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# Evaluation of phytochemicals, sensory acceptability and storage stability of frozen food products of exotic vegetables

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## Abstract
In present study frozen food product developed from organically vis-a-vis conventionally grown exotic vegetables broccoli and kale. Samples were dived into two lots, first no treatment and second was subjected to water blanching for 2 minutes and then sulphuring by dipping in 2 per cent solution of potassium metabisulphite for 5 minutes. These frozen organic and inorganic broccoli and kale samples were utilized in preparation of traditional recipes like *madra* and *sabji* from frozen broccoli and *bhujju* and *katlu* from frozen kale which were stored for 45 and 90 days at -18 °C. Frozen food were evaluate for phytochemical contents and prepared recipes were evaluate for sensory acceptability at fresh and after various storage intervals. Results revealed that phytochemical constituents like beta carotene, chlorophyll and ascorbic acid contents in frozen broccoli and kale samples which were blanched before sulphuring were lower as compared to control frozen samples. The results of prepared recipes revealed that untreated frozen samples at 0 day of storage was more acceptable as compared to recipes prepared from treated samples. The sensory acceptability scores of *bhujju* and *katlu* prepared from treated frozen samples were significantly higher than those prepared from untreated frozen samples. Among the sources of broccoli and kale, recipes prepared from organic sources was rated better. The acceptability scores of the products prepared from stored frozen samples declined as the storage progressed and the scores ranged between "liked extremely" to "liked very much" on nine point hedonic scale. It is concluded that freezing of broccoli and kale can help to minimize their post-harvest losses. The consumption of broccoli and kale should be promoted to harness their health promoting and health protecting beneficial effects.

**Keywords:** Frozen food, phytochemical, sensory acceptability, traditional recipes, exotic vegetables

## Introduction
Vegetables of the *Brassica* group are the most commonly grown and consumed on a global scale. Among plant foods with health benefits, crops from the family *Brassicaceae* (also known as *Cruciferae*) are potent modulator of the innate immune response system with potent phytochemicals activity (Piruthiviraj *et al.,* 2016) [6]. Broccoli and kale are excellent sources of indole-3-carbinol, a chemical which boosts DNA repair in cells and appears to block the growth of cancer cells. They contain sulforaphane (particularly when chopped or minced), a compound with potent anti-cancer properties (Correa *et al.* 2014) [3]. Demand-driven exotic vegetables production is suitable for the farmers as they have assured market through contract with consumers. Exotic vegetables market is growing at the rate of 15 to 20% per annum is increasing day by day since India is importing more than 85% exotic vegetables. These vegetables are perishable and need quick transportation which is an obstacle for farmers.

Freezing is one of the oldest and most widely used methods of food preservation, which allows preservation of taste, texture, and nutritional value in foods better than any other method. The freezing process is a combination of the beneficial effects of low temperatures at which microorganisms cannot grow, chemical reactions are reduced, and cellular metabolic reactions are delayed (Kyureghian *et al.,* 2010) [4]. Frozen Food is increasingly becoming popular among consumers in India.

The frozen food market is one of the largest and most dynamic sectors of the food industry. In spite of considerable competition between the frozen food industry and other sectors, extensive quantities of frozen foods are being consumed all over the world. India frozen food market stood at $ 310 million in 2017 and is projected to grow at a CAGR of over 16% to reach $ 754 million by 2023, backed by rapidly growing demand from middle class consumers with increasing disposable income. Rising urbanization, increasing number of refrigeration facilities

in small retail shops and rural households, and growing cold chain industry are expected to significantly contribute towards the growth of frozen food market in the country over the coming years. Moreover, growing organized retail and e-commerce industry are among few other factors anticipated to propel demand for frozen food in India during forecast period (TechSci, 2019) [10]. The methodologies for value addition to organically grown exotic vegetables need to be standardized to prevent post-harvest losses and to increase their shelf life. Therefore, this study was undertaken with objectives to developed frozen food product from organically vis-a-vis conventionally grown exotic vegetables broccoli and kale.

## Material and Methods

### Materials

Fresh and optimally mature organically grown samples of broccoli (var *Palam Samridhi*) and kale (var *DSK-1*) were procured from the Department of Organic Agriculture, CSKHPKV, Palampur whereas, same varieties of broccoli and kale were grown conventionally using inorganic inputs. After sorting, the material was washed under running water and trimmed.

