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Effect of pretreatments and packaging materials on the quality of minimally processed cauliflower (*Brassica oleracea* var. *botrytis*)

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ABSTRACT

A research study was carried out on Minimal processing of cauliflower in the Division of Post Harvest Technology, Indian Agricultural Research Institute, New Delhi. Pre-treatment of cauliflower florets with 150 ppm sodium hypochlorite for 2 minutes were found to be effective in reducing the bacterial population. Dipping of florets in 1% citric acid for 5 minutes was found to be highly effective in checking bacterial population (3.65 log cfu/g) in the minimally processed cauliflower. The maximum retention of firmness (18.08 N) was found in 1 % $CaCl_2$ treated cauliflower followed by 0.5 % citric acid + 0.5 % $CaCl_2$. The minimally processed cauliflower treated with 150 ppm sodium hypochlorite for 2 minutes and 1 % citric acid for 5 minutes, packed in HDPE (500 gauge), LDPE (100 gauge) and PP (100 gauge) and stored at 5^o C for 20 days. The least weight loss was observed in the cauliflower stored in HDPE (2.35%). The respiratory rate and ethylene evolution was higher in cauliflower stored in LDPE packaging than HDPE. During storage, sinigrin content was found to be the higher in cauliflower packed in HDPE films (55.78 µmol/ 100 g) followed by LDPE (43.74 µmol /100 g). Cauliflower florets packed in HDPE retained significantly higher level of ascorbic acid (43.49 mg/100 g) and firmness (15.92 N). The electrolyte leakage was found to be lower in HDPE (29.5%). The microbial population of minimally processed cauliflower was found to be below the safe level even after 20 days of storage.

Key words: Cauliflower, Citric acid, HDPE, LDPE, Minimal processing, PP, Sodium hypochlorite

With the rapid changes in life styles in metro cities, people find very less time for cooking of vegetables. Preparatory activities, viz. cutting, shredding, washing eliminates the non-edible portion that substantially increases the kitchen garbage. In recent times, the demand for minimally processed vegetables is on increase. The main criteria of minimal processing are to keep the produce fresh without losing its nutritional quality. Minimally processed fresh vegetables are more perishable than unprocessed fresh produce due to tissue damage resulting from processing. The main challenge is to combat the rapid quality deterioration in the minimally processed vegetables.

Microflora present in vegetables poses major safety problems and led to use various chemicals to control them. Sodium hypochlorite, a commonly used disinfectant proved to be effective in checking microbial population. Sodium hypochlorite was more effective against bacteria than fungi. This is due to the oxidizing nature of sodium hypochlorite. Sodium hypochlorite gets hydrolysed in water and spilt in to sodium hydroxide and hypochlorous acid. This hypochlorous acid diffuses through the cell walls of bacteria and change oxidation-reduction potential of the cell. Further, it inactivates triose phosphate dehydrogenase, which is essential for the digestion of food material (glucose) by the micro - organism. Thus the ability of micro organisms to function is inhibited (Delaquis *et al.* 2004).

Citric acid, ascorbic acid, calcium chloride etc., are in use to reduce the microbial profile in addition to nutritional and sensory quality improvement in minimally processed vegetables.

Modified atmosphere packaging is being employed as a potential means of shelf life extension technique. Modified atmosphere within the bag can be beneficial in maintaining the quality of fresh cut vegetables by reducing the respiration rate, ethylene biosynthesis and its action. Modified atmosphere packaging in combination with refrigeration have profound effect in inactivating the enzymes involved in metabolic reactions and in reducing the microbial load. Although some of these techniques have been in use in different vegetables, yet these cannot be generalized for all the species and cultivars of vegetables.

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With this view, this research was carried out to study the effect of chemicals and packaging materials on the quality of minimally processed cauliflower (*Brassica oleracea* L. var *botrytis*).

MATERIALS AND METHODS

Freshly harvested cauliflower curds of var. Sweta were obtained from a commercial grower, Najafgarh, New Delhi. They were transported to Post Harvest Technology laboratory, Indian Agricultural Research Institute, New Delhi within 4-5 hours of harvest. They were washed with tap water and cut into florets (5.5 cm × 3 cm) using sharp serrated knife. The florets were then washed again and air dried.

To reduce the initial microbial load, florets were dipped in 100 and 150 ppm sodium hypochlorite for 1, 2 and 4 minutes. Then, the florets were packed in 500 gauge high density polyethylene (HDPE) and stored at 5^o C in a refrigerator. The treatments were replicated 3 times in a completely randomized design. The observations on bacterial and fungal population were recorded at 0 day and on 7th day of storage.

