Indian Journal of Agricultural Sciences **91** (9): 1353–7, September 2021/Article
https://doi.org/10.56093/ijas.v91i9.116086

Effect of MAP on shelf-life of broccoli and cabbage grown under natural farming

RAKESH SHARMA[1]*, SUNAKSHI GAUTAM[1] and HAMID[1]

Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh 173 230, India

Received: 19 January 2021; Accepted: 26 February 2021

ABSTRACT

An experiment was conducted to study the effect of modified atmosphere packaging (MAP) and storage conditions on the shelf-life and quality of broccoli and cabbage during 2019–20. For MAP, freshly harvested produce was packed in LDPE pouches (25.4 µm and 10 pin holes/100 cm^2 area) was kept under ambient (17±2 C, RH 40-60%) and low temperature conditions (5±2ºC, RH 90-95%) and shelf-life comparison was done on the basis of physiological loss in weight (PLW) at every alternate day up to 28 (broccoli) and 34 days (cabbage). Results revealed that broccoli and cabbage packed in perforated LDPE pouches and stored under low temperature storage retained higher sensory acceptability for 14-20 days with record extended shelf-life for market purpose up to 18 and 22 days, respectively with minimum PLW (≤10%). Both broccoli and cabbage grown under SPNF system contained a good amount of total sugars (4.40, 6.59%), reducing sugars (2.53, 5.34%), ash (8.80, 1.28%) and ascorbic acid (86.20, 45.40 mg/100g), respectively.

Keywords: Broccoli, Cabbage, Modified atmosphere packaging, Natural farming, PLW

The natural farming is an agro-ecological farming approach that promotes growing crops in harmony with nature and opposes the use of synthetic fertilizers (Khadse and Rosset 2019). It is also known as Subhash Palekar Natural Farming (SPNF) or zero budget natural farming (ZBNF). Recently, the choice for food raised by natural/ organic farming has attracted the interest of consumers with regard to nutritional quality, safety and freedom from pesticide residues (Khadse and Rosset 2019, Dhiman *et al*. 2019). Although, consumers are paying higher prices for organic produce, but the scientific literature on shelf-life and nutritive quality of the vegetables produced through SPNF or ZBNF system is relatively scarce. Among different vegetables consumed, broccoli posses many functional compounds like proteins, vitamin C, A, dietary fiber, besides low in fats and a good source of several minerals (Singh *et al*. 2018, Dhiman *et al*. 2019). It contains certain bioactive components, like isothiocyanates and glucosinolates, which have anticarcinogenic and antioxidant properties (Bahadoran *et al*. 2012, Latte *et al*. 2011). Similarly, cabbage head is very high in protective vitamins (Vitamin A, Vitamin C, Folate), dietary fibers and rich in minerals (Ogbede *et al*. 2015).

But, due to their high respiration rate, these vegetables have a very short shelf-life which makes the transportation and storage difficult (Kramchote *et al*. 2012, Singh *et al*. 2018). Whereas, altered atmosphere through MAP effectively helps in delaying the postharvest deterioration and preserve the product safely for longer periods (Serrano *et al*. 2006). Packaging in polyethylene films results in a commodity-generated modified atmosphere, which can positively maintain quality of the produce by minimizing the dehydration and respiration rate (Kumar and Thakur 2020). The minimal cost of MAP appears to be an effective and attractive approach for extending postharvest life and maintaining the quality of fresh horticultural produce (Mangaraj and Goswami 2011). Keeping in view the increased consumer demand for chemical free healthy foods, the present investigation was carried out with the aim to extend the shelf-life of broccoli and cabbage grown under SPNF system of cultivation through modified atmospheric conditions so as to make their availability for longer periods.

