Project ID -465

Competitive Research Grant

Sub-Project Completion Report

on

Validation and up scaling of fresh cut fruits and vegetables processing technologies

Project Duration

May 2017 to September 2018

Postharvest Technology Section,
Horticulture Research Centre
Bangladesh Agricultural Research Institute (BARI)
Joydebpur, Gazipur-1701

Submitted to
Project Implementation Unit-BARC, NATP-2
Bangladesh Agricultural Research Council
Farmgate, Dhaka-1215

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Project Implementation Unit
National Agricultural Technology Program-Phase II Project (NATP-2)
Bangladesh Agricultural Research Council (BARC)
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Acronyms

AV	Aloe vera
BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agricultural Research Institute
C	Centigrade
CFU	Colony Forming Unit
cm	Centimeter
Co-PI	Co-principal Investigator
CRG	Competitive Research Grant
etc	*et cetera*
FCFV	Fresh cut fruits and vegetables
FC	Fresh cut
Fig.	Figure
g	Gram
h	Hour
HRC	Horticulture Research Centre
km	Kilometer
kW	Kilo Watt
l	Litre
LDPE	Low Density Polyethylene
MAP	Modified Atmospheric Packaging
mm	Millimeter
mm	Millilitre
N	Newton
PCR	Project Completion Report
PI	Principal Investigator
RH	Relative Humidity
S	Second
TSS	Total Soluble Solid
TB	Total Bacterial Count
%	Percentage
°	Degree

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Executive Summary

Fruits and vegetables are high in value and loaded with nutrients required for good health and wellness. It has a vital role in income augmentation, poverty mitigation and food security in Bangladesh. Increasing urbanization, changes in life style and involvement of more women into jobs have forced to find out easy way to get safe and nutritious foods. Fresh cut fruits and vegetables have been physically modified (by peeling, trimming, washing and cutting) to obtain 100% edible product that is subsequently packaged and kept in refrigerator. When the intact produce is cut, increases respiration, desiccation, discolouration and microbial spoilage. Lowering storage temperature is the single most important factor to reduce deterioration of FCFV. However, there are many other preservation techniques used for FCFV, such as antioxidants, acidulants, edible coatings, sanitizers and modified atmosphere packaging (MAP), as well as good manufacturing and handling practices. In Bangladesh, research on fresh cut fruits and vegetables is very limited. So it is necessary to develop quality fresh cut processing technologies of fruits and vegetables, its utilization and dissemination. This project aims to develop quality fresh cut (FC) processing technologies of fruits (jackfruit, pineapple, strawberry) and vegetables (carrot, cauliflower and bell peppers) using sanitizers (clorox, calcinated calcium), acidulants (citric acid, ascorbic acid) and edible coatings (Aloe vera, chitosan) and packaging (MAP, vacuum, cling film, polypropylene box) keeping in refrigerator.

Under this project, a survey was conducted in different super shops and street vendors to assess the existing situation and future prospects of FCFVs in Bangladesh. Besides, six experiments on fruits (jackfruit, pineapple, strawberry) and vegetables (carrot, cauliflower and bell peppers) were conducted and developed technologies.

Fresh carrots were cut into 1 cm thick round shape and were treated with warm (60°C) aqua's solution of 2% NaCl (table salt) or warm (60°C) aqua's solution of 2% citric acid for 1 minute. After removing surface water a 100g slices were placed into PP box and kept in refrigerator (4±1^{o}C). Control carrot/without heat treatment was acceptable up to 3 days, carrot treated with warm solution of 2% NaCl was acceptable up to 8 days and carrot treated with warm solution of 2% citric acid was acceptable more than 10 days. Washed cauliflower and green bell pepper was cut into small pieces after removing surface water a 100 g cauliflower or bell pepper pieces were kept open or into polypropylene (PP) box or into LDPE bag (25 µm) and performed vacuum and kept in refrigerator (4±1^{o}C). Control or open FC cauliflower was good up to 4 days, PP box packed one good up to 16 days and vacuum packed cauliflower was good more than 20 days. Control or open FC green bell pepper was good up to 2 days, PP box packed one good up to 8 days and vacuum packed bell pepper was good more than 10 days. Skin of washed pineapple was removed with a sharp knife, quartered and sliced transversely (5 mm thick).Jackfruit (Khaza) bulbs were collected from fruits and seeds were removed. A 5 pieces pineapple or jackfruit bulbs were kept in PP box and put in refrigerator (4±1^{o}C). Fresh cut pineapple and jackfruit bulb was good up to 5 and 9 days respectively. Whole washed strawberries were dipped Aloe vera gel for coating. After drying of surface coating fruits were kept in PP box and then put in refrigerator (4±1^{o}C). Uncoated strawberry was good up to 6 days, strawberry coated with Aloe vera gel was acceptable for more than 9 days.

CRG Sub-project Completion Report (PCR)

A. Sub-project Description

1. Title of the CRG sub-project: **Validation and up scaling of fresh cut fruits and vegetables processing technologies**
2. Implementing organization: Bangladesh Agricultural Research Institute (BARI)
3. Name and full address with phone, cell and E-mail of PI/Co-PI (s):

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4. **Sub-project budget (Tk):**
   4.1 Total: 16,00,000.00 (Sixteen lakh taka only)
   4.2 Revised (if any): Not any

5. **Duration of the sub-project**:
   5.1 Start date (based on LoA signed): 9 May, 2017
   5.2 End date: 30 September 2018

6. **Justification of undertaking the sub-project:**
   Fresh cut fruits and vegetables (FCFVs) is an emerging issue in Bangladesh. Consumer awareness in healthy and nutritious foods and busy life style are increasing the demand of FCFVs. But the shelf life of FCFVs is very less as it is very much susceptible to attack by microorganism and aging. So it is essential to do thorough research to get safe and long lifeFCFVs. But scanty research on FCFVs has been done especially in Bangladesh. That's why this subproject has been undertaken to find out suitable fresh cut processing technologies of three fruits (jackfruit, pineapple, strawberry) and vegetables (carrot, cauliflower and bell peppers) using natural, inorganic and herbal produce and easy ways.

7. **Sub-project goal:** To develop quality fresh cut fruits and vegetables in view to improve nutritional security and reduce postharvest losses.

8. Sub-project objective (s)

8.1 . To know the existing situation of fresh cut fruits and vegetables in Bangladesh

8.2 . To study the use of sanitizer, safe food additives, edible coating and packaging of fresh cut fruits and vegetables to extend the shelf life with quality

8.3 . To determine the microbial load and storage potential of fresh cut fruits and vegetables for safe products

9. Implementing location (s): Postharvest Technology Section, Horticulture Research Centre, BARI, Joydebpur, Gazipur-1701

10. Methodology in brief

Materials:

Fresh ripe jackfruit (Khaja type), pineapple (Giant Kew), fresh carrot (Kuroda),fresh matured cauliflower (Atlas 70)and green bell pepper (California wonder)were purchased from local market at Gazipur and strawberry (BARI strawberry-1) was collected from Fruit Research Field, HRC, BARI. It was immediately brought to the laboratory, and screened for uniformity which was being free from any mechanical damage and diseases, and also same stage of maturity. Selectedfruits and vegetables, knives; all used utensils were washed with sanitizers (200 ppm sodium hypochlorite). After wearing apron, hand gloves, cap and musk, fresh cut processing of fruits and vegetables was done.

Fresh cut processing of carrot

Carrots were peeled with hand peeler and simultaneously trimmed of tap root and stem plate and cut into 1 cm thick round shape with sharp knives. Carrot slices were treated with the following solutions such as: i. normal tap water ii. warm (60°C) aqua's solution of 2% NaCl iii. warm (60°C) aqua's solution of 2% citric acid iv. warm (60°C) aqua's solution of 10% lime juice v. warm (60°C) water. Surface water of slices were removed by using fan. A 100g slices was placed into polypropylene clear box, closed by stapler and then put into refrigerator at 4±1^{o}C temperature.

Fresh cut processing of cauliflower and bell pepper

Washed cauliflower was cut into small pieces with sharp knives. Washed green bell pepper was cut into 5 mm square size. Surface water of cauliflower and bell pepper pieces were removed using fan. A 100 g cauliflower or bell pepper pieces were packed into any one of the following packaging system such as i. without packaging (control); ii. Kept into polypropylene (PP) box and closed by stapling iii. Kept into styro foam tray and wrapped with cling film (17 µm); iv. Kept into 1 % perforated low density polyethylene (LDPE) bag (25 µm); v. Kept into LDPE bag (25 µm) and sealed; vi. Kept into LDPE bag (25 µm) and performed vacuum and kept in to refrigerator at 4±1^{o}C temperature.

Fresh cut processing of pineapple and jackfruit

Skin of washed pineapple was removed with a sharp knife, quartered and sliced transversely (5 mm thick).On the other hand, jackfruit (Khaza type) bulbs were collected from fruits and seeds were removed. Pineapple pieces or jackfruit bulbs were treated with 5 treatments, such as i. soak in tap water ii. soaked in 100 ppm clorox iii. soaked in 0.1% calcinated calcium iv. soaked in

1% citric acid v. without soaked/washed. Surface water of slices were removed by using fan. A 100gslices was placed into polypropylene clear box, closed by stapler and then put into refrigerator at 4±1^{o}C temperature.

Fresh cut processing of strawberry

Whole washed strawberries were dipped with (a) Tap water; (b) 1.5% chitosan solution; (c) 1.5% chitosan solution with 1% $CaCl_2$; (d) 100% Aloe vera gel and (e) 100% Aloe vera gel with 1% $CaCl_2$. After removing surface water using fan, whole fruit or pieces were kept into polypropylene clear box, closed by stapling and then put into refrigerator at 4±1^{o}C temperature.

Preparation of aloe vera (AV) gel and chitosan solution

To prepare 100 ml of 1.5 % chitosan solution, 1.5 g of chitosan was dissolved in 75 ml of distilled water, and 2 ml of glacial acetic acid were added. The mixture was heated with continuous stirring (55°C and 8.33 s^{-1}) for proper dissolution of chitosan. The final pH of the solution was adjusted to 5.6 with 2N NaOHand volume was made up to 100 ml with sterilized distilled water (Jiang and Li, 2001).

Matured leaves of Aloe vera (AV)plants were washed with 25% chlorine solution. AV matrix was then separated from the outer cortex of leaves and this colourless hydro parenchyma was ground using blender and filtered to remove the fibres. The gel was pasteurized at 70°C for 45 min and allowed to cool to ambient temperature. Ascorbic acid (2.0 g L^{-1}) and then citric acid (4.5 g L^{-1}) were added to maintain its pH around 4. To improve the viscosity and coating efficiency of AV gel, 1% carboxy methyl cellulose (gelling agent) was added and mixed properly and then stored in amber glass bottle to prevent oxidation (Nasrin et al., 2017).

Survey works have been conducted in different outlet of super shops like Prince Bazar Ltd., Shwapno, Agora, Meena Bazar, Lavender etc and to some street vendors at Dhaka city using questionnaire.

During storage colour, weight loss, firmness, ascorbic acid, acidity, total soluble solid (TSS), total sugar, reducing sugar, sensory quality (colour, fresh like appearance, fresh like aroma and overall acceptability), microbial load and shelf life were determined. In case of fresh cut carrot, beta carotene content and whiteness index (WI)were determined additionally.

Respiration rate measurement

Respiration rate of fresh cut produce was assayed of each treatment during storage. 20 g from each replication were placed in 500 mL airtight plastic containers equipped with septa and sealed for 2 h (incubation time) at ambient condition (25±2°C). Then one mL of gas was withdrawn from the headspace of container by a gas light hypodermic syringe and analyzed using a gas analyser (CO_2/O_2 gas analyser, Quantek Instrument, Model No. 902D, USA). The percentage of CO_2 gas in the container was recorded. Thereafter, the respiration rate was calculated using total gas volume, sample volume and sample weight in the container and incubation time (Nasrin et al, 2017).

Measurement of firmness

Firmness was analyzed using Fruit Texture Analyzer (GUSS, Model No. GS25, SA). An 8 mm diameter stainless steel cylindrical probe with a flat end was used for this measurement. The

probe was pushed to a depth of 3 mm into cauliflower slices (same position of each sample) at a speed of 5 mm s^{-1}. The maximum penetration force (N) was used as firmness value of sample.

Measurements of colour

Surface colour of fresh cut sample was evaluated with a Chroma Meter (Model CR-400, Minolta Corp., Japan) based on CIE (*L*a*b*)*. *L** is lightness whereas *a** and *b** values were transformed to chroma (c) and hue angle (h°) automatically in this Chroma meter. Before measurement, the equipment was calibrated against a standard white tile. Three readings were taken at different locations on each slice, using 3 slices from each treatment.

Ascorbic acid, titratable acidity, total sugar, reducing sugar, p^H and TSS determination

The ascorbic acid content, titratable acidity, total sugar and reducing sugar of sample were analyzed according to AOAC (1994). TSS of samplejuice was measured using refractometer. Ten (10) g of ground sample was suspended in 100 ml of distilled water and then filtered. The pH of the sample (cauliflower juice) was assessed using a pH meter (HANNA Instrument Inc, pH-211; Microprocessor, pH Meter, Italy).

Microbiological analysis

10 g fresh cut produce were blended and mixed properly with 90 ml of sterile 0.9% Sodium Chloride (NaCl) solution. One ml of each homogenate sample was added into appropriate dilutions ($10^{-1}$to 10^{-6}) using 0.9% NaCl solution. Nutrient agar (Difco TM, USA, PH 7.0-7.4) was used to determine Total Bacterial Count (TBC) and potato dextrose agar (PDA, Hi Media, India) were used to enumerate yeast and molds. Media were prepared according to manufacturer's instruction. Briefly, media was sterilized by autoclave at 121° C for 15 minutes. From appropriate dilution, 100 µl homogenate of each samples was inoculated in respective culture media by using sterile pipette and was spread using sterile glass spreader. Inoculated nutrient agar plates were then kept in an incubator at 37°C for 24 to 28 hours whereas PDA plates were incubated at ambient temperature (26 ± 2°C) for 5 days. Following incubation, plates exhibiting colonies were counted. The average number of colonies in a particular dilution was multiplied by the dilution factor to obtained TBC. Microorganisms associated with samples were expressed as colony forming units per gram (CFU/g). Cell counts (CFU/g) were the average of at least 3 independent experiments (Mahfuza et al., 2016).

Sensory quality

Sensory quality of fresh cut produce was evaluated at 10 and 20 day during storage. Stored fresh cut sample was kept at ambient temperature 1 hour before sensory quality evaluation. The sensorial attributes of fresh cut cauliflower (colour, fresh-like appearance, fresh-like aromaand overall acceptability) were evaluated by a panel of judges consisting of 15 scientific personnel and consumers including both male and female members. Nine-point unstructured scale ranging from 1 (dislike extremely) to 9 (like extremely) was used to evaluate these sensory parameters (Nasrin and Anal, 2015). An average score of 4.5 was considered the limit for acceptability.

Statistical analysis: All the experiments were conducted in triplicate and means ± standard deviations were reported. Analysis of variance was done by one way ANOVA procedures of MSTAT-C software. Comparisons among the samples were done by Duncan's Multiple Range Test (DMRT).

Pictorial presentation of fresh cut processing technique (example pineapple)

Wearing of apron, hand gloves, musk and cap after washing hands with sanitizers

Washing fruits/vegetables, knives; all used utensils with sanitizers (200 ppm sodium hypochlorite/ 0.1% calcinated calcium)

Removing inedible parts.

Removing of peel with eyes with sharp knife

Cutting in suitable size

Keeping into suitable box

Wrapping tray with cling film

Keeping FC pineapple at refrigerator

11. Results and Discussion

Fresh cut processing of carrot

By analyzing physical, chemical, microbial and sensory data, results were found and discussed below:

Respiration rate:

Figure 1 illustrates the effect of heat treatment with acid and base on respiration rate of fresh cut carrot stored at refrigerator (4±1°C) for 12 days. Initial respiration rate of FC sliced carrot was 115.15 mg $kg^{-1}h^{-1}$. The respiration rate of all FCcarrot after storage in refrigeration was reduced but significant reduction was observed in heat treated samples. At 3rd day of storage respiration rate was 61.77 mg $kg^{-1}h^{-1}$ in control carrot whereas it was around 17 mg $kg^{-1}h^{-1}$of heat treated carrot and was not changed significantly throughout the storage period. Kato-Noguchi and Watada (1997) reported that respiration rate of shredded carrot was around 153 mg $kg^{-1}h^{-1}$ and after dipping in citric acid respiration rate of shredded carrots was reduced by 50% or more.

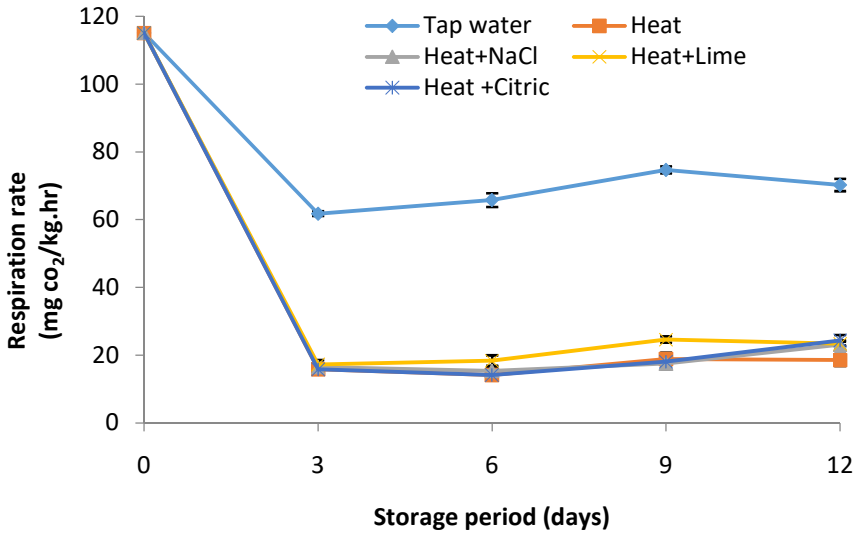

Fig 1.Respiration rate of fresh cut carrot during storage at refrigerator. Tap water=Wash with normal tap water; Heat+NaCl= Heated in 2% NaCl solution at 60°C; Heat+citric = Heated in 2% citric acid solution at 60°C; Heat+lime= Heated in 10% lime juice at 60°C; Heat= Heated in tap water at 60°C . Vertical bars indicate standard deviation.

Firmness

Firmness or texture is a critical quality attribute in the consumer acceptability of FCfruits and vegetables. Figure 2 represents the changes in firmness of treated and non-treated fresh cut carrots during the storage period at refrigerator (4 ± 1°C). Initially the firmness value of sliced carrot was 4.38 N and it decreased gradually with time but untreated or control carrot slice lost their firmness more than the treated FCcarrot. Control carrot lost around 9% firmness whereas carrot treated with warm solution of 2% citric acid had lost around 5% firmness at 9th day of storage period.

