Effect of chlorine wash and packaging techniques on shelf life and quality of cauliflower (*Brassica oleracea var. botrytis L.*)

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Abstract

The major postharvest problems of fresh cauliflower are browning of the curd, shorter shelf life and faster deterioration of quality soon after harvest. The study was conducted to determine the effect of washing materials and packaging techniques on shelf life and quality of cauliflower. The experiment was laid out in Completely Randomized Design (CRD) factorial with three replications. There were two factors. Factor A: washing material with two levels (A1= tap water wash and A2= chlorine wash with 200 ppm sodium hypochlorite) and Factor B: packaging technique with six levels (B1= without packaging/control, B2= None perforated polyethylene B3= 0.5% perforated polyethylene, B4= 1% perforated polyethylene, B5= 1.5% perforated polyethylene and B6= used paper carton). Each replication of the treatments consisted of two cauliflowers. Data on weight loss (%), disease incidence (%), compactness, shelf life (days), acidity (%), vitamin C content (mg/ 100g) and total soluble solid (TSS) (^{0}Brix) were recorded during the experiment. Washing of cauliflower with chlorine, packing in different perforated polyethylene bag and keeping at ambient condition reduced the weight loss and minimized disease incidence. Compositional changes in acidity (0.42% to 0.38%) were non-significant and vitamin C content (53mg/100g - 47.30 mg/100g) was significant after 4 days of storage in cauliflower packed in different perforated polyethylene bag. Cauliflower washed with chlorine and packed in either 0.5% or 1% perforated polyethylene bag had extended shelf life up to 6 days as compared to control for 3 days only.

Key words: Weight loss (%), disease incidence (%), Chemical parameter, Shelf life (day)

Introduction

Cauliflower (*Brassica oleracea var. botrytis L.*) is one of the most important vegetable crops in Bangladesh. It is grown for it's white tender head or curd formed by the shortened flower parts, which are used as a vegetables in curries, soups and for pickling. It plays a vital role in the human dietary by adding vitamins, minerals, fibres etc. Since fruits and vegetables continue their physiological functions even after harvest or separation from the parent plant, the rate of respiration and the transpiration reflect on the storage ability and the perishability of the commodities. It is estimated that around 20-50% of these fruits and vegetables do not reach to the consumer for want of proper harvesting, handling, packaging, transportation, storage and marketing facilities in developing countries (Ammiruzzaman, 2000).

Due to its perishability nature, the postharvest loss has been estimated 34.40% in Bangladesh (Hasan *et al.,* 2010). The loss is mainly occurred due to its rapid physiological changes. If the physiological activities are retard through various technological interventions like washing technique and modified packaging method, the quality and storability of the fresh cauliflower can be prolonged. Literature suggests that the cauliflower can be stored up to 21 days by maintaining temperature 0±1^o C and 90-95% relative humidity. But information is inadequate on fresh cut cauliflower and their shelf life with good quality in the fresh market in Bangladesh context. In case of washing, fruits and vegetables are washed in chlorine or potassium permanganate before packaging (Giraldo *et al.* 1977) to reduce micro flora especially bacteria from the produce. Washing with water is an important part of assuring produce quality during postharvest. The wash water can easily spread disease from one unit of produce to another if there is no uses of clean water with chlorine bleach (hypochlorite). 100 to 200ppm is the recommended level of chlorine in wash water that will provide adequate protection when the pH is 6.5 (Kitinoja, 2001). Chlorine solution is achieved by adding 200ppm sodium hypochlorite in clean water (Amiruzzaman 2000). The storage of fresh fruits and vegetables in plastic films restrict the transmission of respiratory gases for the accumulation of carbon dioxide and depletion of oxygen around the crop, which may increase their shelf life (Kader *et al.* 1989). But, scanty information is available in Bangladesh in this regards. Hence, the experiment was undertaken to study the effect of chlorine wash and packaging technique on shelf life and quality of fresh cauliflower.

