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Effect of edible chitosan coating on combined ultrasound and NaOCl treated kiwi fruits during refrigerated storage

*Vivek, K. and Subbarao, K.V.

Department of Food Engineering and Technology, Tezpur University, Tezpur – 784028, Assam, India

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Abstract

Fresh cut kiwi fruit samples were coated with chitosan solution at concentrations of 0% (control), 0.6%, 0.8% and 1%, respectively. Coated fruits were kept in the previously sterilized zip wrap pouches and stored at 5±1°C for 10days. Fresh cut kiwi fruits were evaluated by measuring mass loss, pH, total soluble solids (TSS), titrable acidity (TA), vitamin C, firmness, respiration rate (RR), total phenolic content (TPC), microbial counts (total bacteria, yeast and mold) and sensory quality. It was observed that the chitosan coating could significantly preserve the fresh cut kiwi fruits by delaying the fruit senescence, minimizing the growth of microorganisms and maintaining the sensory quality (colour, smell, taste, texture and overall liking). Treatment with 0.8 and 1.0% chitosan coating significantly ($p<0.05$) reduced the mass loss, RR, growth of microorganisms and improves the sensory quality of ultrasound combined with sodium hypochlorite (NaOCl) treated fresh cut kiwi fruit during 10 days of storage at 5°C.

Introduction

Kiwifruit (Actinidia delicosa) originated from China (Pal *et al*., 2015). It is also considered as China's miracle fruit and the horticultural wonder of New Zealand. Kiwi fruits are grown mostly in New Zealand, Chile, and Italy and to a minor expansion in France, Greece, Iran, Japan, Turkey, Portugal and United States (Bhardwaj *et al*., 2014). Apart from these places kiwifruit also grown in India. It is one of the most important horticultural crops in world because of medicinal and nutritional value of the fruit. These fruits are rich in bioactive compounds such as ascorbic acid, polyphenols and flavonoids. It has major beneficial health effects i.e. mainly due to their antioxidant properties (Amodio *et al*., 2007).

Kiwi fruit is a perishable fruit with short shelf life of 1-2 weeks depends on total soluble solids (TSS) at which it was harvested, stored and transported at ambient temperature. During storage undesirable changes (physiological, chemical and sensory changes) may take place which reduces the shelf life and quality of kiwi fruit (Hang *et al*.,2012). Senescence and decay are considered to be the most important factors that decrease the storage life of kiwi fruit after harvest, which leads to a significant economic loss (Li and Kader, 1989; Gil *et al*., 1997). The internal and external qualities of kiwi fruit slices are important quality factors in consumer point of view and marketing considerations (Bhardwaj *et al*., 2014). Hence methods to preserve the quality of fresh cut kiwi fruits are necessary for handling, distribution and commercial storage.

Ultrasound in food industry is considered to be an innovative and attractive technology because it has unique advantages over other technologies (Knorr *et al*., 2006; Zheng and Sun, 2006; Stojanovc and Silava, 2007). Ultrasound produces safe, nontoxic and environmental friendly acoustic waves (Chen and Zhu, 2011). Ultrasound combined with aqueous sodium hypochlorite (NaOCl) were found to be more effective in reducing the microbial load, decay and retaining the sensory quality of many fruits when compared with the individual treatments and untreated samples (Zhang and Quantick,1997; Chen and Zhu, 2011; Jang and Moon,2011; Meng *et al*., 2014; Vivek *et al*., 2016).

