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Synergistic Effect of Calcium Chloride and Chitosan Treatment on Physicochemical Characteristics of Pineapple (*Ananas Comosus*) Fruit During Cool Storage

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Abstract: Pineapple (*Ananascomosus*) is one of the most popular agricultural products in the world. It is well-known for its excellent flavour and taste, diversified valuable nutritional components as well as phytochemical and antioxidant properties. However it is quite perishable at ambient condition due to its high respiration rate. It is essential to find an appropriate strategy to extend its stability during storage. This study concentrates on the effectiveness of calcium chloride and chitosan treatments on the post-harvest physicochemical quality of pineapple during storage at 12°C and 80±5% relative humidity. The fruit was treated with different concentrations of $CaCl_2$ (0.5%, 1.0%, 1.5%, 2.0%, 2.5%) via dipping for 4 min and chitosan (0.5%, 1.0%, 1.5%, 2.0%, 2.5% w/v) via coating. Different physicochemical parameters such as weight loss (%), firmness (N), decay percentage (%), total soluble solid (°Brix), ascorbic acid (mg/100g) were thoroughly examined, Our results showed that a combination of 2.0% $CaCl_2$ with 1.5% chitosan created a synergistic effect on physicochemical characteristics of pineapple fruit during 14 days of cool storage. These results implied that calcium chloride combined with chitosan as edible coatings have potential to maintain fruit quality in respect of weight loss, firmness, total soluble solid, ascorbic acid while reducing post harvest spoilage (decay) in pineapple fruit.

Keywords: Pineapple, $CaCl_2$, chitosan, coating, synergistic, physicochemical

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1. INTRODUCTION

Pineapple (*Ananascomosus*) is the third most important tropical fruit in the world. It is known as the queen of fruits due to its excellent flavor and taste. It is a rich source of carbohydrate, vitamins, minerals and organic acids. Bromelain inside pineapple is good for the digestive system and helps in maintaining ideal weight and balanced nutrition[1]. It is also useful as an anti-inflammatory agent as well as reduces swelling in inflammatory conditions such as acute sinusitis, sore throat, arthritis, gout[2]. Pineapple pulp is a clear yellow, very sweet, compact, fibrous and has a high ascorbic acid content but low total acidity[3]. Calcium chloride provides an important mechanism in the reinformance of membranes and cell walls[4]. It retards the ripening process specially the softening and therefore, improve the stability of fruit via modifying intercellular and extracellular reactions[5]. Chitosan has biodegradable, biocompatible, non toxic, antioxidant, antimicrobial activities with great potential in film coating as an excellent semi-permeable barrier against gas and vapor exchange, controlling respiration rate, retarding dehydration and shrinkage, limiting ripening and senescence of the fruit[6-10]. Chitosan has been also implemented as a potential alternative to synthetic fungicides[11]. Combination of calcium chloride and chitosan during preservation of various fruits such as guava, peach, papaya, strawberry have been demonstrated[12-17]. Pineapple fruit is perishable during post harvest. With the purpose of extending the commercial value of this valuable fruit during distribution, our study focused on the way to extend whole fruit shelf-life by verificating the synergistic effect of $CaCl_2$ and chitosan coating in respect of various physicochemical variables such as weight loss (%), firmness (N), decay percentage (%), total soluble solid (°Brix), ascorbic acid (mg/100g).

2. MATERIAL AND METHOD

2.1 *Material*

Pineapple (*Ananascomosus*) fruits were obtained from orchards in KienGiang province, Vietnam. After collection, they must be conveyed to laboratory for experiments. Chemical substances such as calcium chloride, chitosan, acetic acid and other reagents were all analytical grade supplied from Rainbow Trading Co. Ltd., Vietnam

2.2 *Researching procedure*

Chitosan powder was dissolved in acetic acid 1.0%. Pineapple fruits were dipped in $CaCl_2$ solution (0.5%, 1.0%, 1.5%, 2.0%, 2.5%) then coated in chitosan (0.5%, 1.0%, 1.5%, 2.0%, 2.5%). All treated samples were then stored at 12°C and 80±5% RH for 14 days before evaluating weight loss (%), firmness (N), decay percentage (%), total soluble solid (°Brix), ascorbic acid (mg/100g)[18].