Materials and Methods

Cauliflower (Local variety) is used as study materials. Fresh cauliflower was harvested from farmer's field. This research was conducted at the laboratory of Postharvest Technology Section, Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI) during February 2010. The cauliflowers were sorted out to eliminate bruised, punctured and damaged ones. The experiment was laid out in CRD factorial with three replications. There were two factors. Factor A: washing material with two levels (A_1= tap water wash and A_2= chlorine wash with 200 ppm sodium hypochlorite) and Factor B: packaging technique with six levels (B_1= without packaging/control, B_2= None perforated polyethylene B_3= 0.5% perforated polyethylene, B_4= 1% perforated polyethylene, B_5= 1.5% perforated polyethylene and B_6= used paper carton).

Each replication of the treatments consisted of two cauliflowers. Data on weight loss (%), disease incidence (%), compactness, shelf life (days), acidity (%), vitamin C content (mg/ 100g) and TSS (^{0} Brix) were recorded during conducting the experiment.

Weight loss (%)

It was determined by periodical weighing of cauliflowers and expressed as percentage of original weight. Damaged cauliflowers were also included with it. The weight loss was calculated as following formula of Amayogi and Alloli (2007).

$$\%WL = \frac{IW - FW}{IW} \times 100$$

Where, WL= Weight loss of cauliflower

IW= Initial weight of cauliflower

FW= Final weight of cauliflower

Disease incidence (%)

The cauliflowers were observed visually for rotting and microbial infection. Percent disease incidence was identified and calculated using the formula of Mamatha *et al*., (2000).

$$\%DI = \frac{Do}{D} X100$$

Where, DI= Disease incidence

Do= Number of diseased cauliflower

D= Total number of cauliflower

Disease severity was calculated as defined as the percentage of cauliflower area diseased (1/10th). Estimates of disease severity per cauliflower were expressed as the mean disease severity per cauliflower. Disease severity was calculated using the following formula of Molla *et al.* (2011).

$$\%DS = \frac{Ao}{A} X100$$

Where, DS= Percent disease severity

Ao= Area of cauliflower infected by disease

A= Total area of cauliflower

Shelf life (Day)

The shelf life of cauliflowers was determined by judging the non marketability parameter such as damaging, shriveling etc.

Compactness

It was measured organoleptically by formatting a panel of three members with a scale from 1 to 10; where 1 indicate very soft and 10 indicate very hard or compact.

Chemical analysis

Acidity (%), vitamin-C (mg/100g) and TSS (^{0}Brix) were determined at 1stand 4th day of storage period. Acidity, ascorbic acid content and TSS was determined by treating against standard NaOH solution, by 2, 6- Diclorophenol-Indophenol following visual titration method and by brix meter, respectively. These methods were conducted according to Rangana (1990).

Statistical analysis

The experiment was laid out in Completely Randomized Design (CRD) factorial with three replications. A two way analysis of variances (ANOVA) was conducted for shelf life (days), weight loss (%), disease incidence (%) and compactness by using statistical method

(MSTAT-C). The difference was quantified by Duncan's Multiple Range Test (DMRT).

Results and Discussion

Physical parameter

Effect of chlorine wash: Disease incidence and shelf life showed significant variation (Table 1). Cauliflower wash with chlorine solution gained maximum shelf life (4.5 days) while cauliflower wash with tap water gained shelf life for 4.17 days. Maximum disease incidence (56.931%) was shown in cauliflower wash with tap water and minimum (54.58 %) was shown in that wash with chlorine solution. There were no significant differences in weight loss and compactness.

Effect of packaging technique: All of the studied parameters like weight loss, compactness, disease incidence and shelf life were differed significantly (Table 2). Maximum weight loss (86.04%) was found in cauliflower kept in without packaging (control), sealed polyethylene bag and used paper carton while minimum weight loss (12.63%) was found in cauliflower kept in 0.5% perforated polyethylene bag.

Likewise, maximum disease incidence (86.04%) was found in cauliflower kept in without packaging (control), sealed polyethylene bag and used paper carton while minimum disease incidence (24.33%) was found in cauliflower kept in 0.5% perforated polyethylene bag which was statistically similar(24.73%) with that kept in 1% perforated polyethylene bag.

Minimum compactness (0.72%) was found in cauliflower kept in without packaging (control), sealed polyethylene bag and used paper carton. On the other hand, maximum compactness (2.48%) was observed that packed in 0.5% perforated polyethylene bag.

