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Standardization of packing of minimally processed brussels sprout and cauliflower for extension of storage life

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Abstract
Studies on standardization of packing of minimally processed brussels sprout and cauliflower on physico-chemical characters, firmness, storage life, aroma and taste revealed that the physiological loss in weight was minimum (0.26 and 0.54%, respectively) in brussels sprout and cauliflower packed in 200 gauge poly ethylene bag with 0.5 per cent ventilation and stored under refrigerated conditions. The TSS content was maximum (2.03 and 1.68 %) in brussels sprouts and cauliflower packed in poly ethylene bag of 200 gauge with 0.5 per cent ventilation that were stored in refrigerated condition compared to open condition. Maximum firmness was retained when the processed vegetables were packed in 200 gauge poly ethylene bag with 0.5 per cent ventilation and stored under refrigerated condition (2.81 and 1.92 Kg/cm^2) compared to any other treatment and the shelf life was extended to maximum of 21 and 18 days, respectively. The observations made on the presence of aroma and flavour of the vegetables was significant. The vegetables packed with 200 gauge poly bag with 0.5 per cent ventilation and stored under refrigerated condition had pleasant aroma and flavour with a maximum scores of 3.41 and 3.21, respectively.

Keywords: Brussels sprout, cauliflower, TSS, firmness, shelf lie, aroma, physiological loss in weight

Introduction
Vegetables play an important role as protective foods, in the balanced human diet. India is the second largest producer of vegetables in the world next to, China. In recent years most of the people are very conscious about their health and their food choices. The demand for 'minimally processed' vegetables is increasing as people cannot afford to spend much time in cooking. Minimal processing operations have been defined as those procedures such as washing, sorting, trimming, peeling, slicing or chopping that do not affect the quality of vegetables (Burns, 1995) [3].

The most crucial problem in minimal processing is undesirable physiological changes. Loss of cellular integrity at the cut surface of the vegetables that destroys compartmentation of enzymes and substrates, browning reactions and formation of unwanted secondary metabolites are often the consequence. Senescence may accelerate and off flavours may develop as respiration and ethylene production increase near the cut surface and exudates from such cut surface also acts as favourable medium for fungal and bacterial growth.

Hence various approaches have been used to control the undesirable physiological changes that adversely affect quality of minimally processed vegetables. Shelf life and product quality can be maintained by refrigeration, humidity control, pre-packaging, waxing and use of chemicals. Among these methods, packaging seems to be suitable for tropical developing countries. By selecting appropriate packaging, desirable modified atmosphere can be created within and around commodities. Polyethylene films have been used successfully with some commodities to provide useful barriers to moisture, oxygen and carbon dioxide while improving package recyclability.

The packaging of cruciferous vegetables with polyethylene bags is found to have beneficial effect of extending the storage life. With the intention of using polyethylene bags for extending the storage life of minimally processed vegetables, the present investigation on packaging was carried out with minimally processed cauliflower and brussels sprouts at both ambient and refrigerated conditions of storage.

Materials and Methods
The experiment on "Standardization of packing of minimally processed brussels sprout and cauliflower for extension of storage life" was carried out during the year 2005-06 at the Division of Horticulture, University of Agricultural Sciences, Bangalore with the following

objectives. For both Brussels sprout and cauliflower, two gauge levels of polyethylene bags of 100 and 200 measuring 10 x 7 inches were used. Three levels of ventilation i.e., no ventilation; 0.5 per cent ventilation (14 holes or 7 punches) and 1.0 per cent ventilation (28 holes or 14 punches) of 0.4 cm diameter each were made on both the sides of the bags of all the gauges. A single punch machine was used to punch holes in the bags. Freshly harvested healthy disease free brussels sprout and cauliflower were selected and the damaged outer leaves removed. The brussels sprouts shredded into pieces with alcohol sterilized stainless steel knife and washed in salt water (1.5%) and air-dried. The florets of cauliflower weighing 5g each was also separated with alcohol sterilized stainless steel knife and washed in salt water (1.5%) and were air-dried. Surface dried brussels sprout shreds and cauliflower florets weighing 250 g each were packed in polyethylene bags according to treatments and were sealed using a sealing machine. These packed materials were stored at two storage conditions. i.e., ambient condition ($25^0 \pm 1^0$C) & Refrigerated condition ($4^0 \pm 1^0$C). For determining the physiological loss in weight of both fresh and minimally processed vegetables the samples were weighed at regular interval on digital electronic balance and cumulative losses in weight were calculated and the results are expressed in per cent physiological loss in weight on fresh weight basis. The physiological loss in weight was calculated using the formula given by Jagadeesh (1994) as follows;

$$PLW = \frac{P_0 0 - P_1 \text{ or } P_2 \text{ or } P_3 \text{ or } P_4 \text{ or } P_5 \text{ or } P_6 \text{ or } P_7}{P_0} \times 100$$