To reduce the loss of firmness and other undesirable changes in minimally processed cauliflower, florets were dipped in Generally Recognized As Safe (GRAS) chemicals such as 1 % citric acid, 1 % ascorbic acid, 1 % calcium chloride, 0.5 % citric acid + 0.5 % ascorbic acid, 0.5 % ascorbic acid + 0.5 % calcium chloride and 0.5 % citric acid + 0.5 % calcium chloride for 5 min. The treatments were replicated 3 times in a completely randomized design. The observations on firmness, bacterial and fungal population were recorded at an interval of 5 days.

The best treatments from the above two experiments were combined to study the shelf life of minimally processed cauliflower using different packaging materials to modify the atmosphere within the package. Florets of cauliflower were treated with 150 ppm sodium hypo-chlorite for 2 min. and 1 % citric acid for 5 min. packed in 500 gauge high density polyethylene (HDPE), 100 gauge low density polyethylene (LDPE) and 100 gauge polypropylene (PP) and stored at 5^o C for 20 days. The experiment was laid as a completely randomized design. Observations were recorded at 5 days interval up to 20 days for weight loss, firmness, electrolyte leakage, rate of respiration, ethylene evolution, glucosinolates, ascorbic acid, bacterial and fungal count.

Firmness of cauliflower florets was determined by using Instron universal testing machine. The electrolyte leakage of the cauliflower floret was measured by digital conductivity meter. The rate of respiration in cauliflower florets was determined by using Gas Chromatograph. The rate of ethylene evolution in cauliflower florets was determined by using Gas Chromatograph.

Glucosinolates were analyzed as per the method described by Vallego *et al*. (2002). Total titratable acidity was expressed as per cent citric acid (AOAC 1984). Ascorbic acid was determined by titrating a known weight of sample with 2, 6- dichlorophenol indophenol dye using metaphosphoric acid as stabilizing agent (AOAC 1984).

Counting of bacterial and fungal population was done in Standard Plate Count Agar (SPCA) and Martin Rose Bengal Agar (MRBA) medium, respectively. Water blanks were prepared by taking 90 ml of water in 250 ml conical flask and were autoclaved. Ten gram of the florets from each treatment was weighed and added to 90 ml water blank which gives a dilution of 10^{-1}. From 10^{-1} dilution, series up to 10^{-5} were prepared. Dilutions of 10^{-4} and 10^{-5} for bacteria and 10^{-2} and 10^{-3} for fungi were taken for inoculation. The results were expressed as log cfu/g of floret.

RESULTS AND DISCUSSION

Washing with tap water reduced the bacterial population from 7.25 to 4.30 log cfu/g. It is evident from the data presented in Table 1 that sodium hypochlorite treatment drastically reduced the bacterial population in the minimally processed cauliflower. On the 7th day of storage, sodium hypochlorite dosages of 100 ppm for 4 minutes or 150 ppm for 2 minutes or 150 ppm for 4 min were found to be at par with each other having significantly low level of bacterial count compared to other treatments.

The data on firmness (Table 2) revealed that pretreatment with 1% $CaCl_2$ resulted in maximum retention of firmness (18.08 N), which was at par with only 0.5% citric acid + 0.5% $CaCl_2$ treatment.

Table 3 shows that pre treatment with 1% citric acid was found to be highly effective in checking the bacterial population to the least level (3.65 log cfu/g) which was at par with treatment combination of 0.5% citric acid + 0.5% ascorbic acid (3.91 log cfu/g). With respect to fungal population, non-significant difference was observed due to various pre treatments (Table 4). Food borne pathogens, *Salmonella typhimurium, Shigella flexneri* and *Escherichia coli* were found to be absent in treated florets even after 10 days.

Table 1 Effect of sodium hypochlorite on bacterial population (log cfu/g) of minimally processed cauliflower during storage

Treatment	Storage period (Days)		
	0	7	Mean
Control	4.30^b	6.76^d	5.53
100 ppm + 1 min.	3.50^a	5.02^c	4.26
100 ppm + 2 min.	3.33^a	5.01^c	4.17
100 ppm + 4 min.	3.00^a	4.97^b	3.98
150 ppm + 1 min.	3.42^a	5.04^c	4.23
150 ppm + 2 min.	2.92^a	4.95^b	3.93
150 ppm + 4 min.	2.98^a	4.90^b	3.94
Mean	3.35	5.24	
Initial population	7.25 log cfu/g		
CD (P=0.05)			
Treatment (T)	0.08		
Storage period (S)	1.23		
T × S	1.10		