Maximum shelf life (5.67 days) was gained the cauliflower kept in 0.5% perforated polyethylene bag. On the other hand, minimum shelf life (2.5 days) was observed in cauliflower kept in non-perforated polyethylene bag which was statistically similar with those kept in without packaging condition (control). Brinjal in perforated polyethylene bag prolonged shelf life and maintained quality compared to unpacked fruit (Badgujar *et al.* 1987).

Combined effect

Weight loss and disease incidence influenced significantly by different washing and packaging techniques (Table 3). The lowest weight loss (11.84%) was recorded in cauliflower washed

Table 1. Postharvest parameters of cauliflower in storage period affected by chlorine wash

Treatment	Weight loss (%)	Compactness	Disease incidence (%)	Shelf life (days)
A1	50.06	1.52	56.93 a	4.17
A2	50.21	1.57	54.58 b	4.5
Level of significance	NS	NS	**	*
CV %	0.84	4.65	2.21	8.6

Note: A1= Wash with tap water, A2= Wash with chlorine solution; the data were transformed first before analysis. Means with the same letter are not significantly different at 5% level by DMRT, *= significant at 5% level, **= significant at 1% level

Table 2. Postharvest parameters of cauliflower in storage period affected by different packaging technique

Treatment	Weight loss (%)	Compactness	Disease incidence %)	Shelf life (Days)
B1	86.04 a	0.72 c	86.04a	3.00 d
B2	86.04 a	0.72 c	86.04 a	2.50 d
B3	12.63d	2.48a	24.33c	5.67 a
B4	14.48c	2.38a	24.73c	5.50 a
B5	15.60b	2.24b	27.33b	5.17 a
B6	86.04a	0.72c	86.04a	4.00 c
Level of significance	**	**	**	**
CV %	0.84	4.65	2.21	8.6

Note: B1= Control/ without packaging condition, B2= Non perforated polyethylene bag, B3=0.5% perforated polyethylene bag, B4=1% perforated polyethylene bag, B5=1.5% perforated polyethylene bag, B6= Used paper carton. The data were transformed first before analysis. Means with the same letter are not significantly different at 5% level by DMRT, *= significant at 5% level, **= significant at 1% level with tap water and packed in 0.5% perforated polyethylene bag compared to other treatments (Table 3).

Similarly, the lowest disease incidence (21.92%) was recorded in cauliflower washed with chlorine water and packed in 0.5% perforated polyethylene bag compared to other treatments (Table 3). There were no statistically differences for compactness among the different treated cauliflowers (Table 3).

In case of shelf life, the maximum shelf life (6 days) was gained by the cauliflower washed with chlorine water and packed in 0.5% and 1% perforated polyethylene bag while minimum shelf life (2.33 days) was recorded in cauliflower washed with tap water and kept in non-perforated polyethylene bag (Table 3).

The weight loss of cauliflowers washed with chlorine and packed in different packaging technique up to 4th day at each day of storage period is represented in Fig. 1. The trend of percent weight loss was increasing with the advancement of storage period in all treatments. It was highest (15.93 g) in without packaging condition (control) and lowest (1.39g) in non-perforated polyethylene bag at 4th day of storage period.

Fig. 2 represents the changes of compactness of cauliflowers washed with chlorine and packed in different packaging technique up to 4th day of storage period. It is shown in graphical representation that in all treatments, a gentle decrease in compactness was occurred. Maximum change of compactness (from 10 to 2) was observed when cauliflowers kept in without packaging condition while that was minimum (from 10 to 8) when cauliflowers kept in non perforated polyethylene bag. During storage, reduction in firmness is due to the degradation of insoluble protopectin to the more soluble pectic acid and pectin (Salunkhe, 1991).

Fig. 3 represents the changes of diseases incidence of cauliflowers washed with tap water and chlorine solution and packed in different packaging technique at 4th day of storage period. In all packaging technique, diseases incidence was lowest in cauliflower wash with chlorine solution while, it was highest in cauliflower wash with tap water. Maximum diseases incidence (28.33%) was found when cauliflower wash with tap water and kept in without packaging condition. On the other hand, minimum diseases incidence (3.33%) was found when cauliflower wash with chlorine solution and kept in non perforated polyethylene bag. It may due to the effect of chlorine which is used as disinfectant. Besides, in sealed polyethylene bag, the percentage of CO_2 had increased and O_2 had decreased due the respiration.