Where -
P_0 = Initial weight
P_1 = Weight after 2 days
P_2 = Weight after 5 days
P_3 = Weight after 8 days
P_4 = Weight after 12 days
P_5 = Weight after 15 days
P_6 = Weight after 18 days

The firmness of brussels sprout and cauliflower was measured using an Instron Universal testing instrument (model 4201). The force required to penetrate the Brussels sprout and cauliflower, was recorded in kg/cm^2.
Sensory evaluation of fresh and minimally processed cauliflower and Brussels sprouts was carried out at every three days interval for quality attributes such as aroma and flavour and taste by a panel of three judges using a five point reading scale.

The quality attributes such as aroma and flavour and taste by a panel of three judges using a five point reading scale.

Aroma and flavour	Taste	Score
Extremely pleasant	Best	5
Very much pleasant	Better	4
Pleasant	Good	3
Moderately pleasant	Okay	2
Slightly pleasant	Bad	1
Not pleasant	Very bad	0

The experiment was carried out in factorial completely randomized design replicated three times.

Results & Discussion

Physiological loss and Total soluble sugar

The data on physiological Loss in weight (%) & TSS of minimally processed brussels sprout & cauliflower as influenced by main effect of different gauge, ventilation and storage conditions are presented in Table 1 & 2. Results on physiological loss in weight of brussels sprout and cauliflower at three days interval were significant due to the packing effect (gauge), ventilation and storage condition and their interaction throughout the study packing of brussels sprout in 200 gauge poly ethylene bag was better than packing at 100 gauge poly ethylene bag due to lower physiological loss in weight (0.13%). Ventilation with 0.5 per cent in the same gauge of poly ethylene bag recorded lowest physiological loss of weight (0.26%) compared to other treatments. As anticipated, at refrigerated condition, physiological loss in weight was very minimum (0.18%) compared to those kept at ambient condition.

In the case of cauliflower, it was found to be least in 200 gauge (0.40%) as compared to 0.99 per cent in 100 gauge polyethylene packing. Poly bags with 0.5 per cent ventilation recorded the least physiological weight loss of 0.40 per cent during storage as compared to 0.70 per cent with 1 per cent ventilation. As anticipated, Storage in refrigerated condition it was minimum (0.37%) compared to ambient condition. The difference in thickness of polyethylene bags, ventilations and storage conditions resulted in significant reduction in physiological weight in all the treatments.

This observation might be due to maintenance of higher humidity surrounding the vegetables which in turn retarded the rate of respiration. Further, the higher thickness of polyethylene bags might have the respiration rate of vegetables in maintaining the gaseous exchange favourable in increasing the level of carbon dioxide to a level where respiration of the vegetables was greatly reduced within the package helps in extending the shelf life with minimum physiological loss in weight of vegetables. These results are in conformity with the results obtained in other vegetables like Tomato (Bhatnagar *et al.,* 1990) [2].

The observations made on TSS of brussels sprouts and cauliflower differed significantly among the treatments due to effect of gauge, ventilation and storage condition and their interactions.

Table 1: Physiological Loss in weight (%) & TSS of minimally processed Brussels sprout as influenced by main effect of different gauge, ventilation and storage conditions