Chitosan is a high molecular weight cationic polysaccharide and produced by chemical deacetylation of the chitin found in arthropod exoskeletons. This polysaccharide can also be obtained from a cell wall of some plant pathogenic fungi. It is soluble in dilute organic acids and has an ability to prolong the storage shelf life by controlling decay (microbial and non-microbial) of many fruits, like pears, grapes, chestnut, longon, strawberry and water melon (Zhang and Quantick, 1997; Pen and Jiang, 2003; Lin *et al*., 2008; Meng *et al*., 2008;

*Corresponding author.
Email:*vivek.tezu@gmail.com*

Hermandz-Munoz *et al*., 2008). Helander *et al*. (2001) had reported that the chitosan has an antimicrobial activity, because of the interactions between its positively charged molecules over negatively charges microbial cell membrane leads to the disruption and death of microbial cells. A lot of work has been done to increase the shelf life of post-harvest fresh cut fruits and vegetables by chitosan coating but very little information is currently available about the chitosan coating on fresh cut kiwifruit. Therefore, the main aim of this study is to identify the effect of an edible chitosan coating on quality and sensory changes in ultrasound combined with NaOCl treated fresh cut kiwifruits during refrigerated storage at 5°C.

Materials and Methods

Fresh cut kiwifruit preparation

Hayward kiwifruits were hand harvested at a commercial farm in Dirang valley (Arunachal Pradesh, India) in the month of late November, 2015 and transported within 12 h to the laboratory. These fruits had an initial total soluble solids (TSS) of 9 ± 0.5% (w/w) and moisture content of 82.6 ± 0.80% w.b. (wet basis). Kiwi fruits were carefully selected for uniform size, absence of visual wounds and defects for experiment. Raw kiwi fruits (unpeeled) were treated (ultrasound (368 W/cm^2) combined with 30 ppm of sodium hypochloride for 8 mins at 25°C). Then the samples were air dried at 25°C for 15 minutes. The fruits were hand peeled and transversely sliced with a stainless steel knife. Chitosan (MW: 760 kDa, degree of deacetylation >75%) was purchased from Sigma-Aldrich and coated at various concentrations of 0%, 0.6%, 0.8% and 1% i.e. 0,0.6, 0.8 and 1 g/100 ml of 1% acetic acid were prepared. The pH of solution was adjusted to 5.0 with 0.1 M sodium hydroxide (NaOH). An acid solution with a pH of 5.0 without chitosan was used as a control. Fresh cut kiwi fruits were dipped in chitosan solutions for 1 min. the fruit slices were kept in the previously sterilized zip wrap pouches after being air dried at 25°C for 15 min then all the samples were stored at 5°C for 10 days.

Mass loss, pH, total soluble solids, titrable acidity and vitamin C determination

Samples were separated for mass loss determination. The fresh cut kiwi fruit slices were individually packed and weighed at the beginning of an experiment, just after coating, air drying and thereafter at 2, 4, 6, 8 and 10 days during storage period. Mass loss was expressed as a percentage loss of the initial total mass (Meng *et al*., 2008). Ten grams of frozen fruit tissue were homogenized in pre chilled 40 ml of distilled water. The homogenate was centrifuged at 10,000 x g for 15 min at 4°C. The TSS was measured by adding four drops of clarified extract onto a digital refractometer (Atago, 4406 PAL-06S1) calibrated in Brix (gram of sucrose equivalent per 100 g of juice), and expressed as a percentage (Pal *et al*., 2015). Titrable acidity and pH were determined using an automated titrimeter. Ten ml of clarified kiwifruit extracts were placed into a sample cup and titrated to the endpoint of pH 8.1 using 0.1N NaOH. The results were expressed as %citric acid equivalent. Vitamin C content was assayed by the 2,6 dichlorophenolindophenol titration method and the results expressed as mg/100 g of fresh weight (FW) (Pal *et al*., 2015).

Firmness

Firmness of the treated kiwifruits (peeled) were measured according to Meng *et al*. (2014) with minor modifications. Texture profile analysis test was performed with a texture analyzer (TA-HD-plus, Stable Micro Systems, UK) by fitted with a 5 mm diameter stainless steel probe, at a constant speed of 10 mm/min for peeled fruits to a depth of 8 mm. The operating conditions maintained during analyses were pre-test speed: 1.5 mm/s, post-test speed: 10.0 mm/s and trigger force: 0.1 N. The peak puncture force (in Newton) was considered as firmness in kiwifruit flesh (Razavi and Maryan, 2007).