### Preparation of frozen sample

For freezing**,** broccoli and kale samples both grown with organic and inorganic inputs were taken and divided into two lots. One lot was subjected to no treatment (Control). The second lot was subjected to water blanching for 2 minutes and then sulphuring by dipping in 2 per cent solution of potassium metabisulphite for 5 minutes. The treated samples were packed in polythene bags having thickness of approximately 0.20-0.40 cm and stored for 45 and 90 days in a deep freezer at -18 °C.

### Determination of phytochemicals

Beta- carotene was evaluated by standardized method AACC (2010) [1] using n-butanol and absorbance was measured at 440 nm. Standard method of total chlorophyll was used to determination given in Ranganna (2007) [7]. The content of ascorbic acid was determined titrimetrically using 2.6-dichlorophenolindophenol as reported in Ranganna (2007) [7]. Frozen sample were evaluate in triplicate at 0, 45 and 90 days for phytochemical evaluation.

### Sensory evaluation

Prepared recipes were evaluate sensory acceptability at various storage period. Hedonic scale used for evaluation of sensory characteristics. The scores were assigned from extremely liked (9) to disliked extremely (1).

### Statistical Analysis

The data obtained from experiments were subjected to statistical analysis using SAS 9.2 English software copyright © 2002-2008 by SAS Institute Inc., Cary, NC, USA Proprietary Software 9.2 (TS2M2) Licensed to Indian Agricultural Statistics Research Institute, Site 11601386. Differences were considered significant at the 5% significant level. Where significant effects were found, the least significant difference test (LSD) was used to locate any significant differences between the means.

## Results and Discussion

### Phytochemical characteristics of frozen broccoli of kale

Data of Table 1 depicts the effect of storage and treatments on the phytochemical content of frozen broccoli. The average beta carotene content of organic and inorganic broccoli irrespective of treatments and storage was significantly higher and the values were 7.04 and 5.45 ppm, respectively. The beta carotene content decreased with storage but this decrease was a significant between storage of 45 and 90 days. Among the two treatments, the untreated samples retained significantly more beta carotene than blanched and KMS treated samples. Irrespective of treatment, the frozen organic broccoli samples recorded 8.83, 6.16 and 6.13 ppm beta carotene when evaluated fresh and at 45 and 90 days of storage. The corresponding values for inorganic broccoli were 6.18, 5.09 and 5.08 ppm, respectively. Similarly, the chlorophyll content of untreated broccoli samples was significantly higher than that of treated samples. This difference could be due to the reason that during blanching chlorophyll might have leached in water. Irrespective of treatments and source of broccoli, the chlorophyll content declined from 4.10mg/l to 3.96 and 3.35 mg/l after 0, 45 and 90 days, respectively. The ascorbic acid content also depicted similar trends where untreated broccoli samples recorded significantly more ascorbic acid in comparison with blanched samples treated with KMS. With storage, the ascorbic acid content of frozen samples irrespective of source and treatments had significant decline from 70.03 to 68.98 and 66.97 mg/100g after 0, 45 and 90 days of storage, respectively. Among the various source of broccoli, the organic frozen broccoli samples had significantly higher average ascorbic acid content of 74.89 mg/100ml when compared with inorganic broccoli frozen samples (62.43 mg/100g).