MATERIALS AND METHODS

The freshly harvested healthy and disease free mature broccoli var. Palam Samridhi (when bud cluster are green and compact) and cabbage var. Golden Acre (compact and firm heads) were harvested from SPNF Farm, YSPUHF, Solan, India and quickly brought to the laboratory of the Department

Present address: [1]Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh. *Corresponding author e-mail: drrakes@gmail.com.

of Food Science and Technology for conducting further studies (2019–20). For modified atmosphere packaging, low density polyethylene (LDPE) pouches (25.4 µm thickness or 100 gauge) were perforated with 10 pin holes/100 cm^2 area for effective air circulation and transpiration. The produce was taken in two lots which were further divided into two halves. In first half, 5 florets of broccoli and 2 heads of cabbage per replication were packed separately in LDPE (100 gauge) pouches tied up with a thread knot (SPNF-AP) to obtain modified atmospheric conditions and the other half of these vegetables was kept open (SPNF-AO) and both samples were then stored at ambient (17±2ºC, RH 40–60%) conditions. Similarly, in the second lot, produce packed in LDPE pouches (SPNF-RP) and without MAP or open (SPNF-RO) were kept under low temperature conditions (5±2ºC, RH 90–95%).

The shelf-life comparison was done on the basis of physiological loss in weight (PLW) as per method of Kumar and Thakur (2020) at every alternate day up to 28 days in broccoli and up to 34 days in case of cabbage:

$$\text{PLW (\%)} = \frac{\text{Initial weight (g) - Final weight (g)}}{\text{Initial weight (g)}}$$

Spoilage (%) was calculated by noting the weight of spoiled (microbial and storage disorders) portion on each sampling date:

$$\text{Spoilage (\%)} = \frac{\text{Initial spoilage (g) - Weight of remaining sample (g)}}{\text{Initial weight of sample (g)}}$$

Moisture content expressed as per cent was determined by measuring the weight loss of pre-weighed quantity of samples due to evaporation of water in hot air oven (105±1ºC) up to constant weight. TSS was determined by using Abbe's hand refractometer (0–32% range) and expressed as degree Brix (ºB). Titratable acidity was determined by titrating known volume of sample with NaOH solution against phenolphthalein indicator. Ascorbic acid was determined by 2,6-dichlorophenol-indophenol dye method described by Ranganna (2009) in which aliquot prepared in 3 % HPO_3 was titrated with dye to pink colour end point.

Sugars (Total and reducing) were determined according to Lane and Eynon's volumetric method (Ranganna 2009). Total sugar contents were estimated by titrating the sample, after hydrolysis with citric acid, against the known quantity of Fehling's solution using methylene blue as an indicator. While total ash content was determined gravimetrically by taking known weight of sample followed by ashing in muffle furnace (550ºC).

Sensory evaluation was done by using the 9-point hedonic scale (Joshi 2006) at 3 different periodical intervals. At least ten panelists consisting of trained and semi-trained staff members and research scholars were given coded samples for three successive sessions for giving their views on sensory acceptability on the basis of appearance, texture, taste and overall acceptability. The data pertaining to physico-chemical characteristics obtained in this study were replicated five times and presented as mean± standard error. Statistical evaluation was performed by using one-way analysis of variance (ANOVA) with a significance level P< P0.05.

RESULTS AND DISCUSSION

Effect of modified atmosphere packaging and storage conditions on shelf-life

Physiological loss in weight: Data (Table 1) revealed that the MAP and storage conditions exerted significant effect on PLW of broccoli. The PLW mainly results from transpirational and respiratory losses from the surface of produce regardless of the storage environment. As expected, the maximum PLW was observed in SPNF-AO followed by SPNF-RO, SPNF-AP and least in SPNF-RP. In the samples without MAP (SPNF-AO), the florets remain fresh up to only 4th day (PLW 12.07%) beyond which wilting takes place (Table 1). However, in case of the samples with MAP (SPNF-AP), the freshness retained up to the 8th day (PLW 12.58%) and afterwards it increased to 27.23% on the 14th day. After 14th day, the samples were discarded. A similar trend of PLW was found in SPNF-RO samples where the produce retained its freshness up to the 10th day with value ranged from 0.00–12.25% and goes up to 25.19% on the 14th day. Whereas, the produce with MAP (SPNF-RP) was found to be the best as it retained its freshness up to 20 days with PLW value of 12.85%.