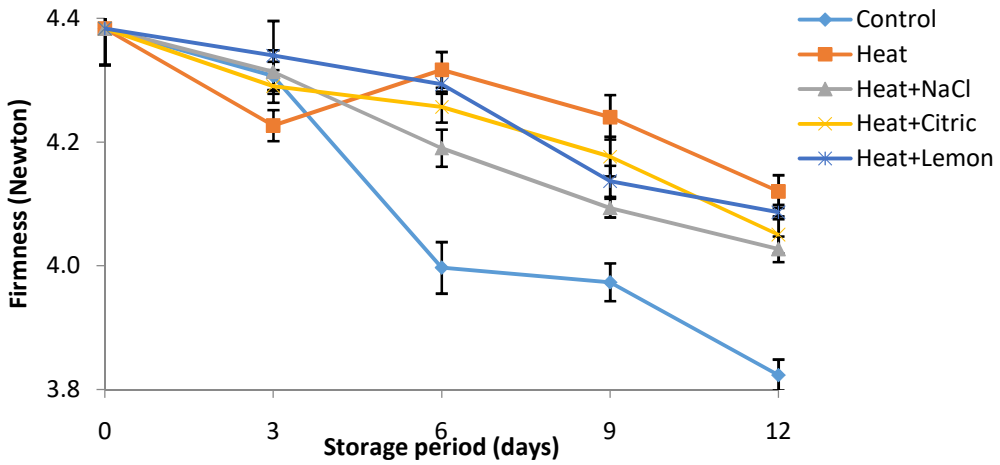

Fig 2.Firmness of fresh cut carrot during storage at refrigerator. Tap water=Wash with normal tap water; Heat+NaCl= Heated in 2% NaCl solution at 60°C; Heat+citric = Heated in 2% citric acid solution at 60°C; Heat+lime= Heated in 10% lime juice at 60°C; Heat= Heated in tap water at 60°C . Vertical bars indicate standard deviation.

Colour parameters (whiteness index)

Just after processing (day 0), WI value was 31.4 but it increased in all samples with storage period as shown in fig. 3. The rate of increment of WI values was significantly higher in control than the heat treated ones. Whiteness index value of control carrot was increased by 48.4% whereas it was only 12.07% in carrot slices treated with warm solution of 2% citric acid. Alegria, et al. (2009) found that heat treatment (before grated, whole carrot treated with hot water 100°C/ 45 s) maintained their initial WI value throughout storage. Amanatidou et al. (2000) reported that dipping in citric acid solution prevented the whitening of the carrot.

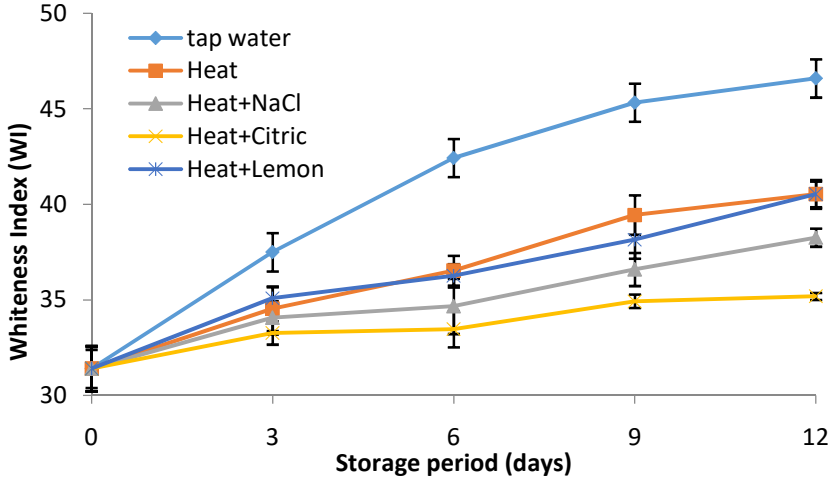

Fig.3. Whiteness index offresh cut carrot during storage at refrigerator. Tap water=Wash with normal tap water; Heat+NaCl= Heated in 2% NaCl solution at 60°C; Heat+citric = Heated in 2% citric acid solution at 60°C; Heat+lime= Heated in 10% lime juice at 60°C; Heat= Heated in tap water at 60°C . Vertical bars indicate standard deviation.

Microbial analysis

French regulations establish a limit of 5×10^8 CFU/g (8.67 log CFU/g) as the maximum acceptable contamination values for the total bacterial count (TBC) in carrot sticks (Aked, 2002). Initial TBC of fresh cut carrot was 2.1 logCFU/g. After heat treatment it was lowered and then it was increased

slightly during storage. Highest amount (4.13log CFU/g) of TBC was observed in control carrot while it was only 2.26 log CFU/g in fresh cut carrot treated with warm solution of 2% citric acid. However TBC in all samples was below the maximum acceptable contamination values for the TBC in carrot slices. Rocha, et al. (2007) also stated that the total counts of micro-organisms at 30°C and 7°C never exceeded the maximum acceptable limit of log CFU g^{-1} = 8 during storage. There were no detectable Yeast and Mold counts in any samples initially and during their storage life. Alegria et al. (2009) reported that no yeast and mold was found in heat treated samples immediately after minimal processing or throughout storage (always less than the detection limit of 10^{1}CFUg-^{1}).

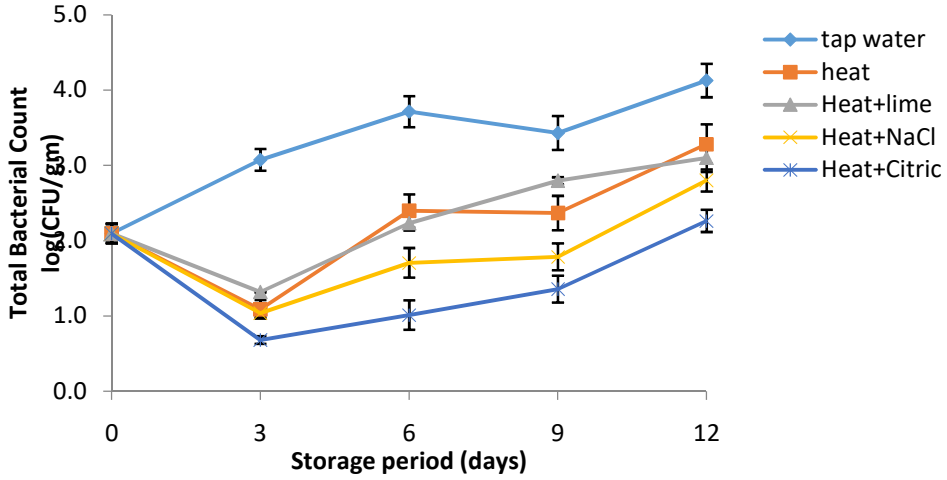

Fig. 4. Total bacterial count of FCcarrot throughout the storage period at refrigerator. Tap water=Wash with normal tap water; Heat+NaCl= Heated in 2% NaCl solution at 60°C; Heat+citric = Heated in 2% citric acid solution at 60°C; Heat+lime= Heated in 10% lime juice at 60°C; Heat= Heated in tap water at 60°C . Vertical bars indicate standard deviation.

Chemical parameters

Total soluble solids (TSS) and pH found for fresh cut carrot was 9.5°Brix and 6.3 respectively (Table 1). During storage slight decreased of TSS and pH were found in all samples.

Table 1. TSS, pH and ascorbic acid content in fresh cut carrot during storage at refrigerator

Treatment	Total soluble solid (TSS)			pH			Ascorbic acid (mg/100g)		
	0 day	5 days	10 day	0 day	5 days	10 day	0 day	5 days	10 day
Control	9.5±.06	9.4±.06	9.3±.06	6.3±.01	6.2±.01	6.1±.01	15.3±.01	10.3±.1	9.3±.01
Heat	9.2±.06	9.1±.06	9.1±.06	6.1±.01	6.0±.01	6.0±.01	14.8±.01	11.8±.13	10.8±.01
Heat + NaCl	9.8±.06	9.8±.1	9.7±.1	6.4±.01	6.3±.01	6.2±.01	14.9±.01	11.9±.15	10.4±.01
Heat + CA	9.9±.06	9.8±.1	9.7±.1	5.3±.01	5.3±.01	5.1±.01	16.6±.01	15.3±.17	14.8±.01
Heat + lime	9.3±.06	9.1±.06	8.8±.06	6.1±.01	6.1±.01	6.0±.01	15.8±.01	12.3±.13	9.9±.01

Tap water=Wash with normal tap water; Heat+NaCl= Heated in 2% NaCl solution at 60°C; Heat+citric = Heated in 2% citric acid solution at 60°C; Heat+lime= Heated in 10% lime juice at 60°C; Heat= Heated in tap water at 60°C .

Fresh cut carrot retained ascorbic acid around 15 (mg/100g) just after processing as shown in table 1. It was reduced during storage in all samples but the reduction rate was different. The lowest (9.3 mg/100g) was observed in control carrot whereas carrot treated with warm solution of 2% citric acid retained the highest (13 mg/100g). Total and reducing sugar content in fresh cut carrot was 6.75% and

2.78% respectively. During storage the both sugar content was reduced slightly and there was no significant difference among the treatment. Kaur et al. (1976) reported that 1.67–3.35% reducing sugars, 1.02–1.18% non-reducing sugars and 2.71–4.53% total sugars were found in 6 cultivars of carrot. Lee et al. (2011) reported that during storage, the total sugar content, glucose and fructose all slightly decreased after 2 weeks at 2°C.

Table 2. Total sugar, Reducing sugar and Beta carotene content in fresh cut carrot during storage at refrigerator

Treatment	Total sugar (%)			Reducing sugar (%)			Beta carotene (µg/ g)		
	0 day	5 days	10 day	0 day	5 days	10 day	0 day	5 days	10 day
Control	6.7±.02	5.9±.04	4.8±.04	2.7±.09	2.3±.03	2.2±.02	44.7±.2	42.8±.3	41.9±.2
Heat	6.2±.02	5.5±.02	4.8±.03	2.3±.09	2.4±.06	2.3±.02	48.4±.3	47.6±.2	46.6±.3
Heat + NaCl	6.3±.02	5.7±.03	4.6±.02	2.4±.09	2.4±.03	2.4±.01	48.4±.2	48.1±.4	45.2±.2
Heat + CA	6.1±.02	5.7±.02	4.7±.04	2.3±.09	2.5±.02	2.4±.02	48.3±.3	47.9±.4	46.3±.1
Heat + lime	6.0±.02	5.4±.03	4.4±.04	2.2±.09	2.4±.02	2.4±.03	48.4±.3	47.7±.3	45.3±.1

Tap water=Wash with normal tap water; Heat+NaCl= Heated in 2% NaCl solution at 60°C; Heat+citric = Heated in 2% citric acid solution at 60°C; Heat+lime= Heated in 10% lime juice at 60°C; Heat= Heated in tap water at 60°C .

The beta carotene content of fresh cut carrot just after processing and during their storage period are shown in table2. Fresh carrot contained 44.7 (µg/g) beta carotene whereas after heat treatment it was increased to around 48 µg/g. Dutta, et al (2005) reported that the beta carotene content had increased from 84 (fresh sample) to 100.8 µg/g (in 3 min. heat treated sample). During storage beta carotene content was reduced in all treatments it was the lowest (41.9 µg/g) in control and the highest (46.6 µg/g) in only heat treated one.

Sensory quality

Sensorial results for colour, fresh-like appearance, fresh-like aroma and overall acceptability are shown in table 3. After processing (day 0), the scores for all attributes of treated and control samples were not significantly different (data were not shown). Concerning heat treated samples during storage, colour maintenance is observed since control samples scored 4.5 while others got more than 7 (scores varied between 6.8 and 8.5) at 4th day of storage. Fresh cut carrot treated with warm solution of 2% citric acid secured 7.3 while it was less than 4 in rest of the samples recognized as unacceptable. Score 4.5 limit the consumer's acceptability. Sensory evaluation of the colour attribute was in agreement with whiteness index evolution during storage.

Table 3. Sensory quality of fresh cut carrot during storage at refrigerator

Treatment	Colour			Fresh-like Appearance			Fresh-like Aroma			Overall acceptability		
	4day	8day	10day	4day	8day	10 day	4day	8day	10 day	4day	8 day	10 day
Control	4.5±.2	3.2±.2	3±.2	4.3±.6	3.4±.7	2.3±.1	5.1±.1	4.1±.3	3.4±.3	4.5±.3	3.5±.3	3.3±.1
Heat	6.8±.3	4.1±.3	3.4±.3	6.1±.7	4.2±.2	3.3±.1	5.3±.1	4.2±.1	3.2±.1	5.3±.2	4.3±.2	3.8±.1
Heat+NaCl	7.5±.1	5.5±.1	4.3±.1	7.7±.1	5.1±.3	4.3±.1	7.8±.1	6.2±.2	5.2±.2	7.8±.1	5.8±.1	4.4±.1
Heat+CA	8.5±.1	7.7±.1	7.3±.1	8.8±.1	7.9±.1	6.3±.1	8.6±.1	8.6±.1	7.6±.1	8.7±.2	8.3±.2	7.3±.1
Heat+lime	6.9±.2	4.2±.2	3.3±.2	7.2±.6	4.4±.4	3.8±.1	6.3±.1	5.1±.5	4.4±.5	5.3±.3	4.3±.3	4.3±.1

Tap water=Wash with normal tap water; Heat+NaCl= Heated in 2% NaCl solution at 60°C; Heat+citric = Heated in 2% citric acid solution at 60°C; Heat+lime= Heated in 10% lime juice at 60°C; Heat= Heated in tap water at 60°C .

Benefit cost ratio

Sodium chloride treated fresh cut carrot

Cost of preparing 5 kg FC carrot:

Item	No./Amount	Rate (Tk.)	Price (Tk.)
Clorox	7 ml	450.00/2 litre	1.6
Sodium Chloride	100 g	35.00/kg	3.5
Labour	3 hrs.	450.00/8hrs	168.75
Packaging materials (PP box)	20 nos	4.00	80
		Total	253.85~254

Farm gate price of 5 kg carrot @ Tk. 40.00/kg = Tk. 200.00 ……. (i)

Sale price of fresh cut (treated with sodium chloride) 5 kg carrot@ Tk. 120.00/kg = Tk. 600.00

Storage cost = 5% of sale price of value added products

So sale price of fresh cut (sodium chloride treated) 5kg carrot = Tk. (600 X0.95) = Tk. 570.00 …… (ii)

Benefit (ii)-(i) = Tk. (570-200) = Tk. 370

Benefit: Cost = 370:254 = 1.46: 1

Based on sensorial, microbial and physicochemical characteristics, control carrot/without heat treatment was acceptable up to 3 days, carrot treated with warm solution of 2% NaCl was acceptable up to 8 days and carrot treated with warm solution of 2% citric acid was acceptable more than 10 days.

Fresh cut carrot, 0 days | **Control carrot stored at 4th day** | **Carrot treated with 2% citric acid warm solution stored at 10th day**

Fig. 5. Pictorial view of fresh cut carrot during storage

Fresh cut processing of cauliflower

By analyzing physical, chemical, microbial and sensory data, results were found and discussed below:

Weight loss

With storage period, weight loss of all samples was happened with time but it was severe in control or without packaging cauliflowers as shown in figure 6. Maximum weight loss (37.45%) was occurred in control whereas it was only around 3% in sealed and vacuum packed FC cauliflowers and around 5% in perforated LDPE, cling wrapped and PPbox packed FC cauliflowers at 20th day of storage.

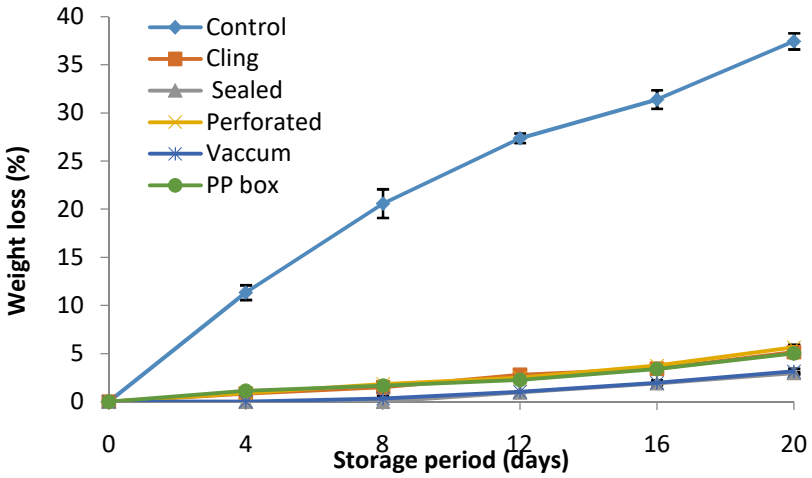

Fig.6. Weight loss of fresh cut cauliflower throughout the storage period at refrigerator (4 ± 1°C). Control=Open/ without packaging; Cling= Kept into styro foam tray and wrapped with cling film; Sealed= Kept into LDPE bag and sealed; Perforated= Kept into 1 % perforated LDPE bag; Vacuum= Kept into LDPE bag and performed vacuum & sealed, PP box=Kept into PP box and closed by stapling. Vertical bars indicate standard deviation.

Among the packaging techniques, except vacuum packeging, moisture condensation was observed all other samples. Simón*et al.* (2008) reported that less mass loss was happened in minimally processed cauliflower stored in polyvinyl chloride (PCV) film, perforated PCV and polypropylene bags resulting condensation inside the package. Nevertheless, when there is humidity excess inside modified atmosphere, it may favour microorganisms' growth causing deterioration.

Respiration rate

Initial respiration rate of fresh cut cauliflower pieces was 109.20 ml $kg^{-1}h^{-1}$. Furlaneto*et al.* (2017)reported that respiration rate of fresh cut cauliflower just after processing was around 120 ml $kg^{-1}h^{-1}$.The respiration rate of all fresh cut cauliflower after storage in refrigeration was reduced significantly as shown in figure 7.

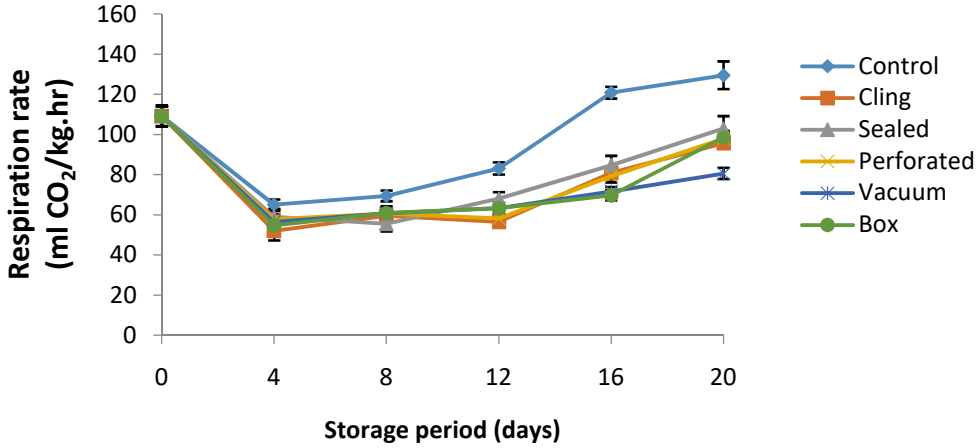

Fig.7. Respiration rate of fresh cut cauliflower throughout the storage period at refrigerator. Control=Open/ without packaging; Cling= Kept into styro foam tray and wrapped with cling film; Sealed= Kept into LDPE bag and sealed; Perforated= Kept into 1 % perforated LDPE bag; Vacuum= Kept into LDPE bag and performed vacuum & sealed, PP box=Kept into PP box and closed by stapling. Vertical bars indicate standard deviation.

Respiration rate of control fruit was higher than packed fruit throughout the storage especially it was raised significantly after 12 day of storage in control. At 20th day of storage respiration rate was 149.47 ml kg^{-1}h^{-1} in control fresh cut cauliflower where as it was 80.57 ml kg^{-1}h^{-1} in vacuum packed and around 100 ml kg^{-1}h^{-1} in the rest of the packaging treatments. Worknehe*t al.* (2001) reported that LDPE film allowed a lower respiration rate and was preferred to the PP although the lowest microbial counts were observed in PP film up to 14 days. The lower the respiration rates the longer the storage life.