**Table 1:** Effect of treatments and storage on phytochemical content of frozen broccoli

| Storage (days) | Organic | | Mean | Inorganic | | Mean | Overall mean |
|---|---|---|---|---|---|---|---|
| | Untreated | Blanched & sulphured | | Untreated | Blanched & sulphured | | |
| **Beta Carotene (ppm)** | | | | | | | |
| 0 | 10.41 | 7.25 | 8.83 | 8.71 | 3.65 | 6.18 | 7.51 |
| 45 | 7.44 | 4.90 | 6.16 | 6.73 | 3.47 | 5.09 | 5.63 |
| 90 | 7.42 | 4.86 | 6.13 | 6.71 | 3.45 | 5.08 | 5.61 |
| Mean | 8.42 | 5.67 | 7.04 | 7.38 | 3.52 | 5.45 | 6.25 |
| **Chlorophyll (mg/L)** | | | | | | | |
| 0 | 4.92 | 4.22 | 4.57 | 3.91 | 3.37 | 3.64 | 4.10 |
| 45 | 4.87 | 4.08 | 4.47 | 3.82 | 3.09 | 3.46 | 3.96 |
| 90 | 4.47 | 3.97 | 4.35 | 3.77 | 2.94 | 3.35 | 3.35 |
| Mean | 4.84 | 4.09 | 4.46 | 3.83 | 3.13 | 0.70 | 3.97 |
| **Ascorbic acid (mg/100g)** | | | | | | | |
| 0 | 87.50 | 64.20 | 75.85 | 80.00 | 48.75 | 64.22 | 70.03 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 45 | 86.44 | 64.03 | 75.23 | 78.65 | 46.82 | 62.73 | 68.98 |
| 90 | 85.26 | 61.95 | 73.60 | 75.89 | 44.80 | 60.34 | 66.97 |
| Mean | 86.40 | 63.39 | 74.89 | 78.19 | 46.69 | 62.43 | 68.66 |
| **LSD (P≤0.05)** | | **Beta Carotene** | | **Chlorophyll** | | **Ascorbic acid** | |
| Source (S) | | 0.33 | | 0.05 | | 0.49 | |
| Storage (So) | | 0.41 | | 0.07 | | 0.60 | |
| Treatments (T) | | 0.33 | | 0.05 | | 0.49 | |

Similarly, Table 2 represents the effect of storage and treatments on the phytochemical constituents of frozen kale samples. Here also, the untreated samples had significantly higher amounts of beta carotene, chlorophyll and ascorbic acid. Among the kale sources i.e. organic or inorganic, organic frozen kale had significantly higher amount of beta carotene and ascorbic acid than inorganic frozen kale. On the contrary, the chlorophyll content of inorganic frozen kale was significantly higher than that of organic kale. This could be due to initially higher values of chlorophyll in inorganic kale. With blanching the ascorbic acid content might have lost and it further declined with storage. Similar results reported by Rickman *et al.* (2011) [8] review study report state that ascorbic acid continues to degrade during prolonged storage of frozen products. Saxena *et al.* (2014) [9] stated that under sub-zero conditions of frozen storage, damage to food nutrients is very less and most of the deteriorative biochemical reactions stand arrested. Zhang *et al.* (2004) [13], Vallejo *et al.* (2003) [12] and Mullen *et al*. (2002) [5] study resulted showed that phytochemical content of broccoli and kale changes with cooking method and storage contention.

**Table 2:** Effect of storage and treatments on phytochemical contents of frozen kale

| Storage (days) | Organic | | Mean | Inorganic | | Mean | Overall mean |
|---|---|---|---|---|---|---|---|
| | Untreated | Blanched & sulphured | | Untreated | Blanched & sulphured | | |
| **Beta Carotene (ppm)** | | | | | | | |
| 0 | 11.91 | 7.92 | 9.18 | 7.06 | 2.45 | 4.75 | 7.34 |
| 45 | 6.95 | 4.58 | 5.77 | 6.92 | 2.16 | 4.53 | 5.15 |
| 90 | 6.67 | 4.58 | 5.63 | 6.89 | 2.11 | 4.50 | 5.07 |
| Mean | 8.51 | 5.70 | 7.10 | 6.96 | 2.24 | 4.60 | 5.85 |
| **Chlorophyll (mg/L)** | | | | | | | |
| 0 | 5.19 | 4.03 | 4.61 | 8.31 | 7.87 | 8.09 | 6.35 |
| 45 | 5.07 | 3.88 | 4.47 | 8.20 | 7.09 | 7.64 | 6.06 |
| 90 | 4.98 | 3.79 | 4.38 | 8.10 | 7.01 | 7.55 | 5.97 |
| Mean | 5.08 | 3.90 | 4.49 | 8.21 | 7.32 | 7.76 | 6.13 |
| **Ascorbic acid (mg/100g)** | | | | | | | |
| 0 | 48.10 | 32.20 | 40.15 | 40.50 | 24.45 | 32.47 | 36.31 |
| 45 | 47.82 | 30.70 | 39.26 | 39.50 | 23.00 | 31.25 | 35.26 |
| 90 | 45.55 | 29.38 | 37.46 | 37.10 | 22.10 | 31.25 | 33.52 |
| Mean | 47.16 | 30.76 | 38.96 | 39.03 | 23.18 | 31.11 | 35.03 |
| **LSD (P≤0.05)** | | **Beta Carotene** | | **Chlorophyll** | | **Ascorbic acid** | |
| Source (S) | | 0.16 | | 0.04 | | 0.30 | |
| Storage (So) | | 0.20 | | 0.05 | | 0.37 | |
| Treatments (T) | | 0.16 | | 0.04 | | 0.31 | |