2.3 *Physico-chemical measurement*

Weight loss (%) was calculated by comparing the initial and final weight of a fruit. Texture firmness (N) was measured by penetrometer model H-1200. Decay percentage (%) was examined by visual appearance. Fruits showing surface mycelial development were considered decayed. Total soluble solid (°Brix) was analyzed by refractometer. Ascorbic acid (mg/100g) was determined by iodometric titration[18].

3. STATISTICAL ANALYSIS

The experiments were run in triplicate with three different lots of samples. Statistical analysis was performed by the Statgraphics Centurion version XVI. The data were presented as mean ± standard deviation. Probability value of less than 0.05 was considered statistically significant.

4. RESULT & DISCUSSION

4.1 *Effect of $CaCl_2$ concentration in preservation of pineapple fruit*

The highest significant weight loss percentage was noticed at untreated fruits (control), while treatments with $CaCl_2$ showed the lowest significant weight loss. The lowest fruit weight loss (%) was obtained in fruits treated with 2.0% $CaCl_2$ after 14 days of storage (Table 1). Weight loss of fresh fruits is primarily owing to water loss as a result of evaporation and transpiration. The low weight loss in $CaCl_2$ treated fruits could be explained by the improvement of fruit texture and tissue rigidity via lowering the enzyme reaction responsible for decomposition of cellular structure, which slow down gas exchange[12]. Fruit firmness is one of the most important variables in evaluating the post-harvest quality and physiology of fruits[19]. It should be noticed that all the treatments had an effect in preserving fruit firmness. Fruit softening is caused either by breakdown of insoluble proto-pectins into soluble pectin or by hydrolysis of starch, or by increased membrane permeability caused by cellular disintegration[12]. Effect of calcium in maintaining fruit firmness may be owing to the calcium binding to free carboxyl groups of polygalacturonate polymer, stabilizing and strengthening the cell wall. The lowest significant decay percentage was recorded at samples treated by $CaCl_2$ 2.0%. Calcium ions play a key role in hindering fruit softening by strengthening the cell walls, as well as covering cuticle and lenticels. Their high antifungal activity reduces respiration, physiological disorders, ripening processes; increases their resistance to infection during storage. Untreated fruits recordedthe lowest soluble solid while the highest was obtained with the treatment of $CaCl_2$ 2.0%. Soluble solid lossis caused by respiration during storage[20]. The highest ascorbic acid contents were obtained with samples treated by $CaCl_2$ 2.0%. It could be due to the reduction in metabolic changes of ascorbic acid into carbon dioxide and water during respiration. In one report, $CaCl_2$ was capable of maintaining shelf-life of fresh-cut fruits for 15 days[21].

Table 1. Effect of $CaCl_2$ concentration to physicochemical variables of pineapple fruit after 14 days of preservation

S Parameter	$CaCl_2$					
	Control	0.5	1.0	1.5	2.0	2.5
Weight loss (%)	9.35±0.03^{a}	4.79±0.01^{b}	4.02±0.00^{ab}	3.57±0.03^{b}	3.12±0.00^{bc}	3.01±0.00^{c}
Firmness (N)	4.17±0.01^{d}	5.34±0.02^{c}	5.83±0.03^{bc}	6.36±0.01^{b}	6.79±0.01^{ab}	6.95±0.01^{a}

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Decay percentage (%)	37.42±0.02^{a}	14.25±0.00^{b}	11.34±0.01^{c}	8.73±0.00^{d}	6.17±0.02^{e}	4.71±0.02^{f}
Total soluble solid (°Brix)	9.29±0.02^{d}	15.63±0.03^{c}	15.94±0.02^{bc}	16.05±0.00^{b}	18.48±0.03^{a}	18.54±0.01^{a}
Ascorbic acid (mg/100g)	9.38±0.00^{d}	15.31±0.02^{c}	17.83±0.02^{bc}	19.55±0.01^{b}	22.07±0.01^{a}	22.16±0.00^{a}

Note: the values were expressed as the mean of three repetitions; the different superscripts (a, b, c, d as denoted above) indicate the significant difference (α = 5%).