Table 2 Effect of pretreatment on firmness (N) of minimally processed cauliflower

Treatment	Storage period (Days)			
	0	5	10	Mean
Control	19.00	15.62	14.52	16.38
1% CA	18.00	16.72	15.90	16.87
1% AA	18.00	16.63	15.97	16.87
1% $CaCl_2$	18.25	18.01	17.98	18.08
0.05% CA + 0.5% AA	18.00	16.50	15.12	16.54
0.05% CA + 0.5% $CaCl_2$	18.15	16.82	16.72	17.23
0.05% CA + 0.5 $CaCl_2$	18.15	16.58 [c]	16.70	17.14
Mean	18.22	16.69	16.13	
CD (P=0.05)				
Treatment (T)		0.92		
Storage period (S)		1.55		
T × S		0.01		

Table 3 Effect of pretreatment on bacterial population (log cfu/g) of minimally processed cauliflower

Treatment	Storage period (Days)			
	0	5	10	Mean
Control	5.52 [b]	6.62 [b]	7.52 [d]	6.55
1% CA	3.15 [a]	3.68 [a]	4.13 [a]	3.65
1% AA	3.78 [a]	3.90 [a]	4.55 [b]	4.07
1% $CaCl_2$	5.01 [b]	6.05 [b]	7.09 [c]	6.05
0.05% CA + 0.5% AA	3.45 [a]	3.79 [a]	4.48 [a]	3.91
0.05% CA + 0.5% $CaCl_2$	3.92 [a]	3.99 [a]	4.53 [b]	4.15
0.05% CA + 0.5 $CaCl_2$	4.00 [a]	4.12 [a]	5.12 [b]	4.41
Mean	4.12	4.59	5.34	
Initial population		6.72 log cfu/g		
CD (P=0.05)				
Treatment (T)		0.40		
Storage period (S)		0.63		
T × S		0.56		

Table 4 Effect of pretreatment on fungal population (log cfu/g) of minimally processed cauliflower

Treatment	Storage period (Days)			
	0	5	10	Mean
Control	0.24 [b]	1.58 [b]	2.90 [b]	1.57
1% CA	0.24 [a]	0.67 [a]	1.30 [a]	0.73
1% AA	0.24 [a]	0.68 [a]	1.43 [a]	0.78
1% $CaCl_2$	0.24 [a]	0.70 [a]	1.43 [a]	0.79
0.05% CA + 0.5% AA	0.24 [a]	0.66 [a]	1.35 [a]	0.75
0.05% CA + 0.5% $CaCl_2$	0.24 [a]	0.69 [a]	1.45 [a]	0.79
0.05% CA + 0.5 $CaCl_2$	0.24 [a]	0.70 [a]	1.43 [a]	0.79
Mean	0.24	0.81	1.61	
CD (P=0.05)				
Treatment (T)		0.03		
Storage period (S)		1.38		
T × S		0.77		

Minimally processed vegetables are living tissues that are undergoing catabolic activities. Packaging of minimally processed cauliflower in permeable polymeric film can reduce O_2 concentration and increase CO_2 concentration in the package atmospheres, thereby, slowing quality changes and increasing product shelf life (Emmambux and Minnaar 2003, Kim *et al*. 2004, Pizato *et al*. 2013).

The weight loss was less in the cauliflower stored in HDPE films and it was significantly lower (2.35%) than florets of LDPE (4.64%) film. This is due to lower water vapour permeability in HDPE than LDPE. The lower weight loss might be partly due to low temperature and high humidity during storage.

The minimally processed cauliflower stored in HDPE films showed significantly higher values of firmness than that of LDPE packaging (Table 5) due to less ethylene production (Watada 1996). The firmness was in the decreasing order with the advancement of storage period and it was non-significant up to 15th day of storage and became significant beyond this period (Manolopoulou and Varzakas 2011).

Electrolyte leakage is an indirect measure of cell membrane damage. The lowest loss of electrolytes in HDPE packaging was at par with PP. It also clear that there was a progressive increase in the loss of electrolytes with advancement of storage period and became significant only on 15th day of storage.