Table 3. Combined effect of chlorine wash and different packaging technique on postharvest physiology of cauliflower

Treatment	Weight loss (%)	Compactness	Diseases incidence (%)	Shelf life (Days)
A1B1	86.04a	0.72	86.04 a	3.00
A1B2	86.04a	0.72	86.04a	2.33
A1B3	11.84e	2.42	26.73c	5.33
A1B4	14.73bc	2.35	26.73c	5.33
A1B5	15.67b	2.20	29.97b	5.00
A1B6	86.04a	0.72	86.04a	4.00
A2B1	86.04a	0.72	86.04a	3.00
A2B2	86.04a	0.72	86.04a	2.67
A2B3	13.41d	2.55	21.92d	6.00
A2B4	14.23cd	242	22.73d	6.00
A2B5	15.52b	2.27	24.69cd	5.33
A2B6	86.04a	0.72	86.04a	4.00
Level of significance	**	NS	**	NS
CV %	0.84	4.65	2.21	8.6

Note: A1= Wash with tap water, A2= Wash with chlorine solution, B1= Control/ without packaging condition, B2= Non-perforated polyethylene bag, B3=0.5% perforated polyethylene bag, B4=1% perforated polyethylene bag, B5=1.5% perforated polyethylene bag, B6= Used paper carton. The data were transformed first before analysis. Means with the same letter are not significantly different at 5% level by DMRT, *= significant at 5% level, **= significant at 1% level.

This environment is not suitable for the growth of most of the microorganisms. The main disease of infected cauliflower was bacterial soft rot caused by *Erwoinia carotovora*. It was also observed some fungi were *Fusarium sp., Aspergillus sp. and Penicillium sp.*

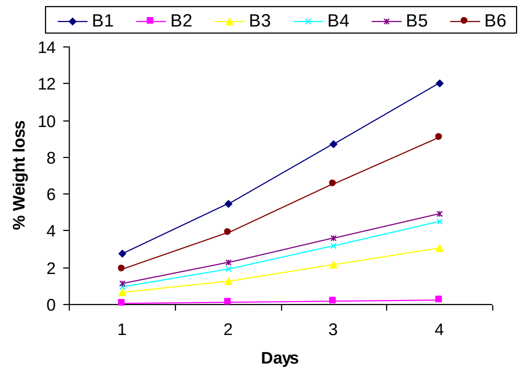

Fig. 1. Weight loss of cauliflower influenced in different packaging technique with respect to time.

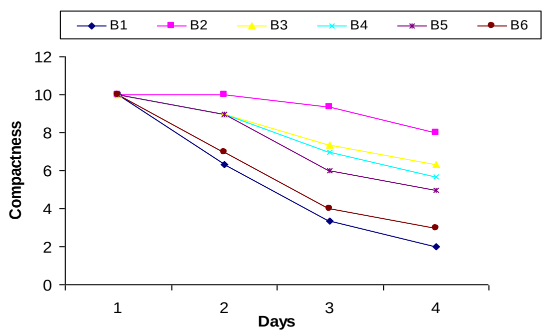

Fig. 2. Compactness of cauliflower influenced in different packaging technique with respect to time.

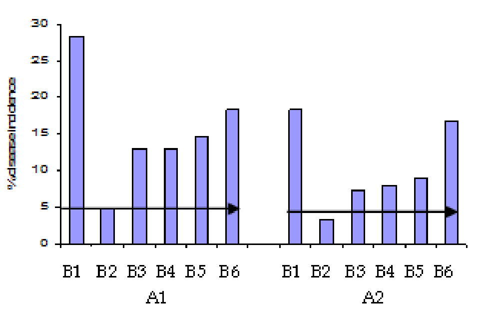

Fig. 3. Effect of different washing and packaging materials on percentage of disease incidence of cauliflower