Table 1 Effect of MAP and storage conditions on PLW (%) of broccoli

Storage interval (Days)	Ambient condition (17 ± 2 ºC)		Low temperature condition (5± 2 ºC).	
	SPNF-AO	SPNF-AP	SPNF-RO	SPNF-RP
0	0.00	0.00	0.00	0.00
2	4.10	3.19	2.18	0.49
4	12.07	5.00	4.95	1.08
6	17.00	9.30	7.21	1.59
8	22.40	12.58	9.50	3.09
10	26.68	16.23	12.25	6.10
12	34.52	20.01	17.00	7.50
14	41.79	27.23	25.19	8.43
16				9.21
18				10.01
20				12.85
22				18.10
24				25.56
26				31.92
28				36.11

AO, without packaging in ambient condition; AP, ambient condition with LDPE packaging; RO, without packaging in low temperature condition; RP, low temperature condition with LDPE packaging.

Overall, according to International standards for PLW, our product packed in LDPE pouches was found suitable for marketing up to 18 days of storage under low temperature (PLW ≤10%), However, as per sensory quality basis, the produce was adjudged suitable to market even up to 20 days (PLW 12.85%). Singh *et al.* (2018) have also reported an increase in PLW with the advancement of storage period of broccoli florets under MAP storage after 49 days of storage (3°C). Kumar and Singh (2017) have also reported that weight loss of broccoli florets was significantly higher in control samples than the samples packed in LDPE packaging and stored at 15 ºC for 10 days.

Data (Table 2) revealed that the fresh sample of cabbage without MAP (SPNF-AO) retained its freshness up to the 8th day of storage (PLW 10.05%), afterwards wilting takes place, whereas SPNF-AP sample retained its freshness only up to 12th day of storage (PLW 11.80%). While, SPNF-RO sample remained fresh upto the 14th day (PLW 12.10%) and beyond which it starts losing its freshness.

The MAP samples (SPNF-RP) were found acceptable upto 22nd day of storage under low temperature with PLW of 10.05%. Whereas, as per sensory/visual quality analysis, it was marketable even up to 24 days of storage (PLW 12.32%) afterword's it become uneatable due to loss in freshness and visual appearance. So, the cabbage heads packed in LDPE pouches and stored under low temperature conditions had the highest shelf-life. Mampholo *et al*. (2012) have also reported the highest weight loss in the unpacked cabbage than cabbage in MAP after 10 days of storage (10ºC). Kramchote *et al*. (2012) have reported that weight loss of cabbage increased with storage much more rapidly at ambient (28ºC) than at 4ºC in LDPE, due to the fact that at ambient temperature vapor pressure deficit increases resulting increased weight and turgidity losses. PE packaging reduces PLW, maintain high RH conditions within container and decreases transpiration losses (Kumar and Thakur 2020).

Table 2 Effect of MAP and storage conditions on PLW (%) of cabbage

Storage interval (Days)	Ambient condition (17 ± 2 ºC)		Low temperature condition (5± 2 ºC).	
	SPNF-AO	SPNF-AP	SPNF-RO	SPNF-RP
0	0	0	0	0
2	2.50	2.21	2.50	0.28
4	5.27	4.78	3.86	0.59
6	7.33	6.21	5.10	1.27
8	10.05	8.15	6.63	2.30
10	13.79	9.30	7.80	2.90
12	16.60	11.80	9.18	3.75
14	18.72	14.23	12.10	4.80
16	23.62	16.15	15.16	5.69
18	27.07	21.15	19.25	7.13
20	33.57	27.38	23.16	8.95
22	40.29	32.28	26.14	10.05
24	47.94	39.25	34.32	12.32
26				14.90
28				18.67
30				20.35
32				26.58
34				36.28

AO, without packaging in ambient condition; AP, ambient condition with LDPE packaging; RO, without packaging in low temperature condition; RP, low temperature condition with LDPE packaging.

