firmness of the rose apples treated with 2 % chitosan was significantly higher than that of the control (5.92 kg/cm^2 and 4.12 kg/cm^2, respectively) [6]. In our current research, raw wax jambu (*Syzygium samarangense*) fruits were coated with different chitosan concentrations (0.5%, 1.0%, 1.5%, 2.0%) by dipping in 15 seconds. Then these fruits will then be dipped into cinnamid acid solution (2.5 mM, 3.0mM, 3.5 mM, 4.0 mM) layer by layer in 2 minutes and then dried at ambient temperature. The treated fruits were monitored total soluble solid (^{o}Brix) during the 0^{th}, 2^{nd}, 4^{th}, 6^{th}, 8^{th}, 10^{th} observational days.

Table 3: Effect of chitosan:cinnamid acid coating on total soluble solid (°Brix) of wax jambu

CH:CA	0th	2nd	4th	6th	8th	10th
0.5%:2.5 mM	9.43±0.02a	9.02±0.05d	8.93±0.05e	8.80±0.03f	8.69±0.04f	8.57±0.06f
0.5%:3.0 mM	9.43±0.02a	9.06±0.04c	8.98±0.03de	8.87±0.05e	8.73±0.01e	8.62±0.04ef
0.5%:3.5 mM	9.43±0.02a	9.10±0.06bc	9.04±0.04cd	8.93±0.01de	8.77±0.03de	8.67±0.02de
0.5%:4.0 mM	9.43±0.02a	9.13±0.02b	9.09±0.01bc	8.97±0.04c	8.82±0.04cd	8.71±0.03cd
1.0%:2.5 mM	9.43±0.02a	9.04±0.03cd	8.95±0.04e	8.84±0.02ef	8.71±0.03ef	8.60±0.05ef
1.0%:3.0 mM	9.43±0.02a	9.08±0.05bc	9.01±0.04d	8.92±0.01de	8.74±0.02e	8.65±0.03de
1.0%:3.5 mM	9.43±0.02a	9.11±0.02bc	9.07±0.02c	8.95±0.06cd	8.80±0.01d	8.69±0.04d
1.0%:4.0 mM	9.43±0.02a	9.15±0.04ab	9.11±0.02b	9.00±0.04bc	8.84±0.03c	8.73±0.05c
1.5%:2.5 mM	9.43±0.02a	9.06±0.03c	8.97±0.04de	8.89±0.01c	8.73±0.02e	8.63±0.07e
1.5%:3.0 mM	9.43±0.02a	9.10±0.03bc	9.05±0.02cd	8.94±0.03d	8.77±0.06de	8.68±0.01d
1.5%:3.5 mM	9.43±0.02a	9.14±0.05b	9.09±0.03bc	8.98±0.05c	8.83±0.01c	8.71±0.05cd
1.5%:4.0 mM	9.43±0.02a	9.17±0.04ab	9.14±0.05ab	9.04±0.06ab	8.88±0.05b	8.77±0.02b
2.0%:2.5 mM	9.43±0.02a	9.08±0.01bc	9.00±0.07d	8.93±0.04d	8.76±0.01de	8.65±0.03de
2.0%:3.0 mM	9.43±0.02a	9.13±0.05b	9.07±0.04c	8.96±0.02cd	8.80±0.04d	8.70±0.02cd
2.0%:3.5 mM	9.43±0.02a	9.16±0.06ab	9.13±0.05ab	9.02±0.04b	8.86±0.07bc	8.75±0.04bc
2.0%:4.0 mM	9.43±0.02a	9.22±0.04a	9.19±0.07a	9.08±0.05a	8.94±0.03a	8.85±0.01a

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α=5%)

Chitosan treatment with cinnamid acid effectively reduced the decay and weight loss rates of mandarin fruit cv. Ponkan during storage at room temperature, delayed the decline of nutritional quality in fruits, increased the antioxidant capacity, and inhibited the accumulation of malondialdehyde [21].

Conclusion

The extracts of wax jambu (*Syzygium samarangense*) fruits, flower and bark have potent free radical scavenging, antioxidation, antimutation and anticancer activities. The leaves of wax apple used as tea and is proposed as a possible supplement for type II diabetes patients. Wax apple studied for its numerous pharmacological properties such as antioxidant and anti-diabetic properties, anti-inflammation and antinociceptive activity, wound healing activity, antiulcerogenic effect, antibacterial, anticancer and also it's potential as an uterotonic agent. The ripe, pink fruits of wax jambu are bell-shaped, sweet and can be eaten fresh or cooked, for sauces, jams, jellies desserts, wines, liquors, and vinegars. There is rising concern for food safety and nutrition amongst the consumers. This increase in health consciousness has led to the demand in organic fruits and vegetables along with healthy preservation techniques. Edible coatings offer a plausible solution to obtain fresh, nutritive comestible products.

Chitosan is presented as a potential material for edible coatings processing, mainly due its non-toxic nature, biocidal activity and gas barrier properties. It is well known to have an antimicrobial activity against various microorganisms we have successfully investigated the efficacy of chitosan-based as edible coating on wax jambu (*Syzygium samarangense*) to extend its product's shelf life. They serve as a semipermeable barrier to gases and water vapour, thereby reducing respiration and water loss. Chitosan-based coating with different antimicrobial agents would probably have wide prospect in the preservation of fruits and vegetables in the future.

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