Respiration rate

Respiration rate was measured in accordance with Wang *et al*. (2015) with minor modifications. Respiration rate was performed by sealing three replicates of about 80±5 g fruits into airtight glass container (total volume of 900 ml) with rubber septum and held at 20±1°C for 1 hour. Samples were taken for respiration rate at 2, 4, 6, 8 and 10 days interval during storage period. 3ml head space gas was taken by the O_2 and CO_2 meter (checkmate 3, PBI, dansensor, Ringsted, Denmark). The results were expressed in mg CO_2 kg^{-1} h^{-1} FW.

Total polyphenols

Total polyphenols of kiwi fruits were measured accordance with Pal *et al*. (2015). The Fresh edible kiwi fruit pulp (5g) was homogenized in 25 ml of extraction solvent (Acetone: Methanol: Water: Acetic acid) in (40:40:19:1) ratio. The mixture was then transferred into a 50ml centrifuge tube and incubated for 1 h at 60°C in a water bath. Samples were centrifuged at 10,000 x g for 15 min at 4°C, then filtered and diluted to a final volume of 50ml. Total polyphenolic content was determined using

spectrophotometer by Folin-Ciocalteu method (Singleton and Rossi, 1965). 200 microliter extracts were mixed with 2.6 ml of double distilled water and blank was prepared without extract in it. 200 microliters of Folin-Ciocalteu reagent (0.4N) was mixed with the sample or blank. The reaction mixture was allowed to stand at room temperature for 6 min. and then 2 ml of 7% sodium carbonate (Na_2CO_3) solution were added to each mixture and allowed to stand at room temperature for 90 min. the absorbance was measured at 750 nm. Results were expressed as mg Gallic acid equivalent (GAE) per 100 g FW.

Microbial analysis

Total bacteria, yeast and mold were examined according to the methods described by Cao *et al*. (2009) with slight modification. Each treated sample of 25 g was put into 225 ml of previously sterilized sample bags with 0.1% peptone water and was homogenized for 5 min. Appropriate dilutions (1:10) were made with 0.1% peptone of each wash solution was surface plated on plate count agar (PCA), Potato dextrose agar (PDA) and incubated for 24 h at 37°C for aerobic bacteria and 72 h at 28°C for yeast and mold count.

Sensory evaluation

A panel of 15 judges (five females, ten males) was formed on the basis of their interest in sensory evaluation, knowledge of the product, good health and willingness to participate in the study on regular basis. Judges were trained by explaining the definition of quality attributes selected for sensory evaluation, demonstrating the score sheet and judging was done between 3.00 - 5.00 pm (Jaya and Das, 2003). Judges were advised to take puffed rice between testing the consecutive samples (Jaya and Das, 2003). Five characteristics of kiwi fruit (colour, taste, smell, texture and overall liking) were analysed for acceptability. Four samples (0%, 0.6%, 0.8% and 1%) were analysedinitially (0day) and finally (10day).

Statistical analysis

The experimental design was randomized with three replications. Data were analysed using one way analyses of variance (ANOVA) by SPSS v 16.0 and significant difference ($p<0.05$). The differences between means were compared with Duncan's multiple range tests.

Results and Discussions

Mass loss, pH, total soluble solids, titrable acidity and Vitamin C

The mass loss is the major determinant of storage life and quality of kiwi fruit. The mass loss of uncoated fresh cut kiwi fruit samples resulted higher compared with the coated samples. However, no significant ($p>0.05$) difference was seen between 0.8 and 1% chitosan coated samples but significant ($p<0.05$) difference was seen between 0 and 0.6% chitosan coated samples on 10th day of storage. Mass loss observed in 0.8 and 1% chitosan treated samples were 2.90%and 2.95% respectively. While the uncoated (0%) and 0.6% coated samples showed 4.25% and 3.45%respectively at the end of the storage period. The increase in mass loss of fresh-cut kiwi fruit over 10 days storage period was shown in Figure1.Results indicate that the chitosan coated samples decelerate the mass loss of fresh cut kiwi fruits throughout the storage period (Figure 1). The slower rate of moisture loss from the chitosan coated fruits may be due to the barrier property of chitosan against diffusion of moisture through stomata. Similar kind of results was showed by many researchers on mango, water melon, guava, litchi, longan, strawberry and papaya (Dong *et al*., 2004; Ribeiro *et al*., 2007; Nongtaodum and Jangchud, 2009; Ali *et al*., 2011; Hong *et al*., 2012).