Spoilage: Data (Fig 1) showed that highest spoilage percentage in broccoli was found in SPNF-AO sample followed by SPNF-AP, APNF-RO and SPNF-RP. The SPNF-AO produce attained the maximum extent of spoilage from 0.00, 15.29 to 50.13 (%) after 0, 6th and 14th days, respectively.

In case of SPNF-AP and SPNF-RO samples, about 11% spoilage was observed after the 10th day of storage. However, SPNF-RP showed a very slow rate of spoilage up to 14th day (2.23%), afterwards it started increasing steadily with each alternate day (as 3.4%, 3.5%, 5.56%, 7.98%, 9.23%, 15.25% and 16.98 %) up to 28th day of storage. This might be due to the fact that MAP films significantly reduced the incidence of spoilage under low temperature. Serrano *et al*. (2006) also reported quick weight loss, chlorophyll degradation and stem hardening in control broccoli compared to those stored under MAP conditions.

During storage of cabbage (Fig 1), the fastest rate of spoilage was observed in SPNF-AO up to 26.87% at 10th day, whereas SPNF-AP and SPNF-RO showed 25% spoilage at 14th and 16th day, respectively. However, SPNF-RP had the slowest rise of spoilage (18.03 %) up to 24th day of storage thereafter it increased steadily (20.14%, 24.87%, 29.11%, 34.28% and 40.11%) on each alternate day up to 34th day of storage, whereas all other samples were spoiled at that time. While, MAP with low temperature conditions (SPNF-RP) was found effective in controlling spoilage of cabbage during storage. This could be due to restriction in the entry of spoilage microbes from surrounding environment and retention of moisture as well. Similarly, Dhall *et al*. (2010) have also reported increase in spoilage with increase in storage period of cauliflower under LDPE packaging.

Effect of storage on sensory quality: Data (Fig 2) depicts that the sensory scores were decreased as storage period proceeded. The appearance score of SPNF-AO was decreased from 8.54 to 5.22 and 2.78 at 0, 7 and 14th day, respectively. Whereas, the texture as well as taste of produce also degraded (from 8.12 to 2.37 and 7.13 to 1.18) and florets lost their tightness and became loose after 14th day compared to other treatments. The overall acceptability was also found as the least preferred due to short shelf-life and abrupt changes in broccoli. However, in case of SPNF-RP, the sensory scores were decreased from 8.59 to 6.47 (appearance), 8.50 to 6.22 (texture) and 8.46 to 6.08 (overall acceptability) from 0 to 14 days of