Treatments	Physiological loss weight (%)								TSS							
	Days after storage								Days after storage							
	3	6	9	12	15	18	21	24	3	6	9	12	15	18	21	24
Polythene gauge (G)																
Gauge-G_1-100	0.18	0.38	0.16	0.27	0.12	0.11	0.12	0.51	1.46	1.76	1.87	1.90	1.93	1.96	1.97	1.99
G_2-200	0.14	0.29	0.07	0.07	0.09	0.10	0.11	0.13	1.35	1.60	1.78	1.84	1.87	1.90	1.92	1.99
S.Em ±	0.005	0.005	0.003	0.003	0.004	0.003	0.003	0.002	0.027	0.025	0.021	0.019	0.019	0.017	0.019	0.012
CD @ 5 %	0.014	0.015	0.010	0.009	0.013	0.004	0.004	0.003	0.079	0.073	0.060	0.056	0.055	0.050	0.055	0.036
Ventilation (V)																
V_1-0%	0.20	0.42	0.43	-	-	-	-	-	1.49	1.76	1.81	-	-	-	-	-
V_2-0.5%	0.24	0.49	0.14	0.15	0.19	0.22	0.24	0.26	1.33	1.65	1.84	1.87	1.90	1.92	1.95	1.98
V_3-1.0%	0.04	0.09	0.07	0.07	0.09	0.11	0.12	0.07	1.39	1.63	1.69	1.75	1.81	0.86	0.91	1.97
S.Em ±	0.006	0.006	0.004	0.004	0.004	0.004	0.004	0.003	0.033	0.030	0.025	0.023	0.023	0.021	0.023	0.015
CD @ 5 %	0.017	0.018	0.012	0.012	0.013	0.012	0.012	0.008	0.097	0.025	0.074	0.069	0.067	0.061	0.0671	0.044
Storage condition (C)																
C_1- Ambient	0.22	0.46	0.13	0.04	0.06	0.06	0.07	0.09	1.44	1.71	1.12	1.16	1.19	1.23	1.27	0.31
C_2- Refrigerated	0.10	0.21	0.09	0.10	0.13	0.16	0.16	0.18	1.37	1.65	1.54	1.59	1.60	1.62	1.64	1.56
S.Em ±	0.005	0.005	0.003	0.003	0.004	0.003	0.003	0.002	0.027	0.025	0.021	0.019	0.019	0.017	0.019	0.012
CD @ 5 %	0.014	0.015	0.010	0.009	0.010	0.009	0.009	0.007	0.079	0.073	0.060	0.056	0.055	0.050	0.053	0.036

Table 2: Physiological Loss in weight (%) & TSS of minimally processed Cauliflower as influenced by main effect of different gauge, ventilation and storage conditions

Treatments	Physiological loss weight (%)						TSS					
	Days after storage						Days after storage					
	3	6	9	12	15	18	3	6	9	12	15	18
Polythene gauge (G)												
Gauge-G_1-100	0.09	0.92	0.37	0.41	0.49	0.99	1.30	1.10	1.69	1.69	1.70	1.48
G_2-200	0.57	0.74	0.23	0.25	0.29	0.40	1.44	1.23	1.73	1.74	1.75	1.53
S.Em ±	0.039	0.004	0.003	0.003	0.005	0.003	0.026	0.024	0.019	1.017	1.019	0.015
CD @ 5 %	0.113	0.010	0.010	0.009	0.010	0.008	0.075	0.071	0.055	1.050	1.055	0.044
Ventilation (V)												
V_1-0%	1.09	1.72	-	-	-	-	1.41	1.44	-	-	-	-
V_2-0.5%	0.19	0.27	0.30	0.33	0.34	0.40	1.34	1.36	1.42	1.44	1.45	1.78
V_3-1.0%	0.31	0.51	0.61	0.66	0.69	0.70	1.36	1.69	1.71	1.71	1.72	1.74
S.Em ±	0.047	0.004	0.004	0.004	0.004	0.003	0.032	0.030	0.023	0.021	0.023	0.018
CD @ 5 %	0.139	0.013	0.012	0.011	0.012	0.009	0.093	0.087	0.067	0.061	0.067	0.054
Storage condition (C)												
C_1- Ambient	0.92	0.96	0.18	0.20	0.24	0.37	1.37	1.93	1.48	1.48	1.49	1.49
C_2- Refrigerated	0.60	0.92	0.42	0.46	0.50	0.51	1.37	1.40	1.94	1.95	1.96	1.52
S.Em ±	00039	0.004	0.003	0.003	0.005	0.003	0.026	0.024	0.019	0.017	0.019	0.015
CD @ 5 %	0.113	0.010	0.009	0.015	0.008	0.076	0.071	0.055	0.050	0.019	0.055	0.044

Packaging

Packing brussels sprout in poly ethylene bags of 100 gauge registered highest TSS content of 1.46 per cent that increased to 1.99 per cent; ventilation at 0.5 per cent had observed higher TSS content of 1.98 per cent at the end of storage. Obviously, in refrigerated condition it was better to the extent of 1.56 per cent.

In case of cauliflower, it was found to be more in 200 gauge (1.53%) poly bag during storage as compared to 1.48 per cent in 100 gauge polyethylene bag packaging. The florets packed in 0.5 per cent ventilation recorded maximum more total soluble solids (1.78%) as compared to 1.74 per cent in 1.0 per cent ventilation at the end of the storage. Cauliflower stored in refrigerated condition registered higher total soluble solids (1.52%).

Firmness, Shelf life, Aroma and Taste

The data on firmness, shelf life, aroma & taste of brussels sprout and cauliflower are given in table 3. The data registered significant differences among the treatments due to packing, ventilation and storage conditions.