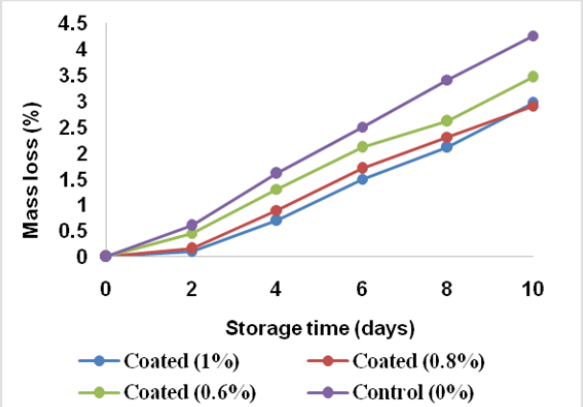

Figure 1. Change in Mass loss of fresh-cut kiwi stored at 5°C

pH is one of the important measurements in kiwi fruit quality. The pH value of 2.5 to 5.5 tends to prolong the shelf life of many fruits and inhibits the multiplication of microorganisms. The trend was similar till 8 days of storage period for both coated samples (0.6%, 0.8% and 1%.) However, no significant ($p>0.05$) difference was seen between0.6, 0.8 and 1% chitosan coated fruitson 10th day of storage. pH observed in0, 0.6, 0.8 and 1% chitosan treated samples were 4.01, 3.85, 3.83 and 3.83

respectively at the end of the storage period. Coating with different concentrations of chitosan did not affect pH of kiwi fruit throughout the storage period. Nongtaodum and Jangchud (2009) had reported that the chitosan coating did not affect pH of mangoes stored at 6°C for 7 days. Hermandaz – Munoz *et al*. (2008) had reported that the chitosan coating from 1 to 1.5% did not affect pH of the strawberry during storage.

Table 1. Mean value of samples during storage (0 day to 10 day)

Storage time (days)	0% chitosan	0.6% chitosan	0.8% chitosan	1.0% chitosan
Titrable acidity				
0	0.44±0.006^{a}	0.44±0.013^{a}	0.44±0.008^{a}	0.44±0.005^{a}
2	0.39±0.015^{a}	0.43±0.006^{b}	0.44±0.006^{b}	0.44±0.006^{b}
4	0.38±0.007^{a}	0.43±0.005^{b}	0.42±0.005^{b}	0.43±0.011^{b}
6	0.37±0.003^{a}	0.41±0.006^{b}	0.42±0.006^{c}	0.42±0.006^{c}
8	0.35±0.006^{a}	0.37±0.017^{a}	0.40±0.006^{b}	0.41±0.006^{b}
10	0.30±0.012^{a}	0.31±0.020^{a}	0.37±0.023^{b}	0.41±0.010^{c}
Total soluble solids				
0	09.00±0.00^{a}	09.00±0.00^{a}	09.00±0.00^{a}	09.00±0.00^{a}
2	10.67±0.29^{a}	10.00±0.00^{b}	10.00±0.00^{b}	9.67±0.58^{c}
4	12.00±0.00^{a}	11.00±0.00^{b}	11.00±0.00^{b}	10.17±0.29^{c}
6	13.33±0.29^{a}	12.33±0.29^{b}	11.33±0.29^{c}	10.50±0.50^{d}
8	14.00±0.00^{a}	13.33±0.29^{b}	12.33±0.29^{c}	11.67±0.29^{d}
10	15.00±0.00^{a}	14.00±0.00^{b}	13.00±0.00^{c}	12.67±0.58^{c}
Total bacterial count				
0	2.89±0.010^{a}	2.88±0.021^{a}	2.89±0.015^{a}	2.88±0.012^{a}
2	3.62±0.037^{a}	3.54±0.005^{a}	3.42±0.083^{b}	3.42±0.053^{b}
4	3.90±0.100^{a}	3.79±0.045^{ab}	3.66±0.099^{b}	3.67±0.053^{b}
6	4.88±0.078^{a}	4.49±0.118^{a}	4.23±0.064^{b}	4.24±0.058^{c}
8	5.64±0.078^{a}	5.08±0.109^{a}	4.71±0.096^{b}	4.70±0.072^{c}
10	6.11±0.100^{a}	5.58±0.036^{a}	5.24±0.009^{b}	5.26±0.065^{c}
Total yeast count				
0	2.68±0.029^{a}	2.67±0.076^{a}	2.66±0.051^{a}	2.67±0.104^{a}
2	2.92±0.076^{a}	2.83±0.040^{a}	2.85±0.050^{a}	2.82±0.060^{a}
4	3.17±0.042^{a}	3.15±0.030^{a}	2.93±0.077^{b}	2.92±0.104^{b}
6	3.37±0.076^{a}	3.34±0.032^{a}	3.12±0.060^{b}	3.10±0.057^{b}
8	3.40±0.050^{a}	3.40±0.045^{b}	3.32±0.029^{c}	3.21±0.035^{c}
10	3.49±0.073^{a}	3.49±0.060^{ab}	3.40±0.100^{b}	3.32±0.076^{b}