Table 5 Effect of modified atmosphere packaging on firmness (N) in minimally processed cauliflower

Treatment	Storage period (Days)				
	5	10	15	20	Mean
Control	15.12	14.60	11.50	8.20	13.68
HDPE	18.41	17.50	16.20	15.92	17.41
PP	17.93	16.92	15.83	14.90	16.92
LDPE	17.46	16.40	15.00	12.17	16.01
Mean	17.23	16.36	14.63	12.79	
Initial value = 19 N					
CD (P=0.05)					
Treatment (T)		2.54			
Storage period (S)		2.92			
T × S		2.78			

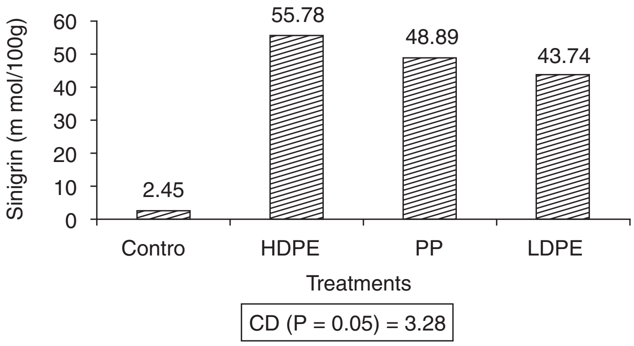

Fig 1 Effect of packaging material on glucosinolates (m mol/100g) in minimally

Cauliflower immediately after cutting exhibited high respiratory rate and ethylene production. The respiratory rate and ethylene evolution was higher in cauliflower stored in LDPE packaging than HDPE and PP packaging. There was a slight increase in respiration during storage period. The slight increasing in ethylene production was due to the increase in respiratory rate (Brecht 1995).

Fig 1 shows that effect of modified atmosphere packaging on the retention of glucosinolate (Sinigrin) content of minimally processed cauliflower on 20th day of storage. The glucosinolates content was found to be the highest in cauliflower packed in HDPE films (55.78 m mol of sinigrin/100 g) followed by LDPE (48.89 m mol of sinigrin/ 100g) and PP packaging (43.74 m mol of sinigrin/100 g). The lower content of glucosinolates in florets packed in LPDE might be due to cell damage, which is evident from data on firmness and electrolyte leakage. Cell rupture and membrane damage would have paved the way to glucosinolates degrading enzyme, myrosinase to come into contact with glucosinolates (Hansen *et al.* 1995). In addition to this, comparatively higher concentration of O_2 in LDPE would have been the responsible factor for degradation of glucosinolates (Rangkadilok *et al.* 2002).

Packaging in HDPE film resulted in the higher (43.49 mg/100 g) retention which was at par with PP packaging (41.41 mg/100 g). At the end of storage, HDPE film packed cauliflower florets retained the higher level of ascorbic acid due to creation of modified atmospheric condition with reduced level of O_2 in HDPE films.

It is evident from the data presented in Table 6 that there was a significant reduction in bacterial population of minimally processed cauliflower. The combined effect of 150 ppm chlorine and 1% citric acid also reduced the initial population of 7.1 log cfu/g to 2.06 log cfu/g. It reduces the microbial activity by lowering the pH of the product (Pal *et al.* 2004). The reduction in microbial population is the combined effect of modified atmosphere, low temperature storage and chemical treatment. The minimally processed cauliflower could be stored up to 15 days in all the packaging material, HDPE, LDPE and PP films. There was no significant difference in fungal population observed irrespective of packaging material and storage period. Food borne pathogens, *Salmonella typhimurium, Shigella flexneri* and *Escherichia coli* were found to be absent in treated florets even after 10 days.

The sensory score of minimally processed cauliflower was significantly higher in florets packed with packaging materials. With respect to storage period, the florets scored above 6 hedonic points in all the combinations and were considered acceptable up to 15 days from marketing point of view.

The minimally processed cauliflower could be stored in HDPE and PP films up to 15 days without significant loss of firmness, electrolyte leakage and ascorbic acid. Minimally processed cauliflower packed in HDPE, PP and LDPE showed significantly lower bacterial population up to 15 days.

Table 6 Effect of modified atmosphere packaging on bacterial population (log cfu/ g) in minimally processed cauliflower

Treatment	Storage period (Days)				
	5	10	15	20	Mean
Control	2.90 ^{a}	3.70 ^{b}	4.80 ^{b}	5.90 ^{c}	3.87
HDPE	2.43 ^{a}	2.90 ^{a}	3.20 ^{a}	3.63 ^{b}	2.84
PP	2.62 ^{a}	3.23 ^{a}	3.31 ^{a}	3.82 ^{b}	3.01
LDPE	3.01 ^{a}	3.45 ^{a}	3.56 ^{a}	3.99 ^{b}	3.21
Mean	2.74	3.32	3.72	4.33	
Initial value	2.06 log cfu/g				
CD (P=0.05)					
Treatment (T)	0.43				
Storage period (S)	0.98				
T × S	1.18				

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