**Sensory acceptability of frozen broccoli and kale-based value-added products**

Attempts were made to utilize frozen broccoli and kale samples in preparation of traditional recipes and assess the suitability of frozen vegetable in traditional preparation to which indigenous people are used to and have developed taste. The physical appearance of frozen broccoli and kale samples revealed that the untreated samples which were frozen for 45 and 90 days had better texture and physical appearance as compared to the treated broccoli and kale samples (Plate- 1).

**Table: 3:** Effect of treatments and storage on sensory acceptability of *madra* prepared from frozen broccoli

| Storage (days) | Organic | | Mean | Inorganic | | Mean | Overall Mean |
|---|---|---|---|---|---|---|---|
| | Untreated | Blanched & sulphured | | Untreated | Blanched & sulphured | | |
| **Colour** | | | | | | | |
| 0 | 9.23 | 7.86 | 8.54 | 8.97 | 8.40 | 8.69 | 8.61 |
| 45 | 9.22 | 7.84 | 8.53 | 8.92 | 8.32 | 8.62 | 8.57 |
| 90 | 8.75 | 7.71 | 8.23 | 8.76 | 8.30 | 8.52 | 8.37 |
| Mean | 9.07 | 7.80 | 8.43 | 8.88 | 8.34 | 8.61 | 8.52 |
| **Taste** | | | | | | | |
| 0 | 9.31 | 7.98 | 8.64 | 8.36 | 8.34 | 8.35 | 8.49 |
| 45 | 9.29 | 9.92 | 8.60 | 8.29 | 8.28 | 8.28 | 8.44 |
| 90 | 8.62 | 7.73 | 8.12 | 8.75 | 8.59 | 8.67 | 8.39 |
| Mean | 9.07 | 7.84 | 8.45 | 8.47 | 8.40 | 8.43 | 8.44 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Flavour** | | | | | | | |
| 0 | 8.72 | 8.01 | 8.37 | 8.73 | 8.55 | 8.62 | 8.50 |
| 45 | 8.61 | 7.97 | 8.29 | 8.41 | 8.53 | 8.49 | 8.38 |
| 90 | 8.73 | 7.62 | 8.17 | 8.74 | 8.68 | 8.71 | 8.44 |
| Mean | 8.69 | 7.87 | 8.28 | 8.63 | 8.59 | 8.61 | 8.44 |
| **Overall acceptability** | | | | | | | |
| 0 | 9.09 | 7.95 | 8.52 | 8.69 | 8.43 | 8.56 | 8.53 |
| 45 | 9.04 | 7.91 | 8.47 | 8.54 | 8.37 | 8.46 | 8.46 |
| 90 | 8.70 | 7.65 | 8.17 | 8.75 | 8.52 | 8.40 | 8.63 |
| Mean | 8.94 | 7.83 | 8.39 | 8.66 | 8.44 | 8.47 | 8.47 |
| **LSD (*P*≤0.05)** | **Colour** | **Taste** | | **Flavour** | | **Overall acceptability** | |
| Source (S) | 0.02 | 0.08 | | 0.15 | | 0.06 | |
| Storage (S) | 0.02 | 0.10 | | 0.18 | | 0.06 | |
| Treatments (T) | 0.02 | 0.08 | | 0.15 | | 0.06 | |

Data of Table 3 pertains to the sensory acceptability scores of *madra* prepared by using frozen treated and untreated broccoli stored for 45 and 90 days at -18$^0$C (Plate-2). As is evident from the data, the average colour scores of frozen organic broccoli *madra* varied non-significantly from 8.54 to 8.53 and 8.23 after 0, 45 and 90 days of storage, respectively. Whereas, this decline was significant in case of *madra* prepared from frozen inorganic broccoli where the corresponding values were 8.69, 8.62 and 8.52, respectively.