$^{a\text{-}b\text{-}c}$ = Different letters in the same row indicates the mean values are significantly different ($p<0.05$)

Total soluble solids (TSS) are one of the important quality factors which determines concentration of sugar in the food product. TSS of the kiwifruit increased with increase in storage period. The TSS of uncoated fresh cut kiwi fruit samples resulted higher compared with the coated samples. However, no significant ($p>0.05$) difference was found between 0.8 and 1% chitosan coated samples but significant difference ($p<0.05$) was seen between 0, 0.6 and 0.8% chitosan coated samples on 10th day of storage. At the end of the storage, TSS observed in 0, 0.6, 0.8 and 1% chitosan treated samples were 15%, 14%,13% and 12.67% respectively. The changes in total soluble solids of fresh-cut kiwi fruit over the 10 days storage period were shown in Table 1. The similar kind of study was conducted for strawberry fruit (Hermandz-Munoz *et al*., 2008).

The titrable acidity (TA) was reported as a percentage of citric acid, since citric acid is the dominant acid in kiwi fruit (Fattahi *et al*., 2010). The TA values of uncoated fresh cut kiwi fruit samples resulted lower and decreased rapidly during the storage compared with coated samples. This may be due to the senescence (Han *et al*., 2004) of kiwi fruit. However, no significant ($p>0.05$) difference was seen between 0 and 0.6 % but significant difference was seen between 0.6 and 0.8% chitosan coated samples at the end of storage period (Table 1). At the end of storage, TA observed in 0, 0.6, 0.8 and 1% chitosan treated samples were 0.30%, 0.31%, 0.37% and 0.41% respectively. The highest level of TA was recorded for 1% chitosan coated samples after 10 days of storage at 5°C where the lowest levels were found in the uncoated samples at the end of storage period. Similar kind of results was reported for papaya, strawberry, peach, tomato and guava (Han *et al*., 2004; Ali *et al*., 2011; Hong *et al*., 2012).