Firmness

Initially the firmness value of fresh cut cauliflower was 1.03 N and it was decreased gradually with time but without packed or control fruits lost their firmness significantly more than the packed fresh cut cauliflower as shown in figure 8. Among the packaging treatment, cauliflower packed in sealed and vacuum packed was most firm during the storage period and it lost only around 21% firmness and 32% by the cauliflower packed in perforated LDPE bag, PP box and cling wrapped whereas unpacked or control FC cauliflower had lost almost 63% firmness at 20th day of storage. Dhall*et al.* (2010) reported that whole cauliflower packed with cling film and LDPE bag stored at 0°C temperature lost 30.87% and 33.33% firmness respectively at 28 days of storage period.

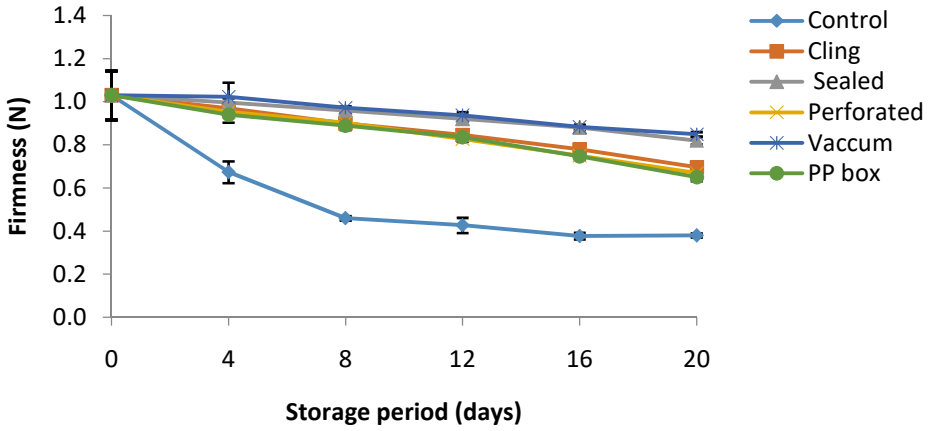

Fig.8. Firmness of fresh cut cauliflower throughout the storage period at refrigerator. Control=Open/ without packaging; Cling= Kept into styro foam tray and wrapped with cling film; Sealed= Kept into LDPE bag and sealed; Perforated= Kept into 1 % perforated LDPE bag; Vacuum= Kept into LDPE bag and performed vacuum & sealed, PP box=Kept into PP box and closed by stapling. Vertical bars indicate standard deviation.

Colour

Colour is an important factor in the perception of cauliflower curd quality. Colour of cauliflower was expressed by lightness (L*), chroma and hue angle. The hue angle of cauliflower displayed a decreasing trend in all treatments with storage period but the more decreasing tendency was found in control cauliflower than packed one stored at refrigerator. On the other hand cauliflower packed in vacuum LDPE bag preserved their original colour more than that of other packaging techniques. The hue value of FC cauliflowers just after processing was between 103.6, which indicate the yellow region of the colour axis. The lower the number the more yellow, it is indicating a deterioration of cauliflower colour.

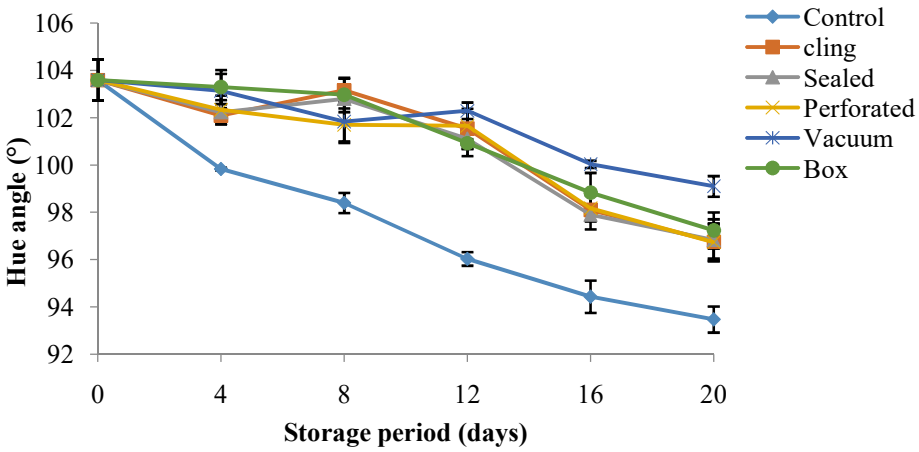

Fig. 9. Colour (hue angle) of fresh cut cauliflower throughout the storage period at refrigerator. Control=Open/ without packaging; Cling= Kept into styro foam tray and wrapped with cling film; Sealed= Kept into LDPE bag and sealed; Perforated= Kept into 1 % perforated LDPE bag; Vacuum= Kept into LDPE bag and performed vacuum & sealed, PP box=Kept into PP box and closed by stapling. Vertical bars indicate standard deviation.

Microbial analysis

French regulations establish a limit of 5×10^8 CFU/g (8.67 log CFU/g) as the maximum acceptable contamination values for the total bacterial count (TBC) in carrot sticks (Aked, 2002). Initial total bacterial count (TBC) of FC cauliflower was 0.15 log CFU/g. The highest amount (around 4.1 log CFU/g) of TBC was observed in four packaging techniques (perforated LDPE bag, sealed LDPE bag, PP box and cling film) of FC cauliflower and 3.67 log CFU/g and 2.26 log CFU/g was found in control and vacuum packed ones respectively at 20th day, stored at refrigerator (4±1°C). FC cauliflower packed in perforated LDPE bag, sealed LDPE bag, PP box and cling wrapped, condensation was produced inside the package. After 16th day of storage there is humidity excess inside packages that helps microorganisms' growth. That's why higher amount of TBC was found in these packages even more than the control samples. However in all samples TBC was below the maximum acceptable contamination values in FC cauliflowers. Sanz, et al, (2007) reported that the microbial load in FC cauliflowers before packaging varied from 3.04 log CFU g^{-1} to 3.92 log CFU g^{-1} for the Dulis variety.

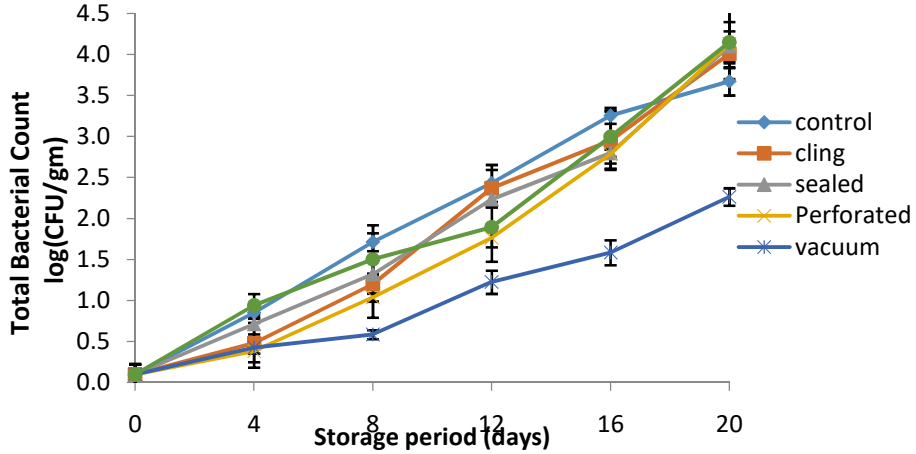

Fig. 10. Total bacterial count of fresh cut carrot throughout the storage period at refrigerator. Control=Open/ without packaging; Cling= Kept into styro foam tray and wrapped with cling film; Sealed= Kept into LDPE bag and sealed; Perforated= Kept into 1 % perforated LDPE bag; Vacuum= Kept into LDPE bag and performed vacuum & sealed, PP box=Kept into PP box and closed by stapling. Vertical bars indicate standard deviation.

There were no detectable Yeast and Mold counts in any samples initially and during their storage life. Alegria*et al.* (2009) also reported that no yeast and mold was found in heat treated samples immediately after minimal processing or throughout storage (always less than the detection limit of 10^1CFU g-^{1}).

Total soluble solids (TSS), pH and titratable acidity content

Titratable acidity, TSS and pH content of fresh cut cauliflower just after processing was 0.25%, 6.5° Brix and 6.8 as shown in table 4. During storage, acidity decreased slightly but TSS and pH increased. Initially, acidity, TSS and ascorbic acid content was 0.15%, 7.7°Brix and 62.97 mg/100g respectively in cauliflower was found by Raja, *et al.* (2011). He also found slight increase in acidity and decreased in ascorbic acid content during storage period.

Table 4. TSS, pH and titratable acidity content in fresh cut cauliflower during storage at refrigerator

Treatment	Total soluble solid (TSS)			pH			Titratable acidity		
	0 day	10 days	20 day	0 day	10 day	20 day	0 day	10 day	20 day
Control	6.8±.06	7.1±.03	7.3±.01	6.5±.01	6.6±.01	6.8±.01	0.25±.03	0.21±.1	0.19±.01
Cling	6.8±.06	6.8±.06	7.1±.02	6.5±.01	6.5±.01	6.6±.01	0.25±.03	0.23±.13	0.22±.01
Sealed	6.8±.06	6.7±.1	6.5±.01	6.5±.01	6.6±.01	6.6±.01	0.25±.03	0.24±.15	0.21±.01
Perforated	6.8±.06	6.8±.1	7.0±.04	6.5±.01	6.5±.01	6.6±.01	0.25±.03	0.23±.17	0.20±.01
PP box	6.8±.06	6.9±.03	7.0±.03	6.5±.01	6.5±.01	6.7±.01	0.25±.03	0.22±.13	0.20±.01
Vacuum	6.8±.06	6.7±.02	6.6±.02	6.5±.01	6.6±.01	6.6±.01	0.25±.03	0.24±.1	0.23±.13

Control=Open/ without packaging; Cling= Kept into styro foam tray and wrapped with cling film; Sealed= Kept into LDPE bag and sealed; Perforated= Kept into 1 % perforated LDPE bag; Vacuum= Kept into LDPE bag and performed vacuum & sealed, PP box=Kept into PP box and closed by stapling.

Higher amount of TSS was found in control cauliflower as more water loss was occurred here followed by cling wrapped and perforated LDPE packed cauliflower than sealed and vacuum packed LDPE bag throughout the storage period. Chitarra and Chitarra (2005) explain that organic acids are used as substrates in respiratory process or transformed into sugars. The minimally processed cauliflower pH values showed increment during 10 days of storage and statistical differences ($p < 0.01$) for control, vacuum and 6% CO_2+ 4% O_2treatments.

Table 5. Total sugar, reducing sugar and ascorbic acid content in fresh cut carrot during storage at refrigerator

Treatment	Total sugar			Reducing sugar			Ascorbic acid (mg/100g)		
	0 day	10 day	20 day	0 day	10 day	20 day	0 day	10 day	20 day
Control	4.7±.02	4.4±.04	4.5±.04	2.1±.04	1.8±.03	1.6±.02	59.3±.01	51.3±.1	39.7±.01
Cling	4.7±.02	4.5±.02	4.4±.03	2.1±.04	2.1±.06	1.8±.02	59.3±.01	57.8±.13	50.8±.01
Sealed	4.7±.02	4.7±.03	4.6±.02	2.1±.04	2.0±.03	1.9±.01	59.3±.01	57.9±.15	48.4±.01
Perforated	4.7±.02	4.6±.02	4.5±.01	2.1±.04	2.0±.02	1.9±.02	59.3±.01	56.2±.17	47.8±.01
PP box	4.7±.02	4.5±.03	4.4±.05	2.1±.04	1.9±.02	1.8±.03	59.3±.01	57.3±.13	49.9±.01
Vacuum	4.7±.02	4.7±.03	4.6±.02	2.1±.04	2.0±.02	1.9±.03	59.3±.01	58.1±.1	53.1±.13

Control=Open/ without packaging; Cling= Kept into styro foam tray and wrapped with cling film; Sealed= Kept into LDPE bag and sealed; Perforated= Kept into 1 % perforated LDPE bag; Vacuum= Kept into LDPE bag and performed vacuum & sealed, PP box=Kept into PP box and closed by stapling.

Ascorbic acid in FC cauliflower was 59.3 mg/100g. At 20th day of storage, ascorbic acid content was reduced severely in without packed cauliflower stored at refrigerator as shown in table 5. On the other hand, total sugar and reducing sugar content of FC Cauliflower just after processing was 4.7% and 2.1% respectively and it was reduced slightly during storage period. Simon *et al.* (2008) reported reducing sugar contents had reduction (27% in 20 days of storage) throughout studied period for cauliflower MP being better conserved in non-perforated PVC. Lee *et al.* (2011) reported that during storage, the total sugar content, glucose and fructose all slightly decreased after 2 weeks at 2°C.

Sensory quality

Sensorial results for colour, fresh-like appearance, fresh-like aroma and overall acceptabilityare shown in table 6. Throughout the storage time, all the samples showed a loss of sensory quality. However, at 10th day of storage, in case of overall acceptability, control/unpacked FC cauliflower secured 4.4 scores (dislike slightly to neither like nor dislike) that indicate unacceptable by the consumer's preference, while more than 8 (like very much to like extremely) scores were obtained by all type of packed FC cauliflowers. However, vacuum packed cauliflower obtained 7.5 scores (like moderately to like very much) whereas rest of the packaged FC cauliflowers scored around 4 (dislike slightly to neither like nor dislike) at 20th day of storage in case of overall acceptability. Score 4.5 limit the consumer's acceptability.

Table 6. Sensory quality of fresh cut cauliflower during storage at refrigerator based on colour, flavor, texture and overall acceptability

Treatment	Colour		Fresh like appearence		Fresh like aroma		Overall acceptability	
	10 day	20 day	10 day	20 day	10 day	20 day	10 day	20 day
Control	4.2±.2	1.8±.2	3.4±.7	2.3±.1	4.1±.3	2.4±.3	4.4±.3	2.3±.1
Cling	7.7±.3	4.5±.3	8.2±.2	4.8±.2	7.8±.1	5.2±.1	8.3±.2	4.2±.1
Sealed	7.5±.1	4.3±.1	8.1±.3	3.8±.5	8.2±.2	5.2±.2	8.6±.1	4.4±.1
Perforated	7.7±.1	4.3±.1	7.9±.1	4.3±.2	8.4±.1	5.6±.1	8.3±.2	4.3±.1
PP box	7.9±.2	4.3±.2	8.4±.4	4.5±.3	8.1±.5	5.4±.5	8.3±.3	4.3±.1
Vacuum	8.7±.2	7.5±.2	8.5±.3	7.5±.2	8.7±.5	7.4±.5	8.8±.3	7.5±.1

Control=Open/ without packaging; Cling= Kept into styro foam tray and wrapped with cling film; Sealed= Kept into LDPE bag and sealed; Perforated= Kept into 1 % perforated LDPE bag; Vacuum= Kept into LDPE bag and performed vacuum & sealed, PP box=Kept into PP box and closed by stapling.

Benefit cost ratio

Vacuum packed fresh cut cauliflower:

Cost of preparing 10 no's FC cauliflower:

Item	No./Amount	Rate (Tk.)	Price (Tk.)
Clorox	7 ml	450.00/2 litre	1.6
Labour (2 nos)	1.5 hrs.	450.00/8hrs	168.75
Packaging materials (LDPE)	20 nos	1.00	20
		Total	190.35~191

Farm gate price of 10 nos cauliflower @ Tk. 40.00/piece = Tk. 400.00 ……. (i)

Sale price of fresh cut (vacuum packed) 10 nos cauliflower @ Tk. 80.00/ piece = Tk. 800.00

Storage cost = 5% of sale price of value added products

So sale price of fresh cut (vacuum packed) 10 nos cauliflower = Tk. (800 X0.95) = Tk. 760.00 ……. (ii)

Benefit (ii)-(i) = Tk. (760-400) = Tk. 360

Benefit: Cost = 360:191 = 1.88: 1

Based on sensorial, microbial and physicochemical characteristics control fresh cut cauliflower without packaging was acceptable up to 4 days, FC cauliflower packed in perforated LDPE bag, sealed LDPE bag, PP box and cling wrapped was acceptable up to 16 days and vacuum packed cauliflower was acceptable more than 20 days.

Fig. 11. Pictorial view of fresh cut cauliflower during storage

Fresh cut processing of Bell pepper

By analyzing physical, chemical, microbial and sensory data, results were found and discussed below:

Weight loss

During storage, weight loss of all samples was occured with time but it was severe in control or without packaging FC bell peppers as shown in figure 12. Maximum weight loss (45.48%) was occurred in control at 6th day where as it was only around 3% in sealed and vacuum packed FC bell pepper and around 4% in cling wrapped and PP box packed FC bell pepper at 8th day of storage. Among the packaging techniques, except vacuum, moisture condensation was observed all other samples. Nevertheless, when there is humidity excess inside modified atmosphere, it may favour microorganisms' growth causing deterioration.

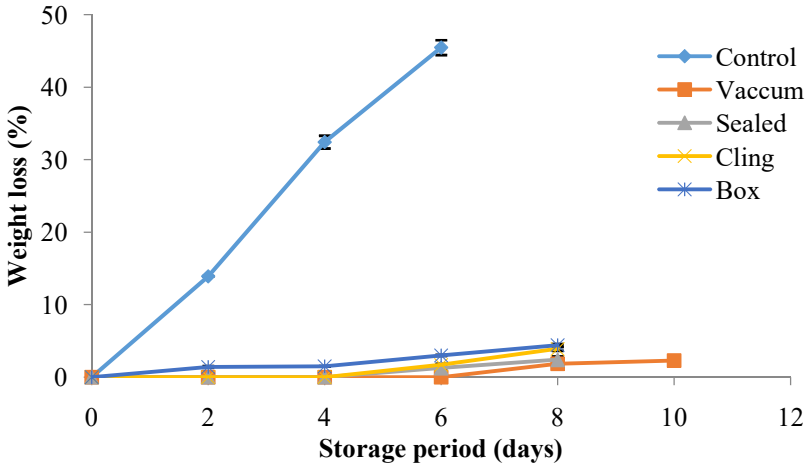

Fig.12. Weight loss of fresh cut green bell peppers throughout the storage period at refrigerator. Control=Open/ without packaging; Cling= Kept into styro foam tray and wrapped with cling film; Sealed= Kept into LDPE bag and sealed; Vacuum= Kept into LDPE bag and performed vacuum & sealed, PP box=Kept into PP box and closed by stapling. Vertical bars indicate standard deviation.

Respiration rate

Initial respiration rate of fresh cut green bell pepper pieces was 25 ml $kg^{-1}h^{-1}$ at ambient condition.

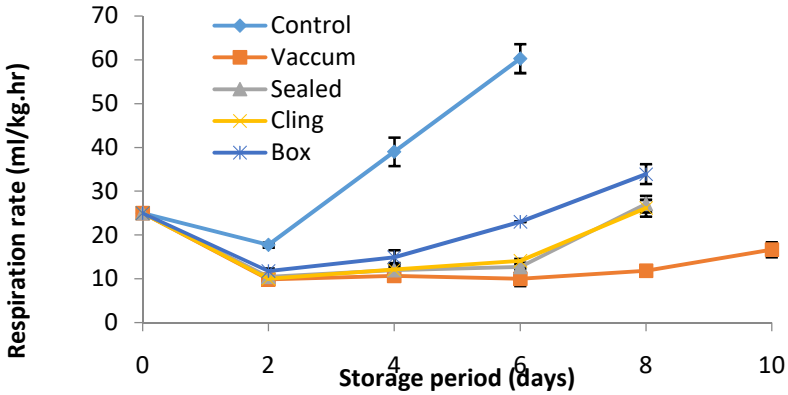

Fig.13. Respiration rate of fresh cut green bell peppers during storage period at refrigerator. Control=Open/ without packaging; Cling= Kept into styro foam tray and wrapped with cling film; Sealed= Kept into LDPE bag and sealed; Vacuum= Kept into LDPE bag and performed vacuum & sealed, PP box=Kept into PP box and closed by stapling. Vertical bars indicate standard deviation.