4.2 Synergistic effect of $CaCl_2$ combined with chitosan in preservation of pineapple fruit

Chitosan coatings create barriers to limit moisture transfer, prevent fruit skin from mechanical damages, heal small injuries and thus decrease dehydration[22]. Chitosan could inhibit fungal proliferation, limit fungal decay, induce host resistance to pathogens and self-polymerisation, prolonging the stability of fruits[23-26]. In our research, the lowest significant weight loss (%), decay percentage (%) while highest firmness (N), total soluble solid (°Brix) and ascorbic acid content (mg/100g) were noted at samples treated by $CaCl_2$ 2.0% and chitosan 1.5% (table 2). Our findings were similar to other reports. 2% $CaCl_2$ and 1% chitosan was most effective in minimizing weight loss and rotten, preserving maximum texture firmness and prolonging stability of peach fruit[12]. A combination of $CaCl_2$ 1.5% and chitosan 1.5% was the most appropriate treatment in modulating physicochemical changes and improving stability of guava during preservation[13]. The best formula for extending shelf-life of papaya fruit proved to be 2.5% chitosan coating[14]. Combination of calcium with 1% chitosan s improved the firmness of strawberry fruit[16]. The combination of 2.5% calcium with chitosan 0.75% completely inhibited spore germinations and significantly prevented mycelia proliferation on papaya fruit[15].

Table 2. Synergistic effect of $CaCl_2$ 2.0% combined with chitosan in different concentration in physicochemical of pineapple fruit after 14 days of preservation

Parameter	$CaCl_2$ 2.0%					
	Control $CaCl_2$ 2.0%	0.5% chitosan	1.0% chitosan	1.5% chitosan	2.0% chitosan	2.5% chitosan
Weight loss (%)	9.35±0.03^{a}	4.79±0.01^{b}	4.02±0.00^{ab}	3.57±0.03^{b}	3.12±0.00^{bc}	3.01±0.00^{c}
Firmness (N)	6.79±0.01^{c}	8.21±0.00^{b}	8.79±0.02^{ab}	9.12±0.00^{a}	9.15±0.00^{a}	9.16±0.02^{a}
Decay percentage (%)	6.17±0.02^{a}	4.53±0.01^{b}	4.11±0.00^{bc}	3.63±0.02^{c}	3.57±0.00^{c}	3.55±0.00^{c}
Total soluble solid (°Brix)	18.48±0.03^{c}	20.71±0.02^{b}	20.97±0.01^{ab}	21.24±0.01^{a}	21.30±0.01^{a}	21.34±0.02^{a}
Ascorbic acid (mg/100g)	22.07±0.01^{c}	23.64±0.01^{b}	23.88±0.03^{ab}	24.01±0.02^{a}	24.06±0.03^{a}	24.09±0.01^{a}

Note: the values were expressed as the mean of three repetitions; Note: the values were expressed as the mean of three repetitions; the different superscripts (a, b, c as denoted above) indicate the significant difference (α = 5%).

Chitosan was reported to be effective in minimizing weight loss by using alone on longan fruit, or in combination with calcium chloride on peach[27-28]. Chitosan film created a barrier to limiting moisture removal and protecting fruit peel from physical damage, trapping small injuries and thus delaying dehydration[29]. The antimicrobial property of chitosan depended on several factors such as the kind of chitosan, storage temperature, and food components[30]. Chitosan played as an inhibitor to various enzymes to delay fruit senescence. Chitosan coating could create a protective barrier on the surface of fresh fruit to slow down microbial proliferation causing fruit decay[31-32]. Interaction of calcium with pectic acid in cell walls to form calcium pectate, a compound helpful for maintaining structure of the fruit[33]. Calcium utilization was demonstrated to be effective in membrane functionality and integrity maintenance in facilitating the postharvest life of various fruits[34].Pineapple (*Ananascomosus*) is one of the most important commercial fruit crops with several health benefits. There is a great demand of pineapple consumption worldwide. Pineapple fruit has a relatively short postharvest stability by physiological, pathological and biochemical changes causing economic losses. Improving its shelf-life is very urgent. We have investigated the feasibility of $CaCl_2$ dipping together with chitosan coating on the physicochemical properties of pineapple fruits on cool storage.

5. CONCLUSION

Our results concluded that 2.0% calcium chloride combined 1.5% chitosan could extend stability of pinepapple fruits by maintaining fruit quality (weight loss, firmness, total soluble solid, ascorbic acid) while slowing down fruit quality decomposition (decay) in 14 days at 12°C and 80±5% relative humidity. The synergistic effect was clearly noted in double coating compared to single calcium chloride treatment.

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7. CONFLICT OF INTEREST

Conflict of interest declared none.

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