Vitamin C in kiwi fruit gradually decreases during storage at 5°C for 10 days, and this reduction was effectively inhibited by 0.8 and 1.0% chitosan coatings (Figure3). Samples coated with 0.8 and 1.0% chitosan delayed the loss of vitamin C when compared with control and 0.6% chitosan coated samples. This may be due to the modified atmosphere generated by chitosan coating subdue the loss of vitamin C. However, no significant ($p>0.05$) difference was seen between 0, 0.6 and 0.8% chitosan coated samples but significant difference was seen between 0.8 and 1.0% at the end of storage period (Figure 3). At the end of storage, vitamin C observed in 0, 0.6, 0.8 and 1% chitosan treated samples were 67.89 mg/100 g, 71.87 mg/100 g, 72.23mg/100 g and 78.67mg/100 g respectively. Therefore, results showed that the kiwi fruits coated with 0.8 and 1.0% chitosan showed a slower decrease in vitamin C hence chitosan coating is capable in slowing down the loss of vitamin C during low temperature storage. Similar kind of results was shown for tomatoes stored at high CO_2 (Mathooko, 2003).

Firmness

Firmness of the kiwi fruit is considered as one of the major quality attributes judged by the consumers

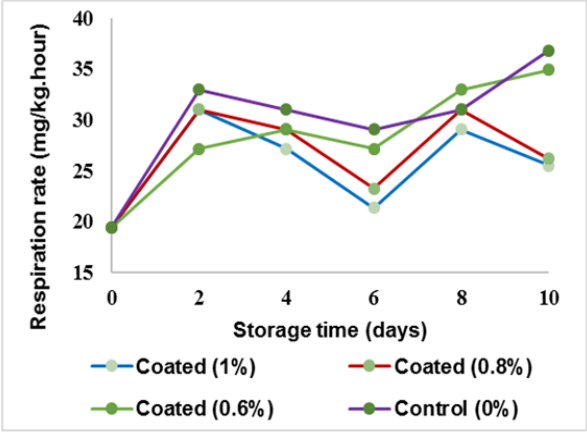

Figure 2. Change in Respiration rate of fresh-cut kiwi stored at 5°C

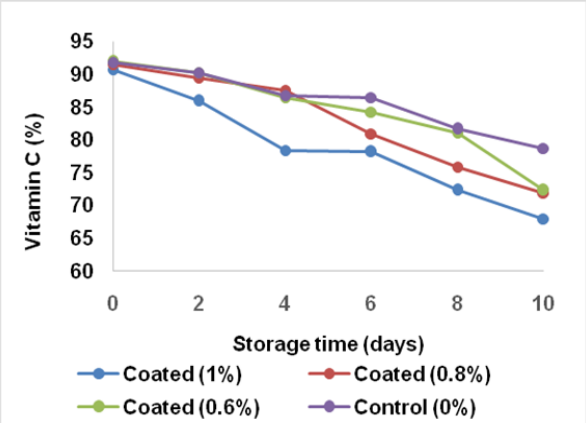

Figure 3. Change in Vitamin C of fresh-cut kiwi stored at 5°C

hence it is very important for overall product acceptance. Due to senescence in kiwi fruit firmness of the fruit losses rapidly which contributes greatly to its short postharvest life and microbial contamination. Samples coated with 0.8 and 1.0% chitosan delayed the loss of firmness compared with control and 0.6% chitosan coated samples. However, significant ($p>0.05$) difference was seen between the 0.8 and 1% chitosan coated samples at the end of storage period. At the end of storage, the firmness observed in 0, 0.6, 0.8 and 1% chitosan treated samples were 5 N, 8 N, 10 N and 10.75 N respectively. With regard to coated samples, 0.8 and 1.0% chitosan coating was more effective in decreasing the fruit firmness than other coated samples at 5°C. This may be due to preventing the deterioration in cell structure, intracellular materials and the cell wall composition (Vivek *et al*., 2016). Tomato and mango had also been reported to be firmer when compared with chitosan coated samples (Zhu *et al*., 2008). The maintenance of firmness in kiwi fruit treated with chitosan coatings could be due to their higher antimicrobial activity, covering of the cuticles and lenticels, thereby reducing infection, respiration and other ripening processes during storage. Various studies were reported the chitosan coating could delay firmness in papaya and sweet cherry (Martinez-Romero *et al*., 2006).