The respiration rate of all fresh cut bell pepper just after storage was reduced and it was raised again in late stage of storage as shown in figure 13. Respiration rate of control fruit was increased significantly and peaked to around 60 ml $kg^{-1}h^{-1}$whereas it is only 10 ml $kg^{-1}h^{-1}$in vacuum packed FC bell pepper at 6^{th} day of storage. Lim et al (2007)reported that respiration rate of green bell pepper at 10°C was around 17mg.$kg^{-1}h^{-1}$ and it was reduced during storage. Saltveit, (1997) observed that the respiration rate of bell pepper stored at 20°C was 32 to 36 mg$kg^{-1}h^{-1}$. Ladaniya, (2008) reported that wounding, rotting and severe shriveling of fruits stimulate respiration and ethylene production. The lower the respiration rates the longer the storage life.

Firmness

Initially the firmness value of fresh cut bell pepper was 0.6 N and it was decreased gradually with time but without packed or control fruits lost their firmness significantly more than the packed fresh cut bell pepper as shown in figure 14.

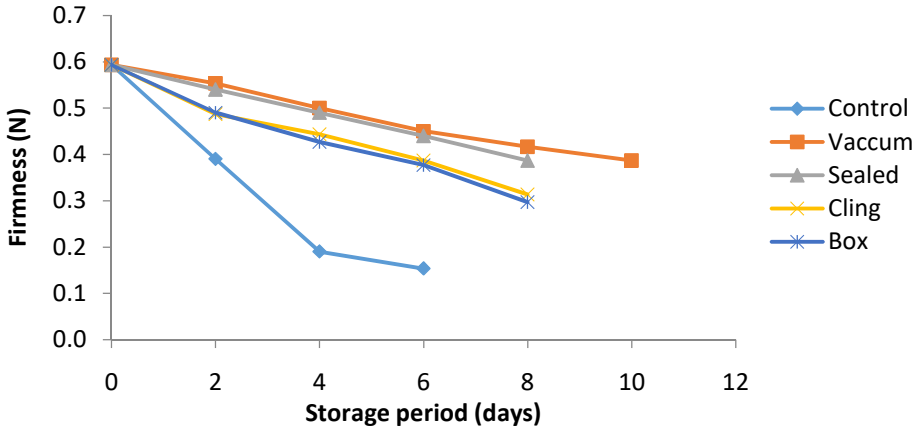

Fig.14. Firmness of fresh cut green bell peppers during storage period at refrigerator. Control=Open/ without packaging; Cling= Kept into styro foam tray and wrapped with cling film; Sealed= Kept into LDPE bag and sealed; Vacuum= Kept into LDPE bag and performed vacuum & sealed, PP box=Kept into PP box and closed by stapling. Vertical bars indicate standard deviation.

Among the packaging treatment, FC bell pepper packed in sealed and vacuum packed was most firm during the storage period and it lost only around 24% firmness and control FC bell pepper had lost almost 75% firmness at 6^{th} day of storage.

Colour

Colour is an important factor in the perception of FC produce quality. Colour of FC bell pepper was expressed by hue angle. The hue angle of FC green bell pepper displayed a decreasing trend in all treatments with storage period but the more decreasing tendency was found in control bell pepper than packed one stored at refrigerator. On the other hand bell pepper packed in vacuum LDPE bag preserved their original colour more than that of other packaging techniques. The hue angle value of FC bell pepper just after processing was between 128.47, which indicate the green region of the colour axis. Manolopoulou*et al.* (2012) reported that the initial hue angle (h*) of fresh cut green bell pepper was 117.5±1.8. Lim *et al*. (2007)reported that hue angle of fresh green bell pepper and 28^{th} day of storage at 10°C was 128.5 and 123.2 respectively.

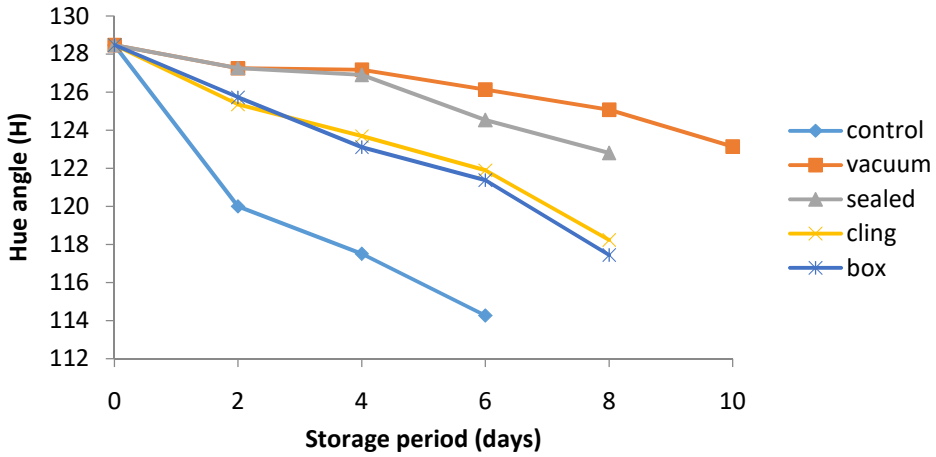

Fig.15. Colour (hue angle) of fresh cut green bell peppers throughout the storage period at refrigerator. Control=Open/ without packaging; Cling= Kept into styro foam tray and wrapped with cling film; Sealed= Kept into LDPE bag and sealed; Vacuum= Kept into LDPE bag and performed vacuum & sealed, PP box=Kept into PP box and closed by stapling. Vertical bars indicate standard deviation.

Microbial analysis

French regulations establish a limit of 5×10^8 CFU/g (8.67 log CFU/g) as the maximum acceptable contamination values for the total bacterial count (TBC) in carrot sticks (Aked, 2002). Initial total bacterial count (TBC) of FC bell pepper was 0.1 log CFU/g. The highest amount (around 4.33 log CFU/g) of TBC was observed in FC bell pepper packed in sealed LDPE bag and this value was similar with that of PP box and cling-wrapped ones at 8^{th} day of storage period. 3.94 log CFU/g and 2.96 log CFU/g was found in control at 6^{th} day and vacuum packed ones at 10^{th} day, stored at refrigerator (4±1°C). FC bell peppers packed in sealed LDPE bag, PP box and cling wrapped, condensation was produced inside the package. The excess humidity inside packages helps microorganisms' growth. That's why higher amount of TBC was found in these packages even more than the control samples. However in all samples TBC was below the maximum acceptable contamination values in FC bell pepper.

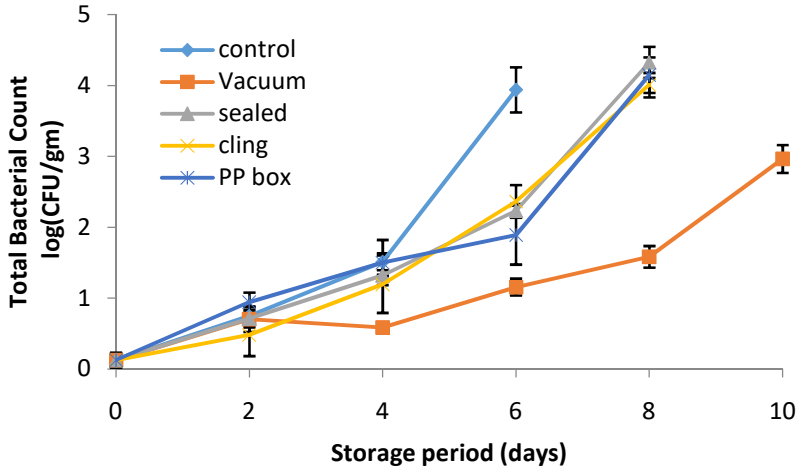

Fig.16. Total bacterial count of fresh cut green bell peppers throughout the storage period at refrigerator. Control=Open/ without packaging; Cling= Kept into styro foam tray and wrapped with cling film; Sealed= Kept into LDPE bag and sealed; Vacuum= Kept into LDPE bag and performed vacuum & sealed, PP box=Kept into PP box and closed by stapling. Vertical bars indicate standard deviation.

Ediriweera*, et al*. (2014) reported that the total microbial count in FC bell pepper was 5.36 log_{10}CFU/g at 7th day of storage at 8-10°C. Tissue damage for precutting and slicing spoiled faster than sound tissue because of leakage of plant nutrients (Varoquaux and Wiley, 1994). If the microbial criterion of 10^7 to $10^8 g^{-1}$ is used for shelf life determination (O' Beirne, 1990) the shelf lives of fresh cut pepper was 6 days for 5°C and 4 days for 10°C storage.

There were no detectable Yeast and Mold counts in any samples initially and during their storage life. Alegria*et al.* (2009) reported that no yeast and mold was found in heat treated samples immediately after minimal processing or throughout storage (less than the detection limit of 10^1CFU g-^{1}).

Ascorbic acid, TSS and pH content

Ascorbic acid, pH and TSS content of fresh cut green bell pepper just after processing was 26.8 mg/100 g,5.96 and 4.95° Brix as shown in table 7. During storage, pH decreased slightly but TSS increased. Maximum TSS was found in control bell pepper as it was not packed (open) results more evaporation than packed one at 6th days of storage in refrigerator.

Table 7. Ascorbic acid, TSS and pH content in fresh cut green bell pepper during storage at refrigerator

Treatment	Ascorbic acid (mg/100 g)		pH		Total soluble solid (TSS)	
	0 day	6 days	0 day	6 day	0 day	6 day
Control	26.8±.02	17.1±.03	5.96±.01	5.83±.14	4.95±.03	6.90±.14
Cling	26.8±.02	21.8±.06	5.96±.01	5.85±.11	4.95±.03	5.11±.13
Sealed	26.8±.02	22.7±.10	5.96±.01	5.89±.13	4.95±.03	4.96±.15
PP box	26.8±.02	20.9±.03	5.96±.01	5.86±.12	4.95±.03	5.03±.13
Vacuum	26.8±.02	23.2±.02	5.96±.01	5.91±.13	4.95±.03	4.96±.12

Control=Open/ without packaging; Cling= Kept into styro foam tray and wrapped with cling film; Sealed= Kept into LDPE bag and sealed; Vacuum= Kept into LDPE bag and performed vacuum & sealed, PP box=Kept into PP box and closed by stapling.

Renu and Chidanand, 2013 reported that there was decrease in pH value and increase in TSS value as the storage time increases in all the treatments.Ediriweera, *et al.,* 2014 reported that the initial pH and TSS of fresh cut green bell peppers was 5.72 and 4.8 respectively those values were 6.15 and 4.33 at 7th day of storage at 8-10°C temperature. On the other hand Maximum loss of ascorbic acid content was occurred in control bell pepper at 6th days of storage in refrigerator. Vitamin C is susceptible to oxidation by ascorbic acid oxidase, and losses can be minimized by modified atmosphere packaging of the produce after harvest (Howard and Hernandez-brenes1998; Barth *et al.*1993). Nerdy, 2018 reported that vitamin C levels in various colors of bell pepper, for green bell pepper 16.52 mg/100 g; yellow bell pepper 159.61 mg/ 100 g; orange bell pepper 121.38 mg/100 g; red bell pepper 81.19 mg/100 g. Ascorbic acid content in our sample was higher than the referenced one it may be due to varietal characteristics.

Sensory quality:

Sensorial results for colour, fresh like appearance, fresh like aroma, texture and overall acceptability are shown in table 8. Throughout the storage time, all the samples showed a loss of sensory quality. However, at 8th day of storage, in case of overall acceptability, control/uncoated FC bell pepper secured 2.4 scores that indicate unacceptable by the consumer's preference, while more than 5 scores were obtained by all type of packed FC bell pepper. However, vacuum packed bell pepper obtained 5.5

scores whereas rest of the packaged FC bell pepper scored around 4 (dislike slightly to neither like nor dislike) at 10th day of storage in case of overall acceptability. 4.5 scores limit the consumers' acceptability.

Table 8. Sensory quality of fresh cut green bell peppers during storage at refrigerator based on colour, fresh like appearance, fresh like aroma and overall acceptability

Treatment	Colour		Fresh like appearance		Fresh like aroma		Overall acceptability	
	8 day	10 day	8 day	10 day	8 day	10 day	8 day	10 day
Control	2.7±.5	1.8±.2	3.4±.7	2.3±.1	2.1±.3	1.4±.3	2.4±.3	1.3±.1
Cling	5.7±.2	3.2±.3	5.2±.2	3.7±.2	5.8±.1	3.8±.1	5.1±.2	3.2±.1
Sealed	7.5±.1	4.5±.1	6.1±.3	4.3±.5	6.2±.2	4.5±.2	6.9±.1	4.4±.1
PP box	5.1±.2	3.8±.2	5.1±.4	3.9±.3	5.1±.5	4.0±.5	5.3±.3	3.1±.1
Vacuum	7.7±.2	5.5±.2	6.5±.3	5.5±.2	6.7±.5	6.4±.5	7.8±.3	5.5±.1

Control=Open/ without packaging; Cling= Kept into styro foam tray and wrapped with cling film; Sealed= Kept into LDPE bag and sealed; Vacuum= Kept into LDPE bag and performed vacuum & sealed, PP box=Kept into PP box and closed by stapling.

Benefit cost ratio

Vacuum packed fresh cut green bell pepper:

Cost of preparing 20 no's FC green bell pepper:

Item	No./Amount	Rate (Tk.)	Price (Tk.)
Clorox	7 ml	450.00/2 litre	1.6
Labour (2 nos)	1.5 hrs.	450.00/8hrs	168.75
Packaging materials (LDPE)	20 nos	1.00	20
		Total	190.35~191

Farm gate price of 20 nos green bell pepper @ Tk. 40.00/piece = Tk. 800.00 ……. (i)

Sale price of fresh cut (vacuum packed) 20 nos green bell pepper @ Tk. 70.00/ piece = Tk. 1400.00

Storage cost = 5% of sale price of value added products

So sale price of fresh cut (vacuum packed) 20 nos bell pepper = Tk. (1400 X0.95) = Tk. 1330.00……. (ii)

Benefit (ii)-(i) = Tk. (1330-800) = Tk. 530

Benefit: Cost = 530:191 = 2.77: 1

In conclusion, based on sensorial, microbial and physicochemical characteristics control fresh cut green bell pepper without packaging was acceptable up to 2 days, bell pepper packed in sealed LDPE bag, PP box and cling wrapped was acceptable up to 8 days and vacuum packed one was goodup to 10 days.

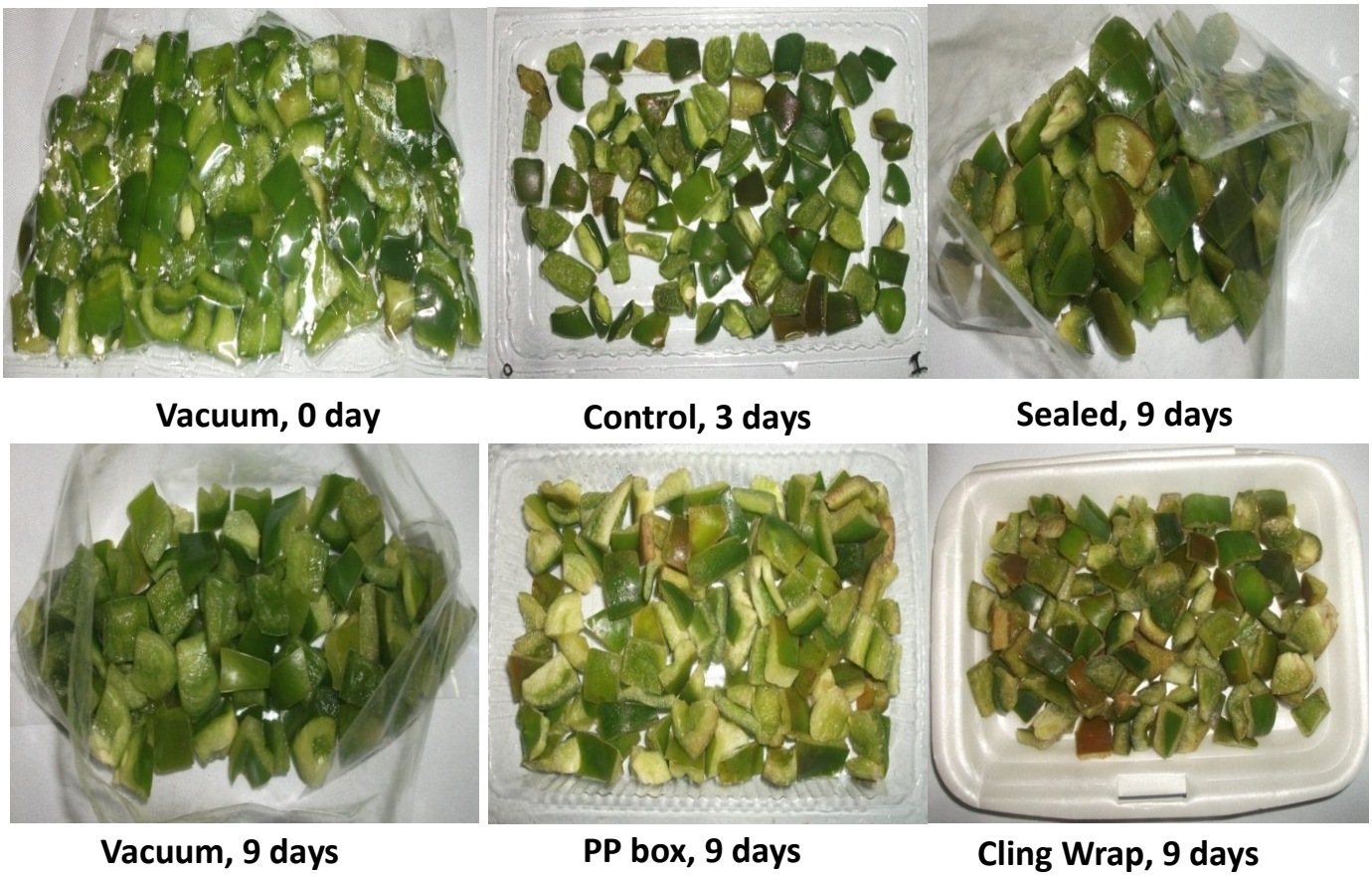

Fig. 17. Pictorial view of fresh cut bell pepper during storage

Fresh cut processing of pineapple

By analyzing physical, chemical, microbial and sensory data, results were found and discussed below:

Respiration rate

Peeling, decoring and slicing caused acceleration in the respiration to an extent of 41.26±1.7 $mg.kg^{-1}.h^{-1}$ at ambient condition. Low temperature storage and sanitizing treatment given to pretreated samples was found beneficial in reducing this cut-induced respiration to around 20 mg CO_2 $kg^{-1}.h^{-1}$ at 2nd day of storage in all samples after that it was increased significantly in tap water treated pineapple slices during storage. The lowest amount (around 29 $mg.kg^{-1}.h^{-1}$) of CO_2 was produced by sanitized pineapple slices whereas the maximum (49.63 $mg.kg^{-1}.h^{-1}$) amount was found in tap water washed samples followed by 37.03 $mg.kg^{-1}.h^{-1}$ found in without washed samples at 6th day of storage in 4±1° C. Samples especially wash with tap water recorded severe raise in respiration rate indicating decay of the samples by spoilage causing microorganism.