**Table 4:** Effect of treatments and storage on sensory acceptability of *sabji* prepared from frozen broccoli

| **Storage (days)** | **Organic** | | **Mean** | **Inorganic** | | **Mean** | **Overall Mean** |
|---|---|---|---|---|---|---|---|
| | **Untreated** | **Blanched & sulphured** | | **Untreated** | **Blanched & sulphured** | | |
| **Colour** | | | | | | | |
| 0 | 7.10 | 8.42 | 8.20 | 7.37 | 8.17 | 7.77 | 7.99 |
| 45 | 7.95 | 8.23 | 8.09 | 7.36 | 8.13 | 7.74 | 7.92 |
| 90 | 7.93 | 8.34 | 8.13 | 7.36 | 8.07 | 7.71 | 7.92 |
| Mean | 7.96 | 8.33 | 8.14 | 7.36 | 8.12 | 7.74 | 7.94 |
| **Taste** | | | | | | | |
| 0 | 8.03 | 9.64 | 8.83 | 7.57 | 8.21 | 7.89 | 8.36 |
| 45 | 8.05 | 9.57 | 8.81 | 7.52 | 8.20 | 7.86 | 8.33 |
| 90 | 8.04 | 8.45 | 8.24 | 7.53 | 8.16 | 7.84 | 8.04 |
| Mean | 8.04 | 9.22 | 8.62 | 7.54 | 8.19 | 7.86 | 8.25 |
| **Flavour** | | | | | | | |
| 0 | 8.03 | 9.12 | 8.87 | 7.66 | 7.94 | 8.18 | 8.18 |
| 45 | 8.02 | 9.10 | 8.55 | 7.57 | 7.93 | 7.75 | 8.15 |
| 90 | 7.31 | 8.64 | 7.97 | 7.61 | 8.14 | 7.87 | 7.92 |
| Mean | 7.78 | 8.95 | 8.46 | 7.61 | 8.60 | 7.93 | 8.08 |
| **Overall acceptability** | | | | | | | |
| 0 | 8.02 | 9.06 | 8.54 | 7.53 | 8.11 | 7.82 | 8.18 |
| 45 | 8.00 | 8.97 | 8.48 | 7.48 | 8.09 | 7.78 | 8.13 |
| 90 | 7.76 | 8.47 | 8.16 | 7.50 | 8.12 | 7.80 | 7.96 |
| Mean | 7.93 | 8.83 | 8.39 | 7.50 | 8.01 | 7.80 | 8.09 |
| **LSD (*P*≤0.05)** | **Colour** | **Taste** | | **Flavour** | | **Overall acceptability** | |
| Source (S) | 0.06 | 0.03 | | 0.04 | | 0.03 | |
| Storage (So) | 0.07 | 0.04 | | 0.07 | | 0.04 | |
| Treatments (T) | 0.06 | 0.03 | | 0.04 | | 0.03 | |

Irrespective of storage periods, the colour score of *madra* prepared with organically grown frozen broccoli was significantly lower than that of *madra* prepared from inorganic frozen broccoli. The taste of *madra* prepared with frozen organic broccoli had non-significantly higher scores when compared with *madra* prepared with inorganic frozen broccoli. On the contrary, the flavor and overall acceptability score of *madra* prepared from inorganic frozen broccoli were slightly higher than those prepared with organic frozen broccoli samples. As it evident from the data, the overall acceptability varied with storage, but the scores ranged between liked very much to like extremely.

Similarly, the data of Table 4 reveals that all the sensory attribute of broccoli *sabji* prepared by using frozen organic broccoli were significantly higher than those of *sabji* prepared with frozen inorganic broccoli samples. The colour, taste, flavor and overall acceptability scores of *sabji* prepared by using frozen broccoli samples were 8.14, 8.62, 8.46 and 8.39, respectively whereas, the corresponding values for inorganic broccoli were 7.74, 7.86, 7.93 and 7.80, respectively. Irrespective of source of broccoli and treatments, the scores for colour, taste, flavor and overall acceptability changed slightly with increase in storage period but these scores remained between like very much to liked extremely. The overall mean scores of broccoli *sabji* for colour, taste, flavor and overall acceptability were 7.94, 8.25, 8.08 and 8.09, respectively.