Respiration rate

Respiration rate is an important consideration in extending the postharvest shelf life of kiwi fruits. Samples coated with 0.8 and 1.0% chitosan reduced the respiration rate compared with control and 0.6% chitosan coated samples. However, no significant ($p>0.05$) difference was seen between 0.8 and 1% chitosan coated fruits but significant difference was seen between 0, 0.6 and 0.8% chitosan coated samples. At the end of storage, respiration rate observed in 0, 0.6, 0.8 and 1% chitosan treated samples were 36.83 mg/kg.h, 34.89 mg/kg.h, 26.17 mg/kg.h and 25.49 mg/kg.h respectively. Changes in respiration rate between control and coated fruit samples during 10 days of storage at 5°C are shown in Figure 2. Reduced respiration rate may be due to the controlled atmosphere created by the chitosan coating over kiwi fruit and it has selective permeability to gases which decreases the CO_2 exchange of coated kiwi fruit. The reduced rate of respiration delays the senescence of kiwi fruits and reduced susceptibility to decay (Romanazzi *et al*., 2007). Ali *et al*. (2011) showed that the chitosan treated papaya fruits resulted in increased internal CO_2 concentrations during storage. Meng *et al*. (2014) showed the CO_2 concentration decreased for 1.2% nano zinc oxide coated samples during storage compared with uncoated samples.

Total polyphenols

Kiwi fruit has been well known for its total Phenolic compounds. Total phenolic content in kiwi fruit gradually decreases during storage at 5°C for 10 days, and this reduction was effectively inhibited by chitosan coatings. Samples coated with 0.8 and 1.0% chitosan delayed the loss of total polyphenolic content compared with the control and 0.6% chitosan coated samples. This may be due to the accumulation of phenylalanine ammonia-lyase in the fruit (Oms-Oliu *et al*., 2008). However, no significant ($p>0.05$) difference was observed between 0.6, 0.8 and 1% chitosan coated fruit but significant ($p<0.05$) difference was observed between 0 and 0.6% chitosan coated samples. At the end of storage, the total polyphenolic content observed in 0, 0.6, 0.8 and 1% chitosan treated samples were 1.21mg GAE/gm, 1.37mg GAE/gm, 1.39mg GAE/gm and 1.46 mg GAE/gm respectively. While the loss of phenolic content was rapid after 8th day of storage for 0.8 and 1% coated samples. Similar kind of results were showed for chestnuts (Pen and Jiang, 2003), they

found that the concentration of chitosan coatings could significantly ($p<0.05$) prevents the changes in phenolic compounds.

Microbial analysis

The major problem with the fresh cut kiwi fruit is microbial contamination. Total bacteria, yeast and mold count in kiwi fruit gradually increases during storage at 5°C for 10 days, and this microbial load was effectively decreased by chitosan coatings (Table1). Samples coated with 0.8 and 1.0% chitosan reduced the microbial (bacterial, yeast and mold) load compared with control and 0.6% chitosan coated samples. This may be due to the anti-microbial effect showed by chitosan coating. However, significant ($p<0.05$) difference was seen between the 0.6, 0.8 and 1% chitosan coated fruits but there was no significant difference between 0 and 0.6% chitosan coated samples for bacteria on 10th day of storage period. Significant ($p<0.05$) difference was observed between the 0 and 0.6% chitosan coated fruits but there was no significant difference was observed between 0.8and 1% chitosan coated samples for yeast and mold. At the end of storage, total bacterial count observed in 0, 0.6, 0.8 and 1% chitosan treated samples were 6.11 Log CFU/g, 5.58 Log CFU/g, 5.24 Log CFU/g and 5.26 Log CFU/g respectively. At the end of storage, total yeast and mold count observed in 0, 0.6, 0.8 and 1% chitosan treated samples were 3.49 Log CFU/g, 3.49 Log CFU/g, 3.40 Log CFU/g and 3.32 Log CFU/g respectively. The increase in bacteria, yeast and mold count of fresh-cut kiwi fruit over the 10 days storage at 5°C period were shown in Table 1. Chitosan coating inhibit the growth of strawberries and carrot (Campaniello *et al*., 2008; Simoes *et al*., 2009).