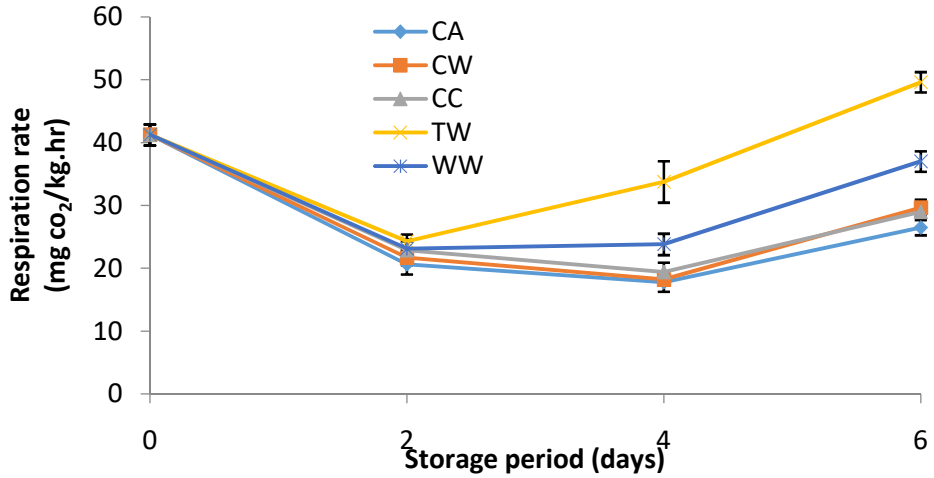

Fig 18.Respiration rate of fresh cut pineapple during storage at refrigerator. TW= Washed with tap water, CA= Washed with 2% citric acid solution, CC= Washed with 0.1% calcinated calcium solution, CW= Washed with 200 ppm sodium hypochlorite solution, WW= Without wash.Vertical bars indicate standard deviation.

Colour

The hue angle indicates the intensity or saturation of the colour, being yellow in the case of pineapple. Initial value of hue angle just after processing was 104.43. The higher fall in hue angle values of samples washed with tap water and without wash sample. Whereas, samples treated with sanitizers preserved the natural yellowish color of pineapple pieces during the storage (Fig. 19). Among the sanitizers adopted in the study, 2% citic acid treated pineapple pieces were observed to maintain the color intensity significantly that retained 94.47 since it was found 89.43 in fresh cut pineapple wash with tap water at 6th day of storage. Bernardino *et al.* (2016) reported that like L* values, higher h* values were also obtained in 1-MCP (1-methylcyclopropene) treated fresh cut pineapple up to 4 daythan control sample.

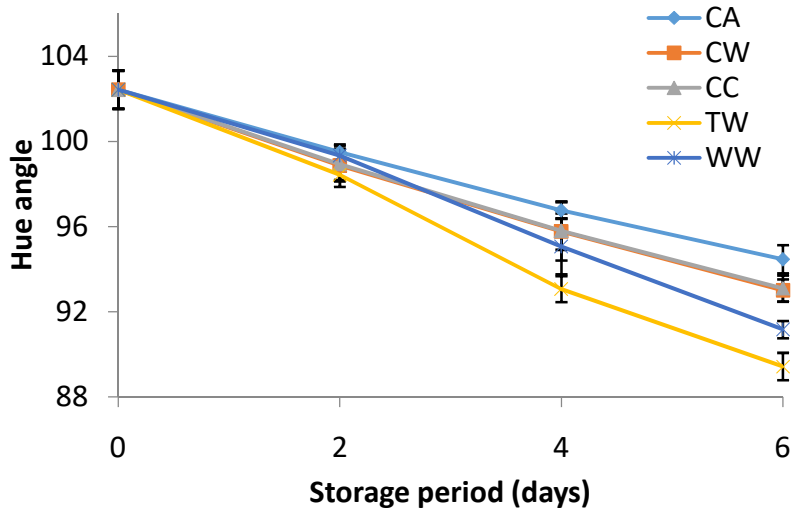

Fig 19.Colour value in terms of hue angle of fresh cut pineapple during storage at refrigerator. TW= Washed with tap water, CA= Washed with 2% citric acid solution, CC= Washed with 0.1% calcinated calcium solution, CW= Washed with 200 ppm sodium hypochlorite solution, WW= Without wash. Vertical bars indicate standard deviation.

Firmness:

Compared to the colour properties, the textural properties were equally important for fresh cut fruits. Initial firmness of the slices varied from 0.42 to 0.43 N. Firmness of fresh cut pineapple was reduced during their storage period with time. Maximum firmness value (0.29 N) was preserved by the bulb dipped with 2% citric acid & 0.1% calcinated calcium solution whereas tap water dipped ones retained only 0.21N at 6th day of storage. Liu, *et al.* (2007) reported that both the pretreatment and MAP could lessen the decrease of firmness in fresh-cut pineapples during storage. It was also noted that the order of textural deterioration was quite similar to that of discolour reaction, as well as the orders of the respiration rate and ethylene production.

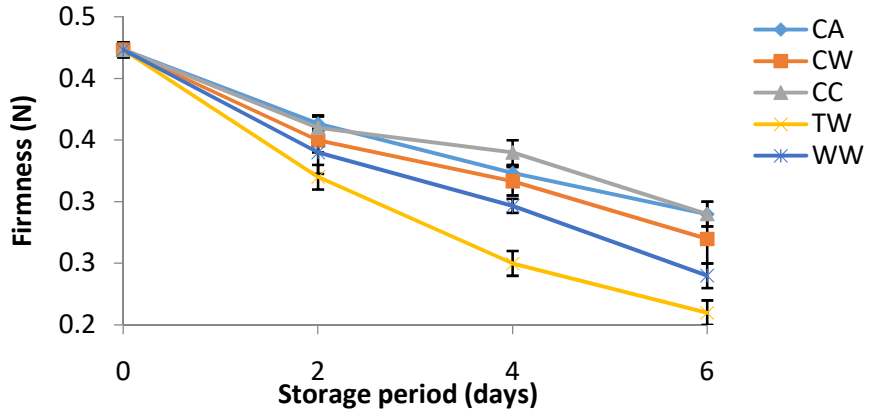

Fig 20.Firmness of fresh cut pineapple during storage at refrigerator. TW= Washed with tap water, CA= Washed with 2% citric acid solution, CC= Washed with 0.1% calcinated calcium solution, CW= Washed with 200 ppm sodium hypochlorite solution, WW= Without wash. Vertical bars indicate standard deviation.

Total soluble solid (TSS)

TSS of fresh cut pineapple was 12.13±0.51% and after washing treatment it was reduced. During storage TSS was decreased slightly in all samples but higher in tap water washed ones.

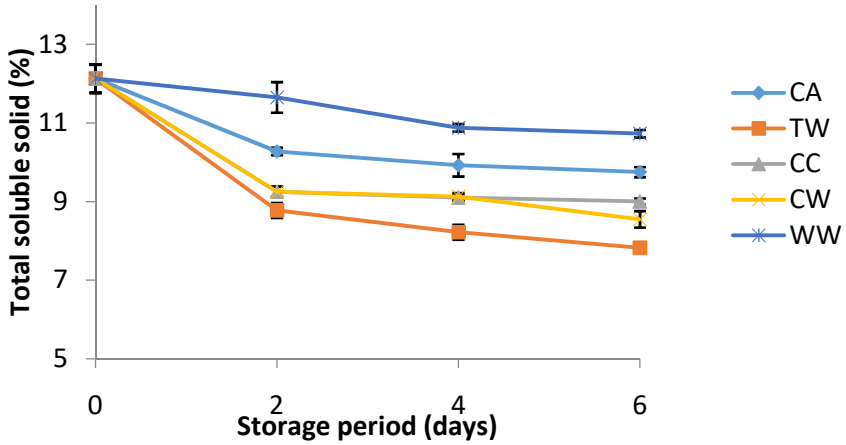

Fig 21.TSS of fresh cut pineapple during storage at refrigerator. TW= Washed with tap water, CA= Washed with 2% citric acid solution, CC= Washed with 0.1% calcinated calcium solution, CW= Washed with 200 ppm sodium hypochlorite solution, WW= Without wash. Vertical bars indicate standard deviation.

Blackson(2013) reported that The TSS of fresh cut pineapples in two varieties namely MD-2 and sugar loaf stored at 5 ±2°C decreased from 14.60 to 11.50% and from 13.60 to 10.50 % respectively for the control samples whiles the treated samples dropped from 14.60 to 12.55 % for MD2 pineapple and

from 13.60 to 11.75% for the sugar loaf variety. The rapid decreased in the soluble sugars in the tap water washed samples may be due to increase in microbial activities as explained by (Brecht, 2006) that microbes are known to degrade sugar and other sugar products through fermentation resulting in sugar reduction in cut fruit.

Microbial analysis

The change in different microbial populations, namely total bacterial count (TBC), yeasts and mold in fresh cut pineapple over 6 days of storage in refrigerator (4 ± 1°C). French regulations establish a limit of 5×10^8 CFU/g (8.67 log CFU/g) as the maximum acceptable contamination values for the TBC in carrot sticks (Aked, 2002).

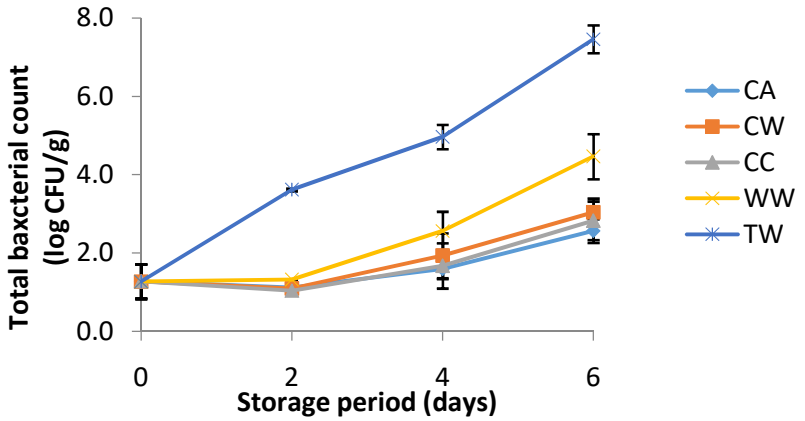

Fig 22.TBC of fresh cut pineapple during storage at refrigerator. TW= Washed with tap water, CA= Washed with 2% citric acid solution, CC= Washed with 0.1% calcinated calcium solution, CW= Washed with 200 ppm sodium hypochlorite solution, WW= Without wash. Vertical bars indicate standard deviation.

Initial TBC of fresh cut pineapple was 1.2 log CFU/g. After wash with sanitizers it was lowered and after sometimes it was increased slightly during storage. Highest amount (7.46 log cfu/g) of TBC was observed in pineapple wash with tap water while it was only around 3 log cfu/g in fresh cut pineapple treated with sanitizers at 6 day of storage. So, TBC in all samples was below the maximum acceptable contamination values for the TBC in fresh cut pineapples at 6 day of storage but it was near threshold in the samples washed with tap water at 6^{th} day of storage. Nwachukwu and Chukwu (2013) reported total bacterial count in pineapple as 3.5×10^5CFU/g. There were no detectable Yeast andMold counts in any samples initially and during their storage life.

Total soluble solids content, pH, total surgar, reducing sugar and ascorbic acid content

The range of pH, titratable acidity and ascorbic acid content in FC pineapple at the day of storage, just after processing was from 3.9 to 4.09, 0.47 to 0.6% and 9.8 to 10.4 mg/100mg, respectively as shown in table 9. Acidity value was increased and pH value was reduced slightly in both the untreated and treated samples during the storage. On the other hand, ascorbic acid was reduced significantly.Compared to the treated samples the changes (especially ascorbic acid) in the untreated samples was at a faster rate. pH in pineapple fruits as ranging from 3.5 to 4.5 as reported by Kongsuwan*et al.,* (2009). The initial content of vitamin C in MD-2 and sugar loaf were 35.37 and 30.40 mg/100ml respectively, which was reduced during storage (Blackson S., 2013). It has been reported that losses as high as 20 to 60 % of ascorbic acid occur in pineapple slices after 9 and 14 days of storage at 5°C (Gonz´alez-Aguilar *et al.,* 2004).

Table 9. TSS, pH and titratable acidity content in fresh cut pineapple during storage at refrigerator

Treatment	Titratable acidity (%)			pH			Ascorbic acid (mg/100g)		
	0 day	3 days	6 day	0 day	3 days	6 day	0 day	3 days	6 day
TW	.50±.03	.53±.02	.55±.02	4.03±.01	3.97±.01	3.95±.01	9.8±.01	9.5±.01	6.3±.01
CA	.60±.02	.60±.01	.62±.03	3.94±.01	3.92±.01	3.92±.01	10.1±.01	9.8±.03	9.1±.01
CC	.47±.02	.47±.01	.49±.01	4.09±.01	4.05±.01	4.06±.01	9.9±.01	9.8±.05	8.8±.01
CW	.55±.05	.56±.02	.58±.01	4.04±.01	4.02±.01	3.99±.01	9.8±.01	9.7±.07	8.8±.01
WW	.53±.06	.55±.02	.57±.02	4.05±.01	4.03±.01	3.97±.01	10.4±.01	9.9±.03	7.9±.01

TW= Washed with tap water, CA= Washed with 2% citric acid solution, CC= Washed with 0.1% calcinated calcium solution, CW= Washed with 200 ppm sodium hypochlorite solution, WW= Without wash.

Total and reducing sugar content of fresh cut pineapple before washing with sanitizers was 5.9% and 3.5% respectively and after washing they were reduced slightly. During storage both sugar content was reduced slightly throughout the storage period. Islam and Kabir (2010) reported that Total sugar, reducing sugar and vitamin C contents in pineapple was found to vary from 3.8-4.8%, 2.13-3.2%, and 9.6-12.6 mg/100g respectively. Rashid *et al.* (1987) reported that pineapple contains 10-25 mg/100g of vitamin C which is very similar to the present findings. Brecht (2006) reported that yeasts are known to degrade sugar and sugar products through fermentation resulting sugar reduction in cut fruit.

Table 10. Total sugar, reducing sugar and non-reducing sugar content in fresh cut pineapple during storage at refrigerator.

Treatment	Total sugar (%)			Reducing sugar (%)			Non reducing sugar (%)		
	0 day	6 days	12 day	0 day	6 days	12 day	0 day	5 days	10 day
TW	5.1±.2	4.9±.4	4.1±.4	3.0±.09	2.9±.03	2.5±.02	2.1±.2	2±.3	1.6±.2
CA	5.4±.3	5.5±.2	5.2±.3	3.2±.09	3.1±.06	2.9±.02	2.2±.3	2.4±.2	2.3±.3
CC	5.3±.2	5.2±.3	4.9±.2	3.1±.09	3.0±.03	2.7±.01	2.2±.2	2.2±.4	2.2±.2
CW	5.2±.3	5.1±.2	4.8±.4	3.0±.09	3.0±.02	2.7±.02	2.2±.3	2.1±.4	2.1±.1
WW	5.9±.2	5.8±.3	4.9±.4	3.5±.09	3.3±.02	2.8±.03	2.4±.3	2.5±.3	2.1±.1

TW= Washed with tap water, CA= Washed with 2% citric acid solution, CC= Washed with 0.1% calcinated calcium solution, CW= Washed with 200 ppm sodium hypochlorite solution, WW= Without wash.

Sensorial analysis

Sensorial results for colour, fresh like appearance, fresh like aroma and overall acceptability are shown in Table 11. After processing (day 0), the scores for all attributes of without wash FC pineapple was slightly higher compared to washed samples. Bulbs treated with sanitizers and without treated sample were observed fine and scored from neither like nor dislike to like slightly since tap water washed bulbs scored dislike moderately at 5th day of storage.

Table 11. Sensory quality of fresh cut pineapple during storage at refrigerator

Treatment	Colour			Fresh-like appearance			Fresh-like aroma			Overall acceptability		
	0 day	5 day	6 day	0 day	5 day	6 day	0 day	5 day	6 day	0day	5 day	6 day
TW	8.3±.2	3.2±.2	2.8±.2	8.1±.6	3.4±.7	2.3±.1	7.5±.2	4.1±.3	3.4±.3	7.8±.3	3.9±.3	3.3±.1
CA	8.6±.3	6.1±.3	5.4±.3	8.3±.7	6.2±.2	5.3±.1	7.9±.3	5.8±.1	5.2±.1	8.0±.2	6.3±.2	5.1±.1
CC	8.4±.1	5.9±.1	4.6±.1	8.1±.1	5.7±.3	4.9±.1	7.4±.1	5.1±.2	4.5±.2	7.8±.1	5.8±.1	4.7±.1
CW	8.2±.1	5.7±.1	4.5±.1	8.0±.1	5.9±.1	4.8±.1	7.2±.1	4.9±.1	4.4±.1	7.9±.2	5.3±.2	4.5±.1
WW	8.5±.2	5.1±.2	4.3±.2	8.5±.6	5.4±.4	3.8±.1	8.8±.2	5.9±.5	4.1±.5	8.8±.3	6.8±.3	4.1±.1

TW= Washed with tap water, CA= Washed with 2% citric acid solution, CC= Washed with 0.1% calcinated calcium solution, CW= Washed with 200 ppm sodium hypochlorite solution, WW= Without wash.

Benefit cost ratio

Fresh cut pineapple:

Cost of preparing 10 no's FC pineapple:

Item	No./Amount	Rate (Tk.)	Price (Tk.)
Clorox	7 ml	450.00/2 litre	1.6
Labour (1)	2 hrs.	450.00/8hrs	112.5
Packaging materials (PP box)	30 nos	4.00	120
		Total	234.1~235

Farm gate price of 10 nos pineapple @ Tk. 50.00/piece = Tk. 500.00 …….(i)

Sale price of fresh cut 10 nos pineapple @ Tk. 100.00/ piece = Tk. 1000.00

Storage cost = 5% of sale price of value added products

So sale price of fresh cut pineapple 10 nos = Tk. (1000 X0.95) = Tk. 950.00…….(ii)

Benefit (ii)-(i) = Tk. (950-500) = Tk. 450

Benefit: Cost = 450:235 = 1.9: 1

Based on sensorial, microbial and physicochemical characteristics fresh cut pineapple washed with sanitizers was acceptable up to 6 days, without wash was acceptable up to 5 days whereas tap water washed pineapple was acceptable up to 4 days. When fresh cut pineapple washed with sanitizers, TSS and flavour was reduced slightly. So after cutting pineapple, without wash with sanitizers is preferable.