The data presented in table revealed that packing brussels sprout and cauliflower at 200 gauge polyethylene bag had more firmness (2.41 and 1.57 Kg/cm^2) with a shelf life of 13.33 and 9.66 days compared to those packed at 100 gauge poly ethylene bag (2.25 and 1.55 Kg/cm^2) with a shelf life of 12.33 and 8.83 days respectively. Ventilation with 0.5 per cent had higher firmness of 2.56 and 1.60 Kg/cm^2 with a shelf life of 21 and 7.45 days, respectively followed by 1.0 per cent ventilation. These vegetables stored at refrigerated condition stayed still firmer (2.64 and 1.63 Kg/cm^2) compared to those stored under ambient condition. The firmness of Brussels sprout and Cauliflower varied depending upon the stage of maturity and the impact of different gauges of polyethylene bags during storage indicate that unpacked vegetables recorded the least shelf life with maximum loss in firmness at the end of storage period. This is due to softening of cell wall due to degradation of cell wall pectic substances, release of ethylene and mechanical bruise and impact during handling. Results similar to this have been reported by Agar *et al.* (1994) [1].

Better firmness and shelf life might be due to higher level of humidity, low temperature and modified gaseous composition of CO_2 and O_2 inside the bags which did not favour growth of any fungi and also acted as a barrier for the entry of the micro-organisms. Low temperature and higher humidity

around packaged vegetable reduced the rate of respiration, release of ethylene gas, delaying enzymatic activity, which are responsible to shorten the shelf life of vegetables. Higher concentration of CO_2 and low temperature are too helpful in suppressing the multiplication of harmful microorganisms. These results are in conformity with that of Kalra *et al.*, 1988 [5] in case of okra.

The organoleptic scores for aroma and flavour of brussels sprout and cauliflower were maximum (1.47 and 1.35, respectively) with 200 gauge polyethylene bags. At 0.5 per cent ventilation the maximum scores (2.11 and 2.43 respectively) have been given, for the vegetables. Obviously, there was better flavour with 0.91 point for sprouts and 1.57 point for cauliflower florets stored under refrigerated condition.

The vegetables packed with 200 gauge poly bag with 0.5 per cent ventilation and stored under refrigerated condition had pleasant aroma and flavour with a maximum scores of 3.41 and 3.21, respectively compared to those subjected to other treatments.

Better scores of 0.31 and 0.85 were given for the taste of brussels sprout and cauliflower, respectively over the other gauge of packing, while the maximum points of 1.35 and 0.95 were recorded at 0.5 per cent ventilation. Under open condition the scores were very less compared to those stored under refrigerated condition (0.56 and 1.08, respectively) for both the vegetables.

Table 3: Shelf life (in days) & firmness (kg/cm^2) of minimally processed Brussels sprout as influenced by main effect of different gauge, ventilation and storage conditions

Treatments	Shelf life (in days)		firmness (kg/cm^2)		Aroma / Flavour		Taste	
	Brussels sprouts	Cauliflower	Brussels sprouts	Cauliflower	Brussels sprouts	Cauliflower	Brussels sprouts	Cauliflower
Polythene gauge (G)								
Gauge-G_1-100	12.33	8.83	2.25	1.55	0.46	1.20	0.31	0.85
G_2-200	13.33	9.66	2.41	1.57	0.47	1.35	0.90	0.89
S.Em ±	0.33	0.333	0.09	0.062	0.025	0.006	0.008	0.006
CD @ 5 %	0.84	0.688	0.19	0.138	0.051	0.013	0.017	0.007
Ventilation (V)								
V_1-0%	6.0	4.00	2.13	1.32	0.00	0.00	0.00	0.00
V_2-0.5%	21.0	7.45	2.56	1.60	2.11	1.40	1.31	0.98
V_3-1.0%	11.5	6.0	2.20	1.42	0.30	2.43	0.50	1.67
S.Em ±	0.68	0.408	0.11	0.082	0.030	0.008	0.010	0.007
CD @ 5 %	0.33	0.842	0.24	0.168	0.063	0.016	0.021	0.015
Storage condition (C)								
C_1- Ambient	10.83	7.33	2.23	1.48	1.03	0.98	0.65	0.60
C_2-Refrigerated	14.83	11.16	2.64	1.63	0.91	1.57	0.56	1.08
S.Em ±	0.40	0.333	0.096	0.062	0.028	0.006	0.008	0.006
CD @ 5 %	0.68	0.688	0.19	0.138	0.051	0.013	0.017	0.12

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