**Table 5:** Effect of treatments and storage on sensory acceptability of *bujju* prepared from frozen kale

| Storage (days) | Organic | | Mean | Inorganic | | Mean | Overall Mean |
|---|---|---|---|---|---|---|---|
| | Untreated | Blanched & Sulphured | | Untreated | Blanched & Sulphured | | |
| **Colour** | | | | | | | |
| 0 | 8.83 | 8.63 | 8.73 | 8.72 | 8.92 | 8.82 | 8.77 |
| 45 | 8.80 | 8.82 | 8.81 | 8.72 | 8.89 | 8.80 | 8.81 |
| 90 | 8.72 | 8.82 | 8.77 | 8.67 | 8.83 | 8.75 | 8.76 |
| Mean | 8.78 | 8.75 | 8.77 | 8.71 | 8.88 | 8.79 | 8.78 |
| **Taste** | | | | | | | |
| 0 | 8.82 | 8.91 | 8.87 | 8.73 | 9.00 | 8.86 | 8.87 |
| 45 | 8.75 | 8.64 | 8.69 | 8.66 | 8.81 | 8.74 | 8.71 |
| 90 | 8.69 | 8.79 | 8.74 | 8.64 | 8.64 | 8.60 | 8.67 |
| Mean | 8.76 | 8.78 | 8.77 | 8.68 | 8.79 | 8.73 | 8.75 |
| **Flavour** | | | | | | | |
| 0 | 8.39 | 8.92 | 8.65 | 8.72 | 8.93 | 8.83 | 8.74 |
| 45 | 8.26 | 8.77 | 8.51 | 8.26 | 8.72 | 8.50 | 8.50 |
| 90 | 8.66 | 8.76 | 8.71 | 8.34 | 8.61 | 8.47 | 8.59 |
| Mean | 8.44 | 8.82 | 8.63 | 8.44 | 8.75 | 8.60 | 8.61 |
| **Overall acceptability** | | | | | | | |
| 0 | 8.82 | 8.92 | 8.87 | 8.78 | 8.96 | 8.87 | 8.87 |
| 45 | 8.77 | 8.86 | 8.82 | 8.73 | 8.90 | 8.81 | 8.82 |
| 90 | 8.73 | 8.83 | 8.78 | 8.67 | 8.86 | 8.76 | 8.77 |
| Mean | 8.77 | 8.87 | 8.82 | 8.73 | 8.90 | 8.82 | 8.82 |
| **LSD ($P \leq 0.05$)** | **Colour** | **Taste** | | **Flavour** | | **Overall acceptability** | |
| Source (S) | 0.02 | 0.03 | | 0.04 | | 0.03 | |
| Storage (S) | 0.04 | 0.04 | | 0.05 | | 0.03 | |
| Treatments (T) | 0.02 | 0.03 | | 0.04 | | 0.03 | |

Data of Table 5 pertains to sensory acceptability scores of *bhujju* prepared from frozen kale (Plate-4.10). The colour scores of *bhujju* prepared with frozen inorganic kale were significantly higher when compared with organic counter parts. Whereas, the taste and flavor scores of *bhujju* prepared from frozen organic kale were significantly higher i.e. 8.77 and 8.63 when compared with inorganic counterparts with corresponding values of 8.73 and 8.60, respectively. The overall acceptability score of *bhujju* prepared with both organic and inorganic frozen broccoli were at par with 8.82 scores. Among the treatments, the overall acceptability scores of *bhujju* prepared with frozen kale samples which were blanched prior to sulphuring of were significantly higher than that of *bhujju* prepared with untreated frozen kale. With storage, the scores for all the sensory attributes i.e. colour, taste, flavor and overall acceptability varied slightly as the storage progressed, but the score ranged between liked very much to like extremely.