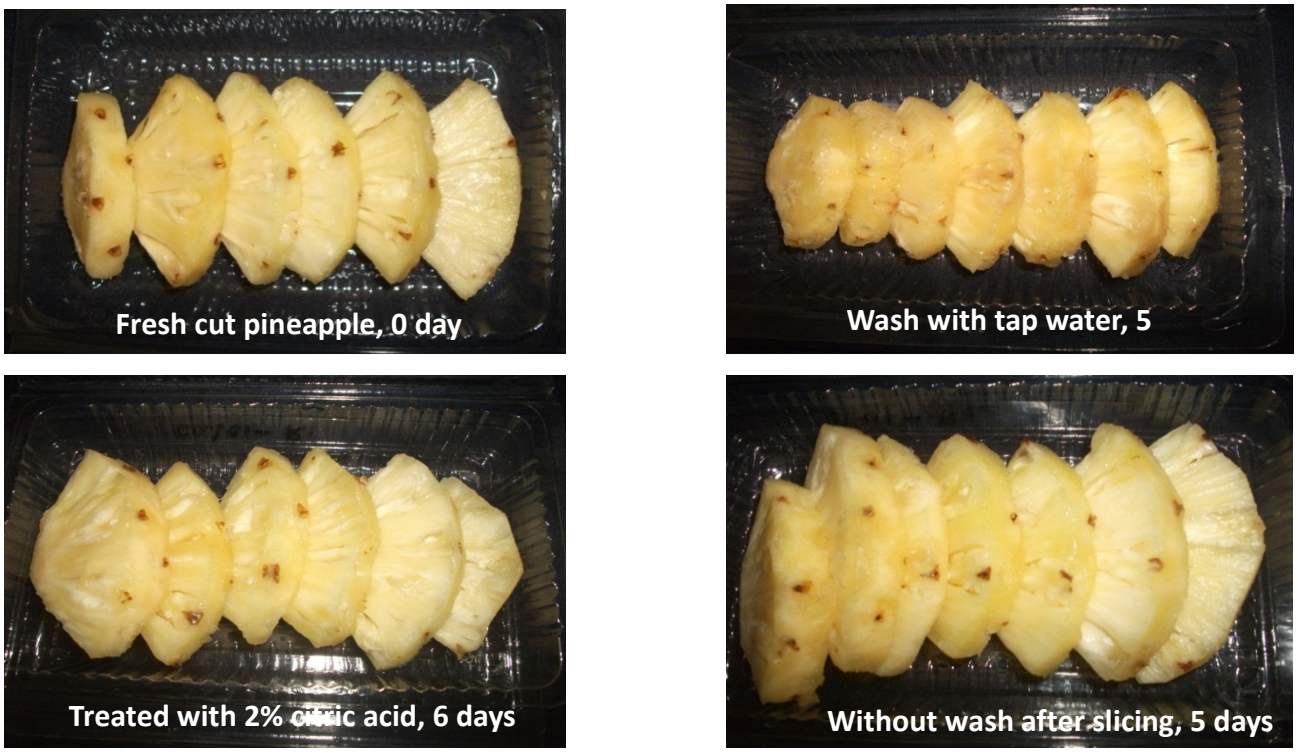

Fig. 23. Pictorial view of fresh cut pineapple during storage

Fresh cut processing of ripe jackfruit

By analyzing physical, chemical, microbial and sensory data, results were found and discussed below:

Respiration rate

The jackfruit bulbs immediately after separation from the fruit showed an enhanced respiration and further size reduction after pitting caused further acceleration in the respiration to an extent of 143.23 mg CO_2 $kg^{-1}h^{-1}$ at ambient condition. Low temperature storage and washed with sanitizers was found beneficial in reducing this cut-induced respiration to 32.97, 63.37 and 53.8 mg CO_2 kg^{-1} h^{-1} in bulbs washed with 2% citric acid, washed with tap water and without washed ones respectively at 9th day of storage in 4±1° C (fig. 24) after that respiration rate was increased significantly washed with tap water and without washed bulbs whereas this increment rate was low in bulbs washed with citric acid, calcinated calcium and chlorinated water up to 12 days of storage time. Bulbs wash with tap water and without wash recorded an early rise in respiration rate from 6 and 9 days respectively onwards, (Fig. 24) indicating decay of the samples by spoilage causing microorganism and end of the shelf-life.

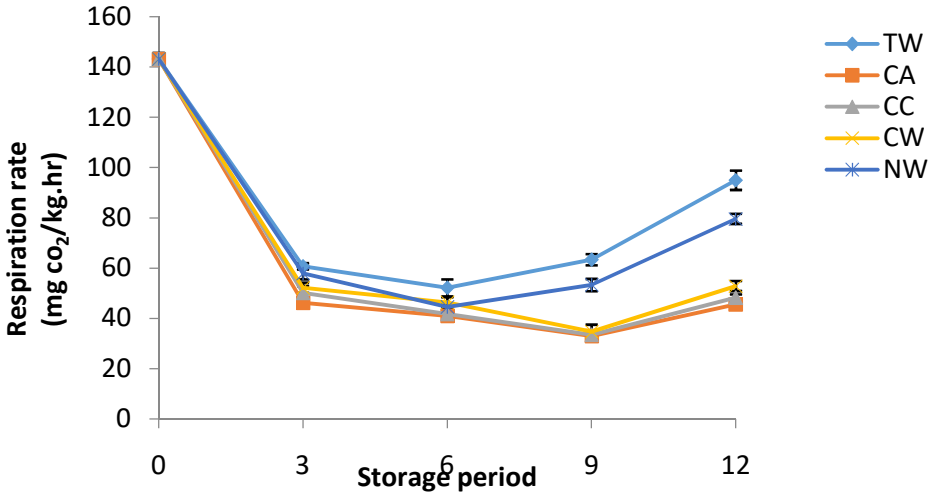

Fig 24.Respiration rate of fresh cut jackfruit bulb during storage at refrigerator. TW= Washed with tap water, CA= Washed with 2% citric acid solution, CC= Washed with 0.1% calcinated calcium solution, CW= Washed with 200 ppm sodium hypochlorite solution, NW= No wash. Vertical bars indicate standard deviation.

Colour

The golden yellowish color of jackfruit bulb is usually a major factor in consumer preference. In the present study, the washing with sanitizers during storage significantly affected the jackfruit bulb color. The luminosity in terms of L value and color intensity in terms of chroma showed a steady decline and the samples washed with sanitizers recorded non-significant changes in values up to 12 days of storage, which indicated, delayed browning of the bulbs during storage. Like luminosity and chroma, maximum hue angle values (9.75%) was also lost in bulbs wash with tap water and the minimum lost (4.4%) was observed in 2% citic acid treated bulbs at 12th day of storage as shown in fig 25.

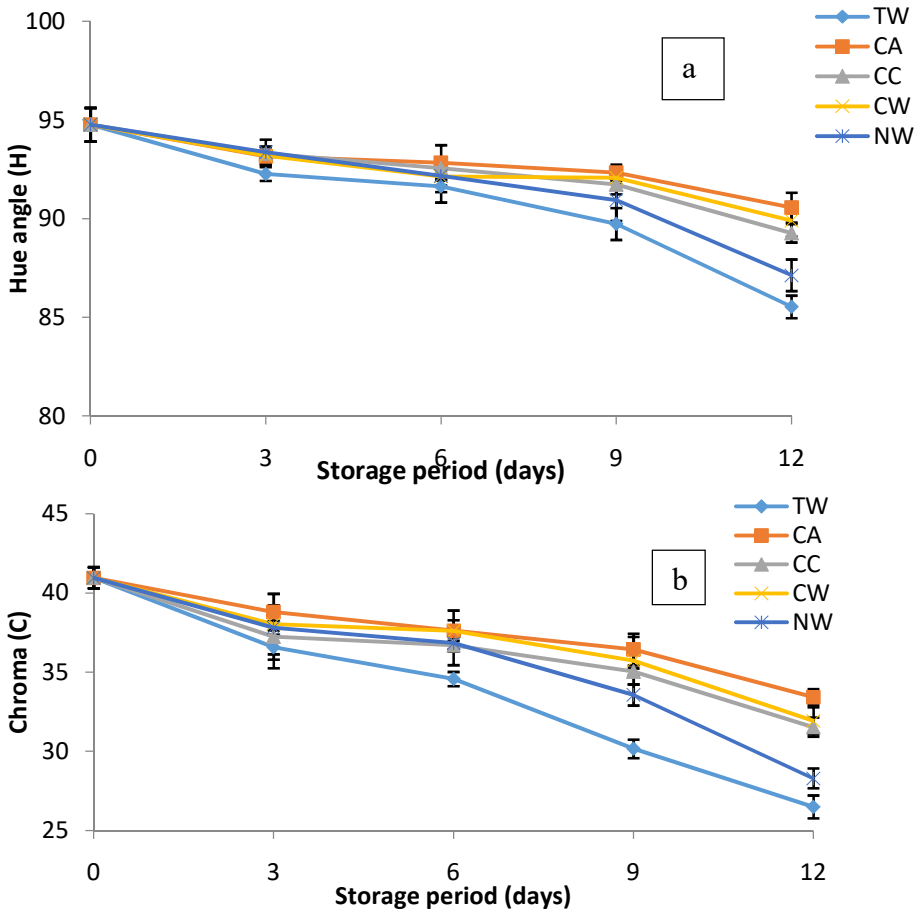

Fig 25. Colour parameters (a) hue angle and (b) chromaof fresh cut jackfruit bulb during storage at refrigerator.TW= Washed with tap water, CA= Washed with 2% citric acid solution, CC= Washed with 0.1% calcinated calcium solution, CW= Washed with 200 ppm sodium hypochlorite solution, NW= Washed with tap water. Vertical bars indicate standard deviation.

Firmness

Softening in jackfruit bulbs is a major factor affecting its quality. Initial firmness of jackfruit bulbs varied from 0.40 to 0.43 N. It was reduced during their storage period with time.

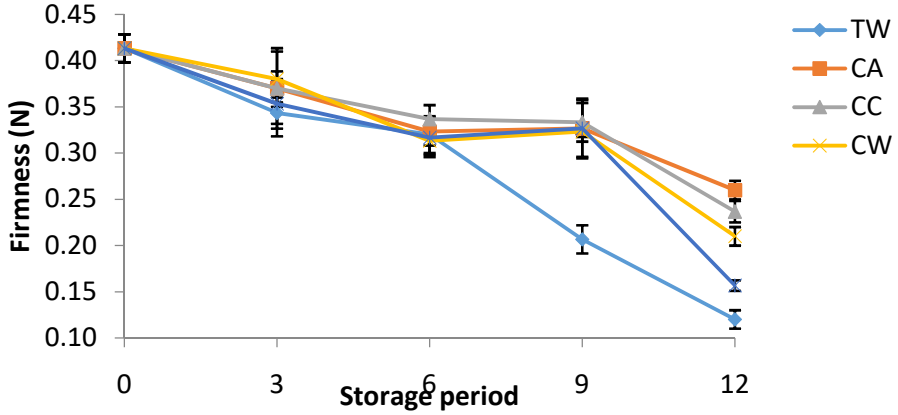

Fig 26.Firmness of **fresh cut jackfruit bulb during storage at refrigerator.** TW= Washed with tap water, CA= Washed with 2% citric acid solution, CC= Washed with 0.1% calcinated calcium solution, CW= Washed with 200 ppm sodium hypochlorite solution, NW= No wash. Vertical bars indicate standard deviation.

Maximum firmness value (0.26 N) was preserved by the bulb dipped with 2% citric acid solution whereas tap water dipped ones retained only 0.12N. The restriction in firmness loss could also be attributed to this stabilized respiration, which could restrict enzymatic hydrolysis of cell wall components resulting in higher retention of firmness in the samples dipped in different sanitizers (Soliva-Fortuny et al., 2002).

Total soluble solids (TSS)

Total soluble solids content of fresh cut jackfruit bulbs washed with different sanitizers during their storage at 4±1°C is representing in Fig 27. TSS of fresh jackfruit bulbs were 15.07±0.51% and after dipping treatment it was reduced slightly in all samples.

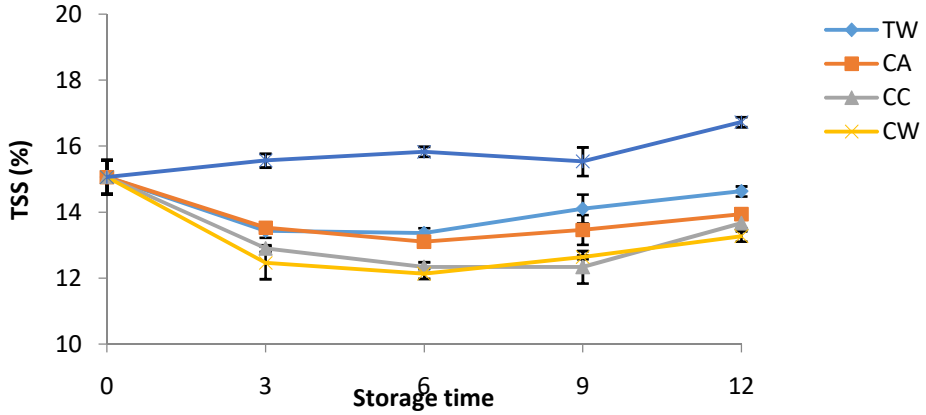

Fig 27.Total soluble solids (TSS)of fresh cut jackfruit bulb during storage at refrigerator. TW= Washed with tap water, CA= Washed with 2% citric acid solution, CC= Washed with 0.1% calcinated calcium solution, CW= Washed with 200 ppm sodium hypochlorite solution, NW= No wash. Vertical bars indicate standard deviation.

During storage TSS was increased slightly in all samples but it was higher in without wash samples. Haque (1991) studied with 32 selected jackfruits and reported that total soluble solids in pulps in the range of 14 to 21.5% which agreed with the present findings for most of the values. Farheen (2013) reported that the TSS (°Brix) values of the minimally processed un-ripe jackfruit bulbs increased during storage.

Microbial analysis

The change in different microbial populations, namely total bacterial count (TBC), yeasts and mold over 12 days of storage in refrigerator (4 ± 1°C) is reported in fig. 28. French regulations establish a limit of 5×10^8 CFU/g (8.67 log CFU/g) as the maximum acceptable contamination values for the TBC in carrot sticks (Aked, 2002).Initial TBC of fresh cut jackfruit bulb was 2.8 log CFU/g. After wash with sanitizers it was lowered and then it was increased slightly during storage. Highest amount (8.13log cfu/g) of TBC was observed in bulb washed with tap water while it was only around 4 log CFU /g in jackfruit bulb treated with citric acid, chlorinated water and calcinated calcium at 12 day of storage. So, TBC in all samples except bulb wash with tap water was below the maximum acceptable contamination values for the TBC in fresh cut jackfruit bulb at 12 day of storage. Rocha, *et al.* (2007) also stated that the total counts of micro-organisms at 30°C and 7°C never exceeded the maximum acceptable limit of log CFU g^{-1} = 8 during storage. There were no detectable Yeast and Mold counts in any samples initially and during their storage life. Alegria*et al.* (2009) also reported that no yeast and mold was found in

heat treated samples immediately after minimal processing or throughout storage (always less than the detection limit of 10^1CFU g-^{1}).

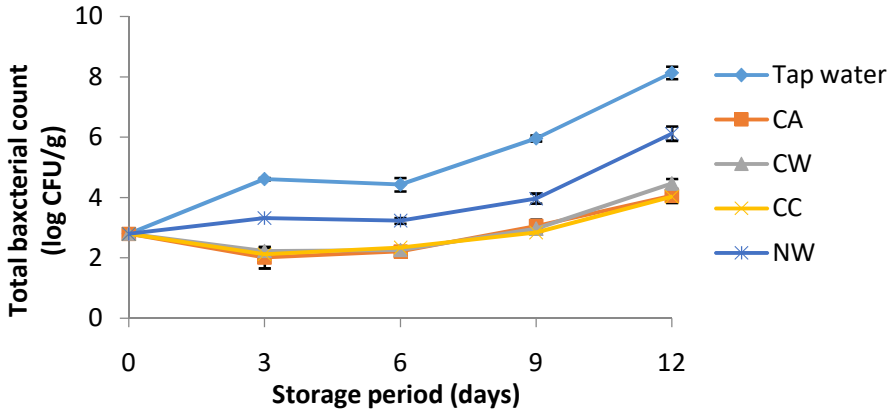

Fig 28.Total bacterial countof fresh cut jackfruit bulb during storage at refrigerator. TW= Washed with tap water, CA= Washed with 2% citric acid solution, CC= Washed with 0.1% calcinated calcium solution, CW= Washed with 200 ppm sodium hypochlorite solution, NW= No wash. Vertical bars indicate standard deviation.

Titratable acidity, pH, ascorbic acid, total sugar, reducing sugar and beta carotene content

Ascorbic acid, titratable acidity and pH in fresh ripe jackfruit bulb were 16.4 mg/100g, 0.30 and 6.8, respectively (table 12). After treatment it was changed little bit. During storage pH was decreased and acidity increased slightly in all sample. During storage loss of ascorbic acid was significantly higher in bulb washed with tap water followed by no wash compared to sanitized jackfruit bulb. At 12th day of storage ascorbic acid content was 9.3, 10.9 and 13.8 mg/100g in bulb wash with tap water, no wash and 2% citric acid dipped ones respectively.

Table 12. Ascorbic acid, pH and titratable acidity content in fresh cut jackfruit bulb during storage at refrigerator

Treat	Titratable acidity			pH			Ascorbic acid (mg/100g)		
ment	0 day	6 days	12 day	0 day	5 days	10 day	0 day	6 days	12 day
TW	.25±.03	.27±.02	.30±.02	6.9±.01	6.7±.01	6.6±.01	15.8±.1	13.3±.1	9.3±.01
CA	.42±.02	.43±.01	.45±.03	6.1±.01	5.9±.01	5.7±.01	16.1±.1	15.8±.3	13.8±.01
CC	.21±.02	.23±.01	.26±.01	6.9±.01	6.8±.01	6.6±.01	15.9±.1	15.5±.5	13.4±.01
CW	.29±.05	.31±.02	.32±.01	6.7±.01	6.7±.01	6.5±.01	15.8±.1	15.6±.7	13.2±.01
NW	.30±.06	.30±.02	.32±.02	6.8±.01	6.7±.01	6.6±.01	16.4±.1	15.1±.3	10.9±.01

TW= Washed with tap water, CA= Washed with 2% citric acid solution, CC= Washed with 0.1% calcinated calcium solution, CW= Washed with 200 ppm sodium hypochlorite solution, NW= No wash.

Total sugar, reducing sugar and beta carotene content in fresh ripe jackfruit bulb was 23.1%, 4.5% and 315.4 (µg/ g)respectively. After dipping treatment sugar content was reduced slightly. During storage the both sugar content was also reduced slightly. Goswamiet al., (2011) found0.46%titrable acidity, 4.57 mg/100g Vitamin C, 16.50% total sugar and 346.03 µg/100g carotene content in pulp of Modhupur*Khaja*jackfruit.

Table 13. Total sugar, reducing sugar and beta carotene content in fresh cut jackfruit bulb during storage at refrigerator

Treatment	Total sugar			Reducing sugar			Beta carotene (µg/ g)		
	0 day	6 days	12 day	0 day	6 days	12 day	0 day	5 days	10 day
TW	22.2±.2	21.9±.4	20.8±.4	4.2±.9	3.9±.3	3.7±.2	314.7±.2	310.8±.3	305.9±.2
CA	21.8±.3	21.5±.2	21.1±.3	3.7±.9	3.6±.6	3.5±.2	314.4±.3	314.6±.2	312.6±.3
CC	22.3±.2	21.7±.3	21.2±.2	3.9±.9	3.8±.3	3.6±.1	316.4±.2	313.1±.4	312.2±.2
CW	22.2±.3	21.5±.2	21.0±.4	4.0±.9	3.9±.2	3.7±.2	315.3±.3	313.9±.4	309.3±.1
NW	23.1±.2	22.8±.3	21.1±.4	4.5±.9	4.3±.2	4.0±.3	315.4±.3	313.7±.3	309.1±.1

TW= Washed with tap water, CA= Washed with 2% citric acid solution, CC= Washed with 0.1% calcinated calcium solution, CW= Washed with 200 ppm sodium hypochlorite solution, NW= Nowash.

Sensory quality:

Sensorial results for colour, fresh-like appearance, fresh-like aroma and overall acceptability are shown in Table 14. After processing (day 0), the scores for all attributes of without wash jackfruit bulb was slightly higher compared to dipped samples but not significantly different (data did not shown). Bulbs treated with sanitizers and without treated sample were observed fine and scored more than 7 since tap water washed bulbs scored 4.4 at 6th day of storage in case of overall acceptability.