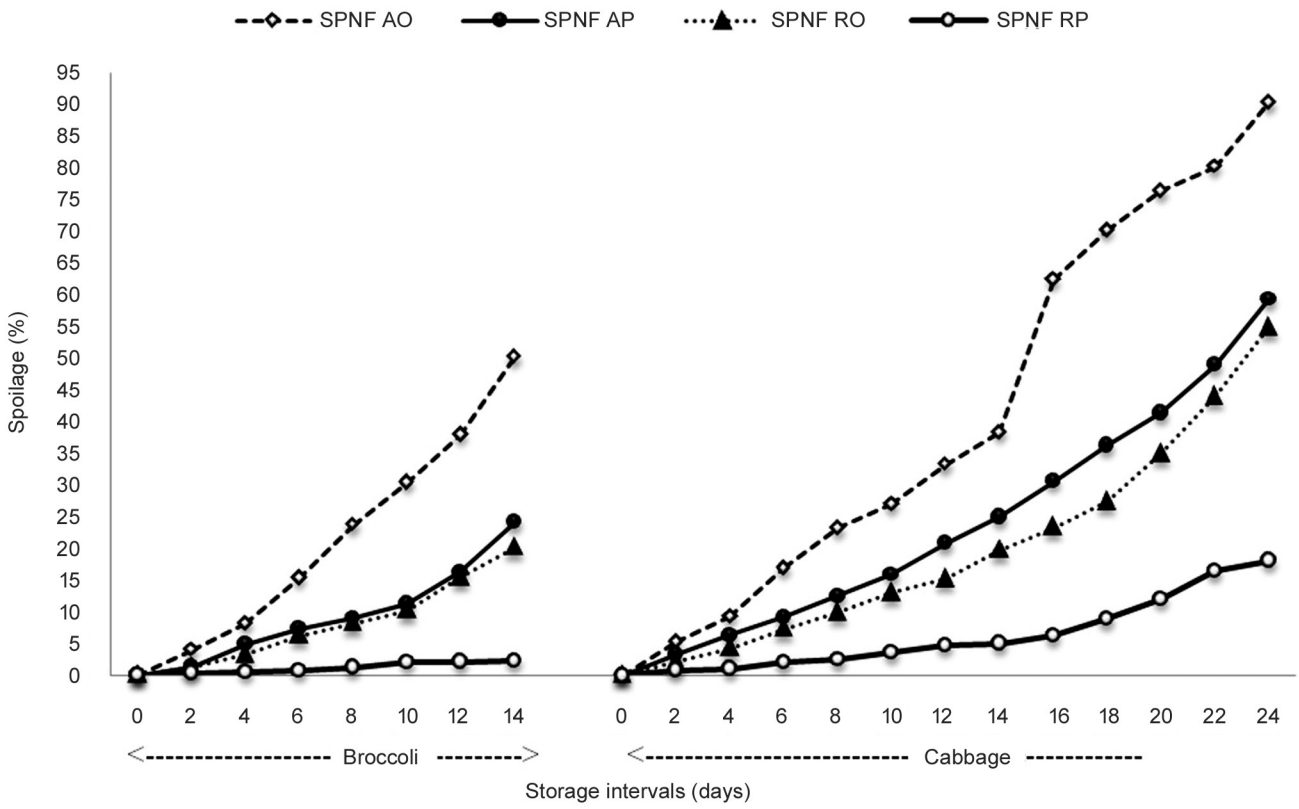

Fig 1 Effect of MAP and storage conditions on spoilage (%) of broccoli and cabbage.

storage. Chlorophyll degradation and higher respiration rate at higher temperatures might have resulted in loss of sensory quality. Kumar and Singh (2017) have also reported that sensory quality of control broccoli florets decreased rapidly during storage (10 days) than broccoli stored (15ºC) in LDPE packaging.

Fig 2 showed that appearance, texture and OA score of SPNF-AO cabbage decreased from 8.50 to 2.34, 8.39 to