Where,

A1= Tap water, A2= Chlorine solution, B1= Without packaging, B2= Non perforated polyethylene bag, B3= 0.5% perforated polyethylene bag, B4= 1.0% perforated polyethylene bag, B5= 1.5% perforated polyethylene bag and B6= Used paper cartons

Chemical parameter

Table 4 shows the chemical compositions of cauliflower such as acidity, TSS and vitamin C at 1st and 4th days of storage period. Initial acidity of cauliflower was 0.42% and decreased slightly with the advancement of storage period. Maximum deterioration of acidity (0.35%) was observed at 4th day of storage in cauliflower washed with tap water and kept in without packaging condition (control) and minimum deterioration of that was 0.39% in cauliflower washed with tap water and kept in non perforated and 1% perforated polyethylene bag. The decreased acidity might be due to inverse relation with the increased of storage periods. The results were an agreement with Singh and Roy (1984).

Vitamin C content of cauliflower was 57 mg/100 g initially and decreasing tendency was observed with the advancement of storage period. At 4th day of storage period, minimum vitamin C content (45 mg/ 100g) was present in cauliflower washed in tap water and chlorine solution and kept in without packaging condition (control). On the other hand, maximum (49.1 mg/100g) was present in cauliflower washed with tap water and kept in 0.5% perforated polyethylene bag. In without packaging conditions both compositions acidity and vitamin–C was lost in larger amount than that of in polyethylene packaging conditions. The decreased vitamin-C might be due to its oxidation during the long concentration steps and storage in room temperature. The results are fully supported by the several researchers (EI. Ashwah *et al.* 1980; Molla *et al.* 2007; Brar *et al*. 2013) while they shown that the vitamin-C content decreased with the increase of storage periods and different kinds of packaging techniques.

TSS content of cauliflower was (10.3^0 Brix) initially and during storage it was increased slightly with the advancement of storage period. Maximum amount (13.6^0 Brix) of TSS was found in cauliflower washed with chlorine water and kept in without packaging condition while minimum (11.0^0 Brix) was recorded in cauliflower washed with tap water and chlorine solution and kept in non perforated polyethylene bag at 4th days of storage period (Table 4).

Table 4. Changes of different chemical compositions of cauliflower at different days of storage period

Treatment	Vitamin-C (mg/100g)		Acidity (%)		TSS (°Brix)	
	1st day	4th day	1st day	4th day	1st day	4th day
A_1B_1	53.00	45.00e	0.42	0.35	10.30	13.30ab
A_1B_2	53.00	46.10cde	0.42	0.39	10.30	11.00c
A_1B_3	53.00	49.10a	0.42	0.38	10.30	11.80bc
A_1B_4	53.00	47.45abc	0.42	0.39	10.30	11.80bc
A_1B_5	53.00	46.37cde	0.42	0.37	10.30	12.00abc
A_1B_6	53.00	45.12de	0.42	0.36	10.30	13.0ab
A_2B_1	53.00	45.00e	0.42	0.36	10.30	13.60a
A_2B_2	53.00	46.78bcd	0.42	0.38	10.30	11.00c
A_2B_3	53.00	49.00a	0.42	0.38	10.30	11.90bc
A_2B_4	53.00	48.30ab	0.42	0.37	10.30	12.00abc
A_2B_5	53.00	47.30bc	0.42	0.37	10.30	12.20abc
A_2B_6	53.00	46.20cde	0.42	0.36	10.30	13.40ab
Level of significance	ns	**	ns	ns	ns	*
CV (%)	-	2.10	-	2.09	-	8.04

Note: A1= Wash with tap water, A2= Wash with chlorine solution, B1= Control/ without packaging condition, B2= Non perforated polyethylene bag, B3=0.5% perforated polyethylene bag, B4=1% perforated polyethylene bag, B5=1.5% perforated polyethylene bag, B6= Used paper carton

Conclusion

The shelf life of cauliflower could be extended up to 6 days without excessive deterioration of quality by washing the cauliflower with chlorine solution (200ppm) and packed in either 0.5% or 1% perforated polyethylene bag at ambient condition as compared to control for 3 days only. This technology may apply to the growers, middlemen and retailers level and also may apply from local fresh market to distant market.

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