Table 14. Sensory quality of fresh cut jackfruit during storage at refrigerator

Treatment	Colour			Fresh like appearance			Fresh like aroma			Overall acceptability		
	6 day	9 day	12 day	6 day	9 day	12 day	6 day	9 day	12 day	6 day	9 day	12 day
TW	4.8±.2	3.2±.2	2.8±.2	5.1±.6	3.4±.7	2.3±.1	5.1±.1	4.1±.3	3.4±.3	4.4±.3	3.5±.3	3.3±.1
CA	8.8±.3	7.1±.3	5.4±.3	8.1±.7	7.2±.2	5.3±.1	8.0±.1	7.2±.1	5.2±.1	8.1±.2	7.3±.2	5.1±.1
CC	8.2±.1	6.9±.1	4.6±.1	7.8±.1	6.7±.3	4.9±.1	7.8±.1	6.8±.2	4.5±.2	7.8±.1	6.8±.1	4.7±.1
CW	8.5±.1	6.7±.1	4.5±.1	7.8±.1	6.9±.1	4.8±.1	7.6±.1	6.6±.1	4.6±.1	7.7±.2	6.3±.2	4.5±.1
NW	7.9±.2	4.7±.2	4.3±.2	8.2±.6	5.4±.4	3.8±.1	8.3±.1	5.1±.5	4.1±.5	7.3±.3	5.3±.3	4.1±.1

TW= Washed with tap water, CA= Washed with 2% citric acid solution, CC= Washed with 0.1% calcinated calcium solution, CW= Washed with 200 ppm sodium hypochlorite solution, NW= Nowash.

Benefit cost ratio

Cost of preparing 5 no's FC jackfruit:

Item	No./Amount	Rate (Tk.)	Price (Tk.)
Clorox	7 ml	450.00/2 litre	1.6
Labour (1)	3 hrs.	450.00/8hrs	168.75
Packaging materials (PP box)	40 piece	4.00	160
		Total	330.35~331

Farm gate price of 5 nos jackfruit @ Tk. 250.00/piece = Tk. 1250.00 …….(i)

Sale price of fresh cut 5 nos Jackfruit @ Tk. 400.00/piece = Tk. 2000.00

Storage cost = 5% of sale price of value added products

So sale price of fresh cut jackfruit bulb (5 nos jackfruit) = Tk. (2000 X0.95) = Tk. 1900.00…….(ii)

Benefit (ii)-(i) = Tk. (1900-1250) = Tk. 650

Benefit: Cost = 650:331 = 1.96: 1

In conclusion, based on sensorial, microbial and physicochemical characteristics, fresh cut ripe jackfruit bulb washed with sanitizers was acceptable up to 12 day, bulb without wash was acceptable up to 9day and bulb washed with tap water was acceptable up to 6 days. When fresh cut ripe jackfruit bulb washed with sanitizers, TSS and flavour was reduced slightly. So ripe jackfruit bulb, without wash is preferable.

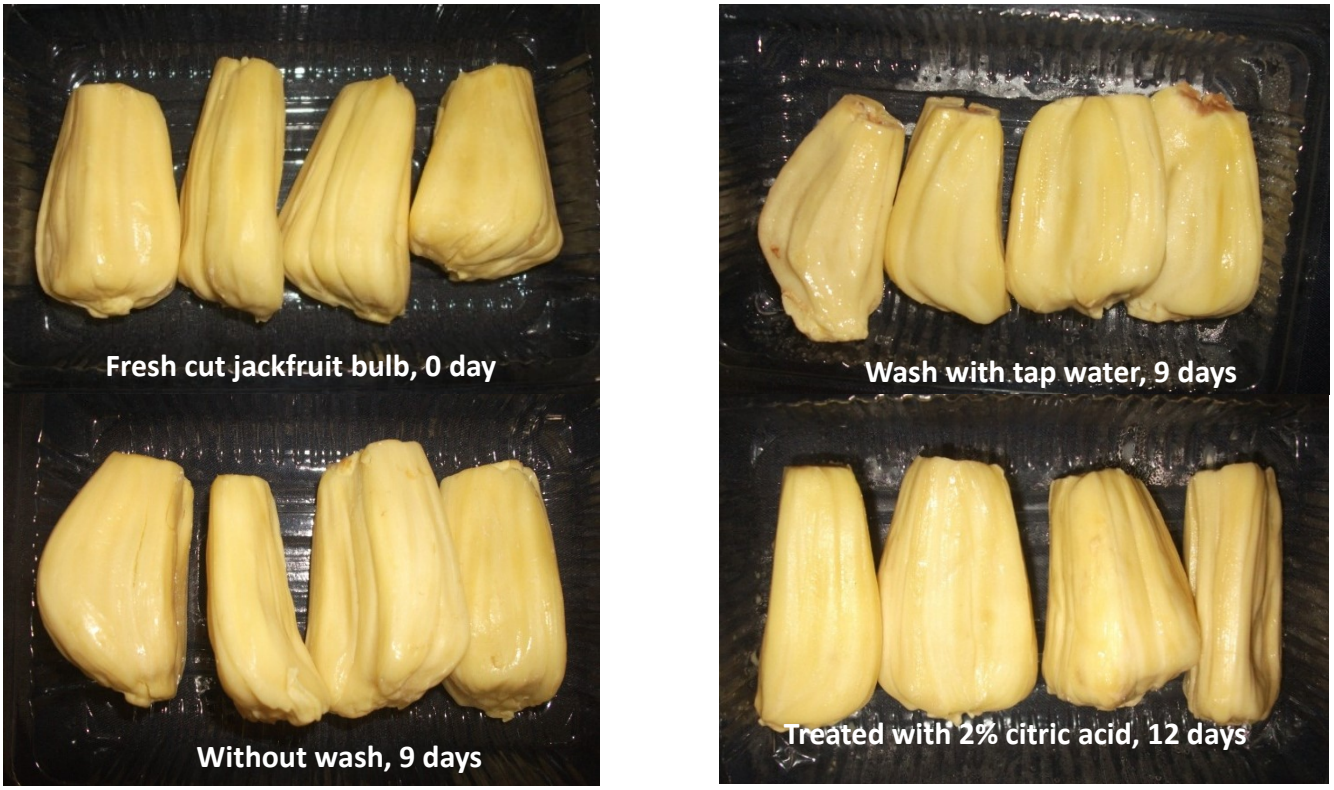

Fig. 29. Pictorial view of fresh cut jackfruit bulb during storage

Fresh cut processing of strawberry

By analyzing physical, chemical, microbial and sensory data, results were found and discussed below:

Respiration rate

Figure. 30 illustrates the effect of different skin coatings on the CO_2 production of strawberry stored at refrigerator for 9 days. Initial respiration rate of strawberry was 63.01ml.kg^{-1}.h^{-1} and it was reduced to almost half when strawberry was coated with only Aloe vera gel or Aloe vera gel+1% $CaCl_2$ and stored at 4±1°C during storage period. The respiration rate of strawberries coated with 1.5% chitosan or 1.5% chitosan+1% $CaCl_2$ was little bit higher than that coated with only Aloe vera gel or Aloe vera gel+1% $CaCl_2$ throughout the storage period. The control samples presented higher respiration rate during storage time compared with coated ones. The explanation for the observed results is the gas barrier between the strawberry tissue and the environment, promoted by edible coatings, that modifies the atmosphere around the fruit and so reduces its respiration rate. The intensity of change in the respiration rate of fruits and vegetables depends on the coating formulation and also on the storage

conditions of the products. Respiration rate behaviour similar to that observed in the present work was reported by Vargas *et al.* (2006) who observed a reduction on cold stored strawberry respiration rate because of the use of chitosan-oleic acid edible coatings. Garcia *et al.* (2010) observed that the respiration rate of strawberries stored at 5°C decreased as the concentration of cassava starch on the coating increased.

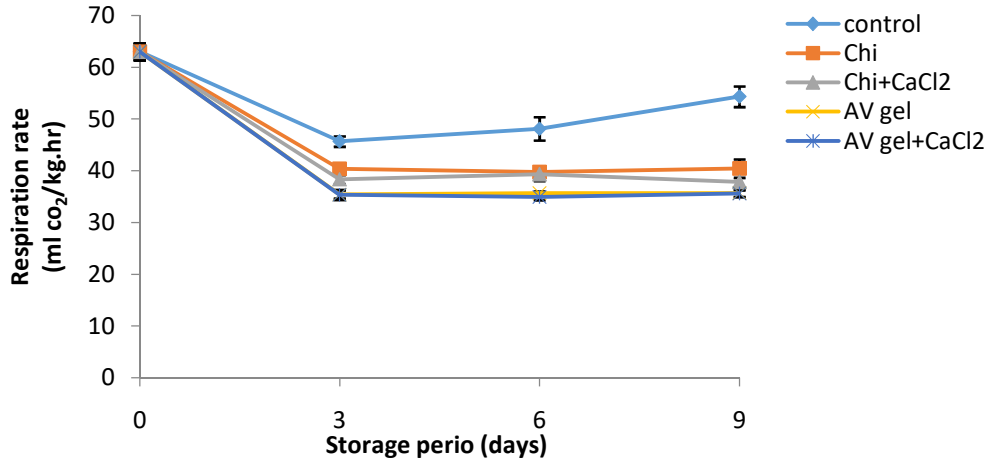

Fig. 30. Respiration rate of uncoated and edible coated strawberries during storage at refrigerator. Control=uncoated, Chi=1.5% chitosan coated, Chi+$CaCl_2$=1.5% chitosan +1% $CaCl_2$coated, AV gel =AV gel coated, AV gel+$CaCl_2$=Aloe vera gel+1% $CaCl_2$ coated. Vertical bars indicate standard deviation.

Firmness

Firmness or texture is a critical quality attribute in the consumer acceptability of fresh fruit and vegetables. Strawberry is a soft fruit that suffers a rapid loss of firmness during ripening which contributes greatly to its short postharvest life and susceptibility to fungal contamination. Fruit texture properties are affected by cell turgidity and the structure and composition of the cell wall polysaccharides. Strawberry softening has been associated with the degradation of the middle lamella of cortical parenchyma cells, resulting in a dramatic increase in pectin solubilisation, with slight changes in pectin molecular weight (Kohand Melton,2002) and small decreases in the content of hemicelluloses.

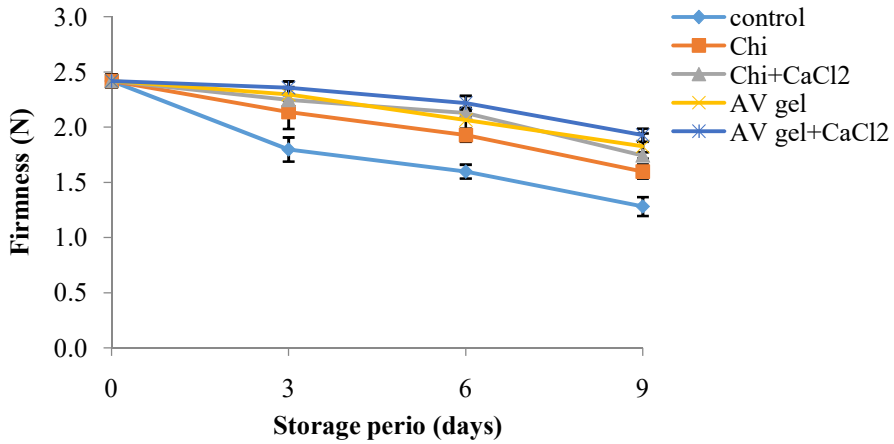

Fig. 31. Firmness of uncoated and edible coated strawberries during storage at refrigerator. Control=uncoated, Chi=1.5% chitosan coated, Chi+$CaCl_2$=1.5% chitosan +1% $CaCl_2$coated, AV gel =AV gel coated, AV gel+$CaCl_2$=Aloe vera gel+1% $CaCl_2$ coated. Vertical bars indicate standard deviation.

Figure 31 represents the changes in flesh firmness of control and coated fruit during the storage period of 9 days at refrigerator (4±1°C). Initially the firmness value of strawberry was 2.42 N and it wasdecreased gradually with time but the rate was different for different treatments.Among the treatment, Aloe vera gel+1%$CaCl_2$ coated strawberry was most firm during the storage period and it lost only 20.21% firmness whereas uncoated strawberry had lost 47.03% firmness at 9th day of storage period. Chitosan coatings also exerted a beneficial effect on fruit firmness throughout the storage period. The beneficial effect of chitosan coating on firmness has also been reported for tomato (El Ghaouth*et al.,* 1992), peach, Japanese pear, kiwifruit (Du *et al.,* 1997) and 'Murcott' tangor (Chien*et al.,* 2007).

Weight loss

Fruit weight loss is mainly associated with respiration and moisture evaporation through the skin. The thin skin of strawberry fruits makes them susceptible to rapid water loss, resulting in shriveling and deterioration. Edible coatings act as barriers, thereby restricting water transfer and protecting fruit skin from mechanical injuries, as well as sealing small wounds and thus delaying dehydration. Figure 32 shows weight loss during storage at refrigerator of uncoated fruit compared to fruit coated with chitosan and Aloe vera gel. All samples demonstrated a gradual loss of weight during storage. Throughout storage, the loss of weight of uncoated fruit was significantly greater than that of coated fruit. At 9th day of storage, uncoated strawberries showed 9.07% weight loss, whereas the losses of samples coated with 1.5% chitosan with or without 1% $CaCl_2$ and Aloe vera gel with or without 1% $CaCl_2$ were around 6% and 5%, respectively. Hernandez-Munoz*el al.* (2008) found that at 7th day of storage, untreated strawberries showed 28.7% loss in weight, whereas the weight losses of samples coated with 1% and 1.5% chitosan were 19.6% and 14.2%, respectively when stored at 10°C and 70 ± 5% RH. Apart from strawberry fruit, chitosan coatings have been effective at controlling water loss from other commodities, including cucumber and pepper (El Ghaouth, *et al.,*1991) and longan fruit (Jiang and Li, 2001).

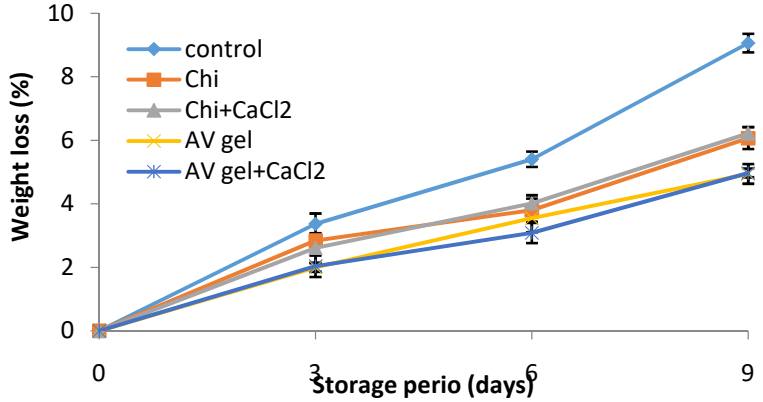

Fig. 32. Weight loss of uncoated and edible coated strawberries during storage at refrigerator. Control=uncoated, Chi=1.5% chitosan coated, Chi+$CaCl_2$=1.5% chitosan +1% $CaCl_2$coated, AV gel =AV gel coated, AV gel+$CaCl_2$=Aloe vera gel+1% $CaCl_2$ coated. Vertical bars indicate standard deviation.

External fruit colour

Colour is an important factor in the perception of strawberry fruit quality. Fig. 33 a–b illustrates the changes in surface colour of strawberries stored at 4±1°C and 50 ± 5% RH for 9 days, as given by lightness (L*) and hue angle. The L* parameter is an indicator of fruit darkening. As can be observed in Figure33a, all the samples showed decreasing L* values with storage time. Uncoated fruit was significantly darker than coated fruit throughout the storage period. On the other hand, Aloe vera gel coated strawberries were less dark than chitosan coated one and addition of $CaCl_2$with coating is better for both. At 9th day of storage period, L* had decreased by around 29.5% for control fruit and by around 14.75% and 11.72% for fruit coated with 1.5% chitosan+1% $CaCl_2$and Aloe vera gel+1% $CaCl_2$, respectively.

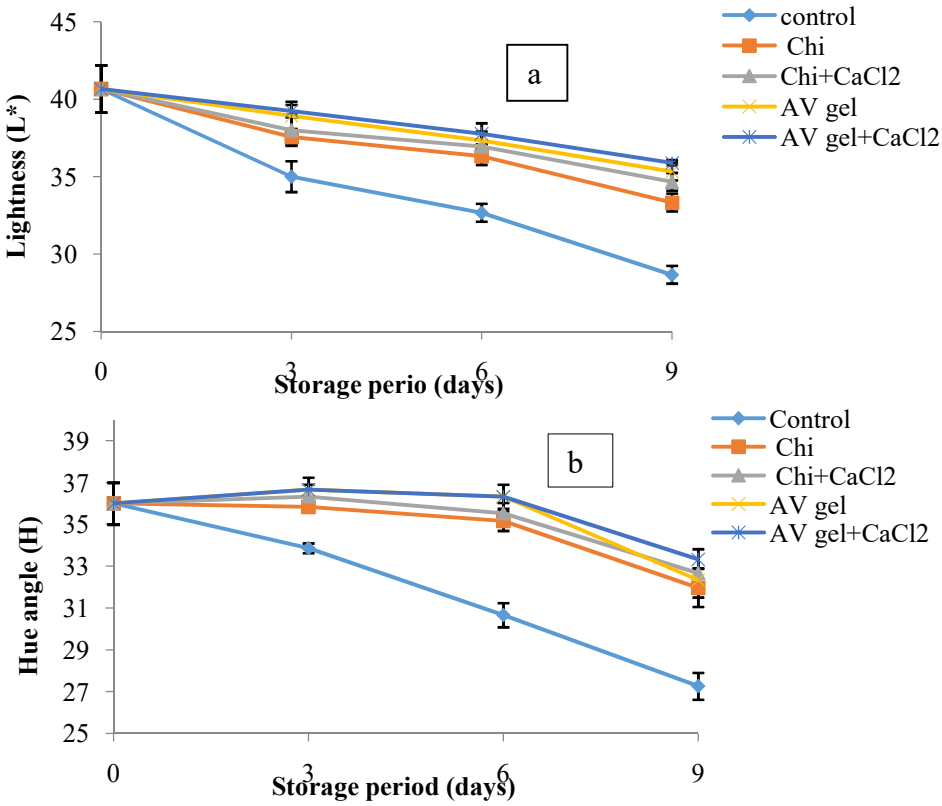

Fig. 33. External colour evolution (a) lightness and (b) hue angle of uncoated and edible coated strawberries during storage at refrigerator. Control=uncoated, Chi=1.5% chitosan coated, Chi+$CaCl_2$=1.5% chitosan +1% $CaCl_2$coated, AV gel =AV gel coated, AV gel+$CaCl_2$=Aloe vera gel+1% $CaCl_2$ coated. Vertical bars indicate standard deviation.

The hue angle of uncoated strawberry began to decrease after the second day of storage and at the 9th of the storage period the decline was 24.25%. The hue angle of coated fruit did not show any significant change up to 6th day of storage after that it was reduced slightly. Colour changes in harvested, fully red, ripe strawberries occur progressively during storage. Fruit darkens, skin colour becomes less chromatic and surface browning develops. Less red skin and darkening due to oxidative browning reactions have been found to be more marked in ripe strawberries that suffer greater moisture loss during storage (Nunes, *et al.,* 2005). The control of moisture loss by edible coatings contributes to minimizing external colour changes in fully ripe strawberries.

Microbial analysis

The change in different microbial populations, namely total bacterial count (TBC), yeasts and mold over 9 days of storage in refrigerator (4±1°C) is reported in Fig. 34. The lack of microbial quality standards in many countries for fresh-cut fruits makes it difficult to define a CFU number threshold beyond which the product can be considered unacceptable. However, French regulations establish a limit of 5×10^8 CFU/g (8.67 log CFU/g) as the maximum acceptable contamination values for the TBC in carrot sticks (Aked, 2002). Initial TBC of strawberry was 2.11 log CFU/g. After coating treatment, it was lowered slightly and then it was increased during storage. Highest amount (8.13log CFU /g) of TBC was observed in control strawberry while it was only 3.10 log CFU/g in strawberry coated with AV gel+$CaCl_2$ at 9th day of storage. However, TBC in all samples except strawberry wash with tap water was below the maximum acceptable contamination values for the TBC at 9th day of storage.