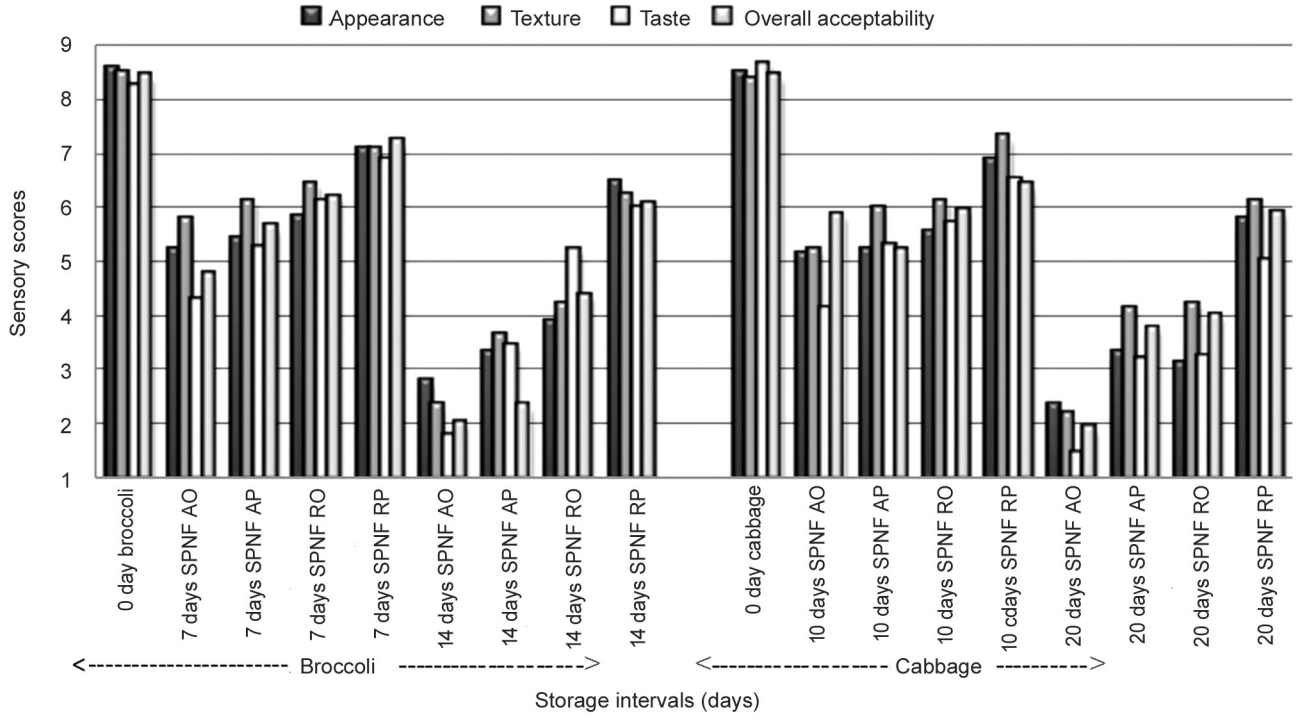

Fig 2 Effect of MAP and storage conditions on sensory scores of broccoli and cabbage.

2.19and 8.46 to 1.95, respectively under ambient conditions. However, the overall sensory scores were found best in packed cabbage (SPNF-RP) with slight decrease in overall acceptability score (8.46 to 5.92). Whereas, rapid decrease in overall acceptance of unpacked cabbage after 10 days of storage might be due to highest weight loss and chlorophyll degradation (Mampholo *et al*. 2012). Similarly, Dhall *et al*. (2010) have also reported decrease in overall acceptability of cauliflower under LDPE packaging during storage.

Quality characteristics of broccoli and cabbage produced through SPNF System: Data pertaining to the physico-chemical characteristics unveil that SPNF broccoli contained higher moisture (80.23%), TSS (12.00±0.11ºB), total solids (19.77±0.09%), titratable acidity (0.82±0.11%), total sugars (4.40±0.81%), reducing sugars (2.53±0.25%), ash content (8.80±0.25%) and ascorbic acid (86.20±0.04 mg/100g). Almost similar values for moisture, TSS, sugars, ash and acid content of organically grown broccoli were also reported by Dhiman *et al*. (2019). However, in case of SPNF cabbage, it contained higher moisture content (91.07±0.05%), TSS (7.30±0.81 ºB), total sugars (6.59±0.06%), reducing sugars (5.34±0.29%), titratable acidity (1.87±0.3%), ascorbic acid (45.40±0.02 mg/100g) with lower amount of ash content (1.28±0.08%) and total solids (8.93±0.03%). Ogbede *et al*. (2015) have also reported slightly lower moisture content and higher ascorbic acid and ash content in cabbage.