**Table 6:** Effect of treatments and storage on sensory acceptability of *katlu* prepared from frozen kale

| Storage (days) | Organic | | Mean | Inorganic | | Mean | Overall Mean |
|---|---|---|---|---|---|---|---|
| | Untreated | Blanched & sulphured | | Untreated | Blanched & sulphured | | |
| **Colour** | | | | | | | |
| 0 | 8.62 | 8.72 | 8.67 | 8.52 | 8.37 | 8.45 | 8.56 |
| 45 | 8.55 | 8.70 | 8.63 | 8.51 | 8.39 | 8.45 | 8.54 |
| 90 | 8.53 | 8.30 | 8.42 | 8.43 | 8.37 | 8.40 | 8.41 |
| Mean | 8.56 | 8.58 | 8.57 | 8.49 | 8.38 | 8.44 | 8.50 |
| **Taste** | | | | | | | |
| 0 | 8.61 | 8.72 | 8.67 | 8.56 | 8.36 | 8.56 | 8.46 |
| 45 | 8.60 | 8.72 | 8.66 | 8.53 | 8.41 | 8.57 | 8.47 |
| 90 | 8.52 | 8.69 | 8.61 | 8.42 | 8.39 | 8.51 | 8.42 |
| Mean | 8.57 | 8.71 | 8.70 | 8.39 | 8.34 | 8.55 | 8.45 |
| **Flavour** | | | | | | | |
| 0 | 8.63 | 8.72 | 8.68 | 8.35 | 8.30 | 8.33 | 8.50 |
| 45 | 8.53 | 8.77 | 8.65 | 8.47 | 8.42 | 8.45 | 8.55 |
| 90 | 8.56 | 8.95 | 8.76 | 8.36 | 8.29 | 8.33 | 8.54 |
| Mean | 8.57 | 8.81 | 8.70 | 8.39 | 8.34 | 8.37 | 8.53 |
| **Overall acceptability** | | | | | | | |
| 0 | 8.62 | 8.72 | 8.67 | 8.47 | 8.35 | 8.41 | 8.54 |
| 45 | 8.56 | 8.73 | 8.65 | 8.56 | 8.41 | 8.46 | 8.55 |
| 90 | 8.54 | 8.65 | 8.60 | 8.40 | 8.35 | 8.38 | 8.49 |
| Mean | 8.57 | 8.70 | 8.64 | 8.46 | 8.37 | 8.42 | 8.53 |
| **LSD ($P \leq 0.05$)** | **Colour** | **Taste** | | **Flavour** | | **Overall acceptability** | |
| Source (S) | 0.02 | 0.02 | | 0.02 | | 0.01 | |
| Storage (So) | 0.03 | 0.03 | | 0.03 | | 0.01 | |
| Treatments (T) | 0.02 | 0.02 | | 0.02 | | 0.01 | |

Data depicted in Table 6 presents the effect of treatments and storage on the sensory acceptability of *katlu* prepared by using frozen kale. As is evident from the table, that among the sources of kale i.e. organic and inorganic, the *katlu* prepared from organic frozen kale had significantly higher scores for colour (8.57), taste (8.70), flavor (8.70) and overall acceptability (8.64) when compared with those prepared with inorganic frozen kale where the corresponding values were 8.50, 8.55, 8.37 and 8.42, respectively. Among the various treatments, the taste, flavor and overall acceptability scores of *katlu* prepared with frozen samples which were blanched and then sulphured were significantly higher than those of untreated frozen samples. Irrespective of source and treatments, the sensory scores for colour, taste, flavor and overall acceptability changed slightly with storage but the scores for all the parameters ranged between liked very much to liked extremely on nine-point hedonic scale. The present study result supported by Al-Bulushi *et al*. 2013 [2] who observed that freezing preservation is one of the best methods of food preservation as it delivers food product with best sensory, physico-chemical and microbiological attributes as compared to thermal processing. Torres and Canet (2001) [11] study the effect of freezing food on the overall acceptability in terms of its flavor, texture, aroma, color, visual appearance besides microbiological safety and nutritional quality. They found that it depends on size and shape of ice crystals formed during the freezing process, maintenance of desired sub-zero temperature during subsequent storage of frozen food products, type of packaging material used as well as physiological and bio-chemical nature of the material being frozen.

## Conclusion

It can be concluded that organic broccoli and kale had better nutrition quality as compared to the inorganic counterparts. They are rich in health–promoting phytochemicals so should be included in our food basket to provide protection against various diseases especially cancer. Freezing of broccoli and kale can help to minimize their post-harvest losses as these vegetables are highly perishable due to high moisture content. The frozen broccoli and kale vegetables can be used for the preparation of traditional food preparations like *madra, sabji, bhujju* and *katlu* after thawing. The cultivation and consumption of broccoli and kale should be promoted to harness their health promoting and health protecting beneficial effects.

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