Sensory evaluation

The results of sensory evaluation for coated and uncoated fruits were presented in Table 2. Four characteristics of kiwi fruit (colour, smell, taste and overall acceptability) were analysed for acceptability of the product. Initially the liking scores of coated and uncoated kiwi fruit samples were not significantly($P>0.05$) different. But at the end of storage period liking scores of both the coated and uncoated samples were significantly different ($p<0.05$). Samples coated with 0.8 and 1.0% were not significantly different ($p>0.05$) at the end of the storage period. However, chitosan coated samples got better score compared with the control and 0.6% chitosan coated samples (Table 2). No significant ($p>0.05$) difference was observed between 0.8 and 1.0% for taste, texture and overall liking of chitosan coated fruits on 10th day of storage period. But significant difference was seen between 0.6 and 0.8% for colour, taste, texture and overall liking of chitosan coated fruits on 10th day of storage period. While no significant difference was observed between the different chitosan coatings for all the sensory attributes on 0th day. But significant difference was observed between 0.8% and 1.0% chitosan coatings for texture and overall liking on 6th day of storage period (Table 2). Better sensory traits were obtained for 1% chitosan coated mangoes for 21 days storage compared with the waxol treated mangoes (Kittur *et al*., 2001).

Table 2. Effect of chitosan on sensory quality of fresh cut kiwi fruit stored at 5°C

Attributes	Storage time (days)	0 % chitosan	0.6 % chitosan	0.8% chitosan	1% chitosan
Colour	0	8.12± 0.98a	8.25± 1.47 a	8.22± 1.02a	8.15± 0.58 a
	6	7.01± 0.60 a	8.10± 0.11b	8.25± 0.17b	8.17± 0.11b
	10	6.13± 1.31a	7.50± 0.74 b	8.10± 0.70 c	8.67± 0.49 d
Smell	0	8.52± 0.85 a	8.32± 1.08 a	8.30± 1.11 a	8.45± 0.95 a
	6	7.03± 0.17 a	7.80± 0.98b	8.41± 0.19c	8.50± 0.67c
	10	5.46± 0.59 a	7.00± 1.20 b	7.13± 1.46 b	7.20± 1.01 b
Taste	0	8.53± 0.64 a	8.33± 0.49 a	8.13± 0.74 a	8.13± 1.00 a
	6	6.99± 0.22 a	7.71± 0.51b	8.31± 0.23c	8.29± 0.36c
	10	3.40± 0.88 a	6.20± 0.56 b	7.13± 1.46 c	7.27± 1.03 c
Texture	0	9.00± 0.76 a	9.07± 0.59 a	8.87± 0.83 a	9.07± 0.59 a
	6	7.11± 0.10 a	8.35± 0.15b	8.73± 0.5c	9.11± 0.12d
	10	3.13± 0.96 a	7.10± 0.96 b	9.00± 0.76 c	9.10± 0.96 c
Overall liking	0	8.12± 0.76 a	8.56± 1.07 a	8.03± 1.00 a	8.00± 0.96 a
	6	6.21± 0.12 a	7.31± 0.40b	7.47± 0.14b	7.89± 0.23c
	10	4.73± 0.98 a	6.22± 0.56 b	7.03± 0.35 c	7.01± 0.94 c

$^{a\text{-}b\text{-}c\text{-}d}$ = Means within a row with different letters are significantly different ($p<0.05$)

Conclusion

Chitosan coatings could delay the decay (microbial and non-microbial) and extends the shelf life of ultrasound combined with NaOCl treated fresh cut kiwi fruit during storage at 5°C for 10 days. This study concluded that the treatment with 0.8 and 1.0%

chitosan coating significantly ($p<0.05$) reduced the mass loss, RR, growth of microorganisms, maintains TSS, retarded the loss of firmness, TA, vitamin C and improves the sensory quality (colour, smell, taste, texture and overall liking) of kiwi fruit. Hence, application of chitosan appears to be highly promising in the field of food processing for extending the shelf life of kiwi fruits during storage with superior quality.

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