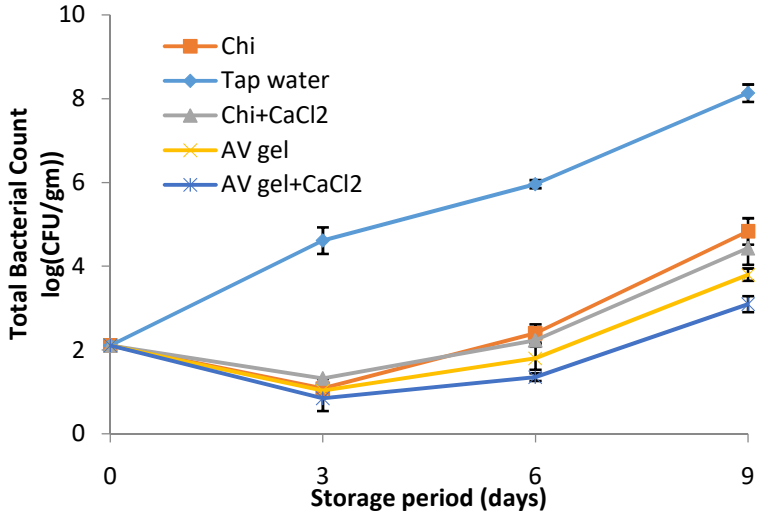

Fig.34.Total bacterial count of uncoated and edible coated strawberries during storage at refrigerator. Control=uncoated, Chi=1.5% chitosan coated, Chi+$CaCl_2$=1.5% chitosan +1% $CaCl_2$coated, AV gel =AV gel coated, AV gel+$CaCl_2$=Aloe vera gel+1% $CaCl_2$ coated. Vertical bars indicate standard deviation.

There were no detectable Yeast and Mold counts in any samples initially and during their storage life. Alegria*et al.* (2009) also reported that no yeast and mold was found in heat treated samples just after minimal processing or throughout storage (always less than the detection limit of 10^1CFU g^{-1}).

Titratable acidity, pH, ascorbic acid, total sugar, reducing sugar and beta carotene content:
Initial ascorbic acid in strawberry was 47.82 mg/100g. The coated strawberry preserved more ascorbic acid than uncoated one. At 9th day of storage, ascorbic acid content reduced severely to 35.60 mg/100g in uncoated fruits, while 44.9 mg/100g in the strawberry coated with Aloe vera gel containing $CaCl_2$. Initial acidity and TSS was 0.83 % and 7.5°Brix, respectively.

Table 15. Ascorbic acid, pH and acidity content in strawberryduringstorage at refrigerator

Treatment	Ascorbic acid (mg/100g)		Acidity (%)		pH	
	0 day	9 day	0 day	9 day	0 day	9 day
Control	47.82	35.60c	0.86	0.73b	3.94	3.99
Chi	47.82	41.57b	0.86	0.73b	3.94	3.97
Chi+$CaCl_2$	47.82	41.47b	0.86	0.77a	3.94	3.97
AV gel	47.82	42.13b	0.86	0.73b	3.94	3.96
AV gel+$CaCl_2$	47.82	44.90a	0.86	0.77a	3.94	3.95

Control=uncoated, Chi=1.5% chitosan coated, Chi+$CaCl_2$=1.5% chitosan +1% $CaCl_2$coated, AV gel =AV gel coated, AV gel+$CaCl_2$=Aloe vera gel+1% $CaCl_2$ coated. Figures having the same letter in a column are not different significantly.

At 9th day of storage, acidity decreased slightly and TSS increased moderately ranged from 9.3°Brix to 10.4°Brix. Maximum TSS (9.4°Brix) was found in control strawberry as maximum water loss was occurred here. Initial pH was 3.94 and it was increased very slightly during storage. Total sugar and reducing sugar content in fresh strawberry was 5.62% and 4.13% respectively and these values also increased slightly at 9th day of storage. Muzzaffar*et al.,*2016 reported that ascorbic acid, TSS, acidty, total sugar and reducing sugar content of fresh strawberry (Camarosa variety) was 38.64 mg/100g, 8.0°Brix, 1.28%, 5.25% and 4.26% respectively.

Table 16. Total sugar, reducing sugar and TSS content in strawberry during storage at refrigerator

Treatment	Total sugar (%)		Reducing sugar (%)		TSS (°Brix)	
	0 day	9 day	0 day	9 day	0 day	9 day
Control	5.62	5.9	4.13	4.27	7.5	9.4a
Chi	5.62	5.7	4.13	4.23	7.5	8.6b
Chi+$CaCl_2$	5.62	5.7	4.13	4.22	7.5	8.5b
AV gel	5.62	5.7	4.13	4.21	7.5	8.3b
AV gel+$CaCl_2$	5.62	5.7	4.13	4.17	7.5	8.3b

Control=uncoated, Chi=1.5% chitosan coated, Chi+$CaCl_2$=1.5% chitosan +1% $CaCl_2$coated, AV gel =AV gel coated, AV gel+$CaCl_2$=Aloe vera gel+1% $CaCl_2$ coated. Figures having the same letter in a column are not different significantly.

Sensory quality:

Sensorial results for colour, fresh like appearance, fresh like aroma and overall acceptability are shown in table 17. Throughout the storage time, all the samples showed a loss of sensory quality. However, at 7th day of storage, in case of overall acceptability, control/uncoated strawberry secured 4.4 scores that indicate unacceptable by the consumer's preference, while more than 5 scores were obtained by all type of coated strawberry. However, strawberry coated with Aloe vera gel with or without $CaCl_2$ obtained 5.5 scores whereas rest of the coated strawberry scored less than 4.5 at 9th day of storage in case of overall acceptability. 4.5 scores limit the consumers' acceptability.

Table 17. Sensory quality of strawberry during storage at refrigerator

Treatment	Colour		Fresh like Appearance		Fresh like Aroma		Overall acceptability	
	7 day	9 day	7 day	9 day	7 day	9 day	7 day	9 day
Control	4.1±.5	3.8±.2	4.4±.7	3.3±.1	4.1±.3	2.8±.3	4.4±.3	2.3±.1
Chi	5.7±.2	4.2±.3	5.2±.2	4.3±.2	5.8±.1	4.4±.1	5.5±.2	4.2±.1
Chi+$CaCl_2$	5.5±.1	4.4±.1	5.1±.3	4.5±.5	6.2±.2	4.5±.2	5.8±.1	4.4±.1
AV gel	7.1±.2	5.8±.2	6.8±.4	5.9±.3	7.1±.5	5.0±.5	7.3±.3	5.5±.1
AV gel+$CaCl_2$	7.5±.2	5.5±.2	6.8±.3	5.5±.2	7.3±.5	5.4±.5	6.8±.3	5.5±.1

Control=uncoated, Chi=1.5% chitosan coated, Chi+$CaCl_2$=1.5% chitosan +1% $CaCl_2$coated, AV gel =AV gel coated, AV gel+$CaCl_2$=Aloe vera gel+1% $CaCl_2$ coated. Figures having the same letter in a column are not different significantly.

Benefit cost ratio

AV gel coated fresh cut strawberry:

Cost of preparing 400 ml Aloe vera (AV) gel and 5 kg AV gel coated strawberry:

Item	No./Amount	Rate (Tk.)	Price (Tk.)
Aloe vera leaf	5	20.00	100.00
Ascorbic acid	0.6 g	3200.00/500g	3.84
Citric acid	1.2 g	1200.00/500g	2.88
Labour	6 hrs.	450.00/8hrs	337.5
Packaging materials (PP box)	30 nos	4.00	120
Total			564.22~565

Farm gate price of 5kg strawberry @ Tk. 250.00/kg = Tk. 1250.00 ……(i)

Sale price of value added (Aloe vera gel coated) 5kg strawberry@ Tk. 500.00/kg = Tk.2500.00
Storage loss (weight) and cost = 10% of sale price of value added products
So sale price of Aloe vera gel coated 5kg strawberry =Tk. (2500 X0.9) =Tk. 2250.00 ….(ii)
Benefit (ii)-(i) = Tk. (2250-1250) = Tk. 1000
Benefit: Cost = 1000:565 = 1.77: 1

In conclusion, based on sensorial, microbial and physicochemical characteristics control or without coated strawberry was acceptable up to 6th day, strawberry coated with 1.5% chitosan with or without $CaCl_2$ was acceptable up to 8th day and strawberry coated with Aloe vera gel with or without $CaCl_2$ was acceptable more than 9 days.

Fresh strawberry, 0 day

Without coated strawberry, 9 days

Aloe vera gel coated strawberry, 9 days

1.5% Chitosan coated strawberry, 9 days

Fig. 35. Pictorial view of fresh cut Strawberry during storage.

Key points of fresh cut fruits and vegetables in super shops:

- Survey works have been conducted in some super shops like Prince Bazar Ltd., Shwapno, Agora, Meena Bazar, Lavender etcat different outlets especially of Dhaka city.
- Fruits like pineapple, guava, pomegranate, golden apple, pummelo, papaya, mango etc. are used as fresh cut.
- Vegetables like mixed vegetables, bitter gourd, sweet gourd, cabbage, drumstick, cucumber, carrot, etc. are used as fresh cut
- Here whole fruits and vegetables are washed with normal tap water (did not use any sanitizers), cut into suitable sizes, kept in styro foam tray and wrapped with cling film and stored.
- Storage temperature 15-20°C and 20-30%R.H.
- Shelf life: 1-2days for fresh cut vegeables and 2-3days for fresh cut fruits.
- If remain unsold withing that period, it is disdtributed within staff of the shops in reduced prices, sometimes free of cost.
- During processing workers did not use any apron, hand gloves, musk or cap. Their hands, knife and utensils are not sterilized even not cleaned.
- Mixed vegetables and bitter gourd were the two most polar item as fresh cut.
- Profit: 20-30%
- Total bacterial count (TBC) in fresh cut fruits and vegetables ranged from 1.3×10^4 to 4.0×10^4 CFU/g.

Fig. 36. Some photographs taken from super shops.

Key points of fresh cut fruits and vegetables in street vendors:

- Survey works have been conducted to some street vendors in Dhaka and Gazipur city.
- Fruits like pineapple, guava, golden apple, pummelo, papaya, Indian olive are used as fresh cut.
- Among vegetables only cucumber and carrot are used as fresh cut.
- Here whole fruits are washed with water (did not use any sanitizers) and the same water is used several time to wash, so it become dirty
- Peel, cut into suitable sizes and usually kept in open condition.
- Sometimes spices are mixed with fresh cut fruits or vegetables.
- Sometimes fresh cut fruits and vegetables are kept in small polyethylene packet
- Street vendors sell their produce in ambient condition and try to sell in a day, excess produce are consumed by themselves.
- During processing workers did not use any apron, hand gloves, musk or cap. Their hands, knife and utensils were not clean.
- Golden apple and cucumber are two most popular item as fresh cut.
- Profit: more than 50%
- Total bacterial count in fresh cut fruits and vegetables ranged from 1.3×10^4 to 4.0×10^4 CFU/g.

Fig. 37. Some photographs taken from Street vendors

12. Research highlight/findings (Bullet point – max 10 nos.):

- Fresh cut carrot without heat treatment was good up to 4 days, FC carrot treated with warm solution of 2% NaCl was acceptable up to 8 days and carrot treated with warm solution of 2% citric acid was acceptable more than 10 days during storing at refrigerator.
- Fresh cut cauliflower without packaging was good up to 4 days, FC cauliflower packed in perforated LDPE bag, sealed LDPE bag, PP box and cling wrapped was acceptable up to 16 days and vacuum packed cauliflower was acceptable more than 20 days during storing at refrigerator.
- Fresh cut green bell pepper without packaging was acceptable up to 2 days, bell pepper packed in sealed LDPE bag, PP box and cling wrapped was acceptable up to 8 days and vacuum packed one was acceptable up to 10 days during storing at refrigerator.
- Fresh cut pineapple washed with sanitizers (0.1% calcinated calcium or 2% citric acid solution) was acceptable up to 6 days, without wash after slicing was acceptable up to 5 days whereas tap water washed pineapple was acceptable up to 4 days during storing at refrigerator. When fresh cut pineapple washed with sanitizers, TSS and flavour was reduced. So after slicing pineapple wash with sanitizers is not preferable.
- Fresh cut ripe jackfruit (Khaza type) bulb washed with sanitizers (0.1% calcinated calcium or 2% citric acid solution) was acceptable up to 12 day, bulb without wash was acceptable up to 9day and bulb washed with tap water was acceptable up to 6 days. When fresh cut ripe jackfruit bulb washed with sanitizers, TSS and flavour was reduced slightly. So ripe jackfruit bulb, without wash is preferable.
- Fresh strawberry without coating was acceptable up to 6 days, strawberry coated with 1.5% chitosan with or without 1% $CaCl_2$ was acceptable up to 8 days and strawberry coated with Aloe vera gel with or without 1% $CaCl_2$ was acceptable up to 9 days.

B. Implementation Position

1. Procurement:

Description of equipment and capital items	PP Target		Achievement		Remarks
	Phy (#)	Fin (Tk)	Phy (#)	Fin (Tk)	
(a) Office equipment (Laptop)	1	60000.00	1	100%	
(b) Lab &field equipment (Refrigerator)	1	70000.00	1	100%	
(c) Other capital items (Chemical & apparatus)		288200.00		100%	

2. Establishment/renovation facilities:

Description of facilities	Newly established		Upgraded/refurbished		Remarks
	PP Target	Achievement	PP Target	Achievement	

3. Training/study tour/ seminar/workshop/conference organized:

Description	Number of participant			Duration (Days/weeks/ months)	Remarks
	Male	Female	Total		
(a) Training	12	8	20	1 day	
(b) Workshop					

C. Financial and physical progress Fig in Tk

Items of expenditure/activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)	Reasons for deviation
A. Contractual staff salary	377994	377994	377994	0	100.0	
B. Field research/lab expenses and supplies	707980	703821	687025.5	16795.5	97.0	
C. Operating expenses	83006	83329	78251	5078	94.3	
D. Vehicle hire and fuel, oil & maintenance	58100	58100	58100	0	100.0	
E. Training/workshop/seminar etc.	74200	74200	74200	0	100.0	
F. Publications and printing	110000	81442	20000	61442	18.2	PCR will be published by NATP
G. Miscellaneous	58720	26046	23875	2171	40.7	
H. Capital expenses	130000	130000	130000	0	100.0	

D. Achievement of Sub-project by objectives: (Tangible form)

Specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output(i.e. product obtained, visible, measurable)	Outcome(short term effect of the research)
To know the existing situation of fresh cut fruits and vegetables in Bangladesh	Survey has been conducted in super shops (different outlets of Prince Bazar, Shwapno, Agora, Meena Bazar, Lavender etc in Dhaka) and(Shwapno, Agora, Meena Bazar, Fultaj etc at Chittagong district) and to the street vendors of Dhaka and Gazipur city.	-Fruits like pineapple, guava, pomegranate, golden apple, pummelo, papaya, mango etc. and vegetables like mixed vegetables, bitter gourd, sweet gourd, cucumber, carrot, etc. are used as fresh cut in super shops. -During processing workers did not use and apron, hand gloves, musk or cap. Their hands, knife and utensils are not sterilize even not clean.	-Known the demand of FCFV processing -Known the existing FCFV processing methods
To study the use of sanitizer, safe food additives, edible coating and packaging of fresh cut fruits and vegetables to extend the shelf life with quality	-Study on fresh cut processing of Jackfruit bulb and pineapple using sanitizers. - Study on fresh cut processing of cauliflower and bell pepper using packaging techniques. - Study on fresh processing of strawberry using Aloe vera gel and chitosan edible coating. - Study on mild heat treatment with acid in fresh cut processing of carrot	-FC carrot without heat treatment and carrot treated with warm solution of 2% citric acid was good up to 4 & 10 days respectively during storing at refrigerator. -FC cauliflower without packaging and vacuum packed one was good up to 4 &20 days respectively during storing at refrigerator. -FC bell pepper without packaging and vacuum packed one was good up to 2 & 10 days respectively during storing at refrigerator. -FC pineapple washed with tap water and no wash pineapple after slicing was good up to 4 & 5 days respectively during storing at refrigerator. -FC jackfruit bulb washed with tap water and no wash bulb was good up to 6&9 days respectively during storing at refrigerator. -Fresh strawberry without coating & Aloe vera gel coated one was acceptable up to 6 & 9 days, respectively during storing at refrigerator.	Developed quality & long storage life technologies of vegetables (carrot, bell pepper and cauliflower) & fruits (Jackfruits, pineapple and strawberry)
To determine the microbial load and storage potential of fresh cut fruits and vegetables for safe	The change in different microbial populations, namely total bacterial count (TBC), yeasts and mold in logCFU/g was detected in all fresh cut fruits and vegetables processing studies initially and	In most of the fresh cut fruits and vegetables processing studies, total bacterial count (TBC) only in control sample was exceeded the maximum acceptable contamination values during last stage of storage. There were no detectable Yeast & Mold counts in any samples	Developed quality and microbal safe technologies of vegetables (carrot, bell pepper and cauliflower) & fruits

products	during storage	initially & during storage life	(Jackfruits, pineapple &strawberry)

E. Materials Development/Publication made under the Sub-project:

Publication	Number of publication		Remarks (e.g. paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
Technology bulletin/ booklet/leaflet/flyer etc.		**1**	**dj I mewRi †d«kKvU c^{a}‡mwms (evsjv)**
Journal publication			
Information development			
Other publications, if any (**Training manual)**		**1**	Training manual on Fresh Cut Fruits and Vegetables Processing

F. Technology/Knowledge generation/Policy Support (as applied):

i. Generation of technology (Commodity & Non-commodity)

- Fresh cut processing techniques of carrot through mild heat treatment with citric acid or sodium chloride
- Fresh cut processing techniques of Jackfruit bulb using citric acid.
- Fresh cut processing techniques of pineapple.
- Fresh cut processing of bell pepper through vacuum packaging techniques.
- Fresh cut processing of cauliflower through vacuum packaging techniques.

ii. **Generation of new knowledge that help in developing more technology in future**

New knowledge on vacuum packaging that is simple and easy that will help to develop more technologies. Besides, new knowledge on natural sanitizers like calcinated calcium and herbal edible coating like Aloe vera gel will be used to other crops to develop safer and nutritious fresh cut processing technologies.

iii. Technology transferred that help increased agricultural productivity and farmers' income

Fresh cut processors have been trained on safe and long shelf life fresh cut processing technologies of fruits and vegetables that will help to get quality fresh cut produce to the busy consumers, processors will earn more moneys and postharvest loss of fresh fruits and vegetables will be reduced.

iv. Policy Support

Encourage fresh cut processors of super shops and street vendors to produce quality produce (technological support, training support, provision of subsidy, soft loans, etc.)

G. Information regarding Desk and Field Monitoring

i) Desk Monitoring[description & output of consultation meeting, monitoring workshops/seminars etc.):

Description	Output
New Innovation through the project should be reported	Reported in the PCR
Title, objectives, activities, output and outcomes should be corrected and consisted in the PCR	Corrected in the PCR

ii) Field Monitoring (time& No. of visit, Team visit and output):

A field monitoring team consisted of Dr. Md. Mia Syed Hasan, Dr. Md. Abdul JalilBhuyan and M&E Specialist of PIU, BARC monitored the project activities on 14 March 2018 and expressed their satisfactions on the status of the sub-project. Internal Monitoring (Evaluation committee, BARI) visited the project activities on February 2018.

H. Lesson Learned/Challenges (if any)

Signature of the Principal Investigator
Date …….
Seal

Counter signature of the Head of the organization/authorized representative
Date ……..
Seal

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