The results from the present study confirms that broccoli and cabbage packed in perforated LDPE under low temperature storage showed good sensory acceptability up to 14th and 20th days of storage. For marketability purpose, on the basis of minimum increase in PLW and spoilage, significant superiority in quality of SPNF broccoli and cabbage (packed in perforated LDPE) under low temperature condition was observed over longer period of storage (18 and 22 days). Further, it can be concluded that high level of moisture content in broccoli and cabbage leads faster physiological degradation which can be prevented and preserved effectively for longer periods by creating modified atmosphere through effective MAP. The physico-chemical quality of the both broccoli and cabbage produced through natural farming was comparable to that of inorganic produce, which suggests the suitability of SPNF system to produce good quality product with minimum input costs.

ACKNOWLEDGMENTS

The authors are grateful to the Executive Director, SPNF scheme (HP) for financial support and Head, Department of Food Science and Technology, Dr YSPUHF Nauni, Solan (HP), for providing infrastructural facility to carry out the research work.

REFERENCES

Bahadoran Z, Tohidi M, Nazeri P, Mehran M, Azizi F and Mirmiran P. 2012. Effect of broccoli sprouts on insulin resistance in type 2 diabetic patients: a randomized double-blind clinical trial. *International Journal of Food Sciences and Nutrition* **63**: 767–71.

Dhall R K, Sharma S R and Mahajan B V C. 2010. Effect of packaging on storage life and quality of cauliflower stored at low temperature. *Journal of Food Science and Technology* **47**: 132–35.

Dhiman A K, Attri S and Hamid. 2019. Nutritional quality of organic and conventionally grown broccoli (*Brassica oleracea* L var. *italica*). *Pharma Innovation* **8**: 160–62.

Joshi V K. 2006. *Sensory Science: Principles and Applications in Food Evaluation*. Agrotech Publishing Academy, India.

Khadse A and Rosset P M. 2019. Zero budget natural farming in India – from inception to institutionalization. *Agroecology and Sustainable Food Systems* **43**: 848–71.

Kramchote S, Srilaong V, Wongs-Aree C and Kanlayanarat S. 2012. Low temperature storage maintains postharvest quality of cabbage (*Brassica oleraceae* var. *capitata* L.) in supply chain. *International Food Research Journal* **19**: 759–63.

Kumar R and Singh G. 2017. Changes in quality of broccoli stored under modified atmosphere packaging in polymeric films. *International Journal of Current Microbiology and Applied Sciences* **6**: 924–37.

Kumar S and Thakur K S. 2020. Active packaging technology to retain storage quality of pear cv. "Bartlett" during shelf-life periods under ambient holding after periodic cold storage. *Packaging Technology and Science* **33**: 239–54.

Latte K P, Appel K E and Lampen A. 2011. Health benefits and possible risks of broccoli - an overview. *Food and Chemical Toxicology* **49**: 3287–309.

Mampholo B M, Sivakumar D, Beukes M and Rensburg W J V. 2012. Effect of modified atmosphere packaging on the quality and bioactive compounds of Chinese cabbage (*Brasicca rapa* L. ssp. *chinensis*). *Journal of Science of Food and Agriculture* **93**: 2008–15.

Mangaraj S and Goswami T K. 2011. Modeling of respiration rate of litchi fruit under aerobic conditions. *Food and Bioprocess Technology* **4**: 272–81.

Ogbede S C, Saidu A N, Kabiru A Y and Busari M B. 2015. Nutrient and anti-nutrient compositions of *Brassica oleracea v*ar. *capitata L. IOSR Journal of Pharmacy* **5**: 19–25.

Ranganna S. 2009. *Handbook of Analysis and Quality Control for Fruit and Vegetable Products*. Tata McGraw Hill, New Delhi, India.

Serrano M, Martinez-Romero D, Guillen F, Castillo S and Valero D. 2006. Maintenance of broccoli quality and functional properties during cold storage as affected by modified atmosphere packaging. *Postharvest Biology and Technology* **39**: 61–68.

Singh S, Rai A K, Alam T and Singh B. 2018. Influence of modified atmosphere packaging (MAP) on the shelf-life and quality of broccoli during storage. *Journal of Packaging Technology and Research* **2**: 105–13.