International Journal of
Innovative Research

International Journal of Innovative Research, **8(3)**: 63–71, 2023
ISSN 2520-5919 (online)
www.irsbd.org

RESEARCH PAPER

Effect of Hydrocooling and Storage Condition on Postharvest Quality of Coriander Leaf

Dipty Paul, Jewel Howlader*, Md. Roman Akon and Litun Ahmed Labib

Department of Horticulture, Patuakhali Science and Technology University, Dumki, Patuakhali-8602, Bangladesh.

ARTICLE HISTORY

Received: October 05, 2023
Revised : November 10, 2023
Accepted: December 10, 2023
Published: December 31, 2023

*Corresponding author:
jewelhrt@pstu.ac.bd

ABSTRACT

An experiment was conducted to evaluate the influence of different hydrocooling (HC) treatments and storage (S) conditions on the postharvest quality of coriander leaves. The two-factor experiment employed a completely randomized design (CRD) with five replications. Four hydrocooling treatments (cool water at 5 ± 0.5 °C) were designated as factor A: T_1 for 5 minutes (min) HC, T_2 for 10 min HC, T_3 for 20 min HC, and T_4 for 40 min HC. Additionally, two low-temperature storage conditions (at 4 ± 0.5 °C) were considered as factor B: S_1 for chiller storage and S_2 for refrigerator storage. Significant variations were observed concerning different hydrocooling treatments and storage conditions. The 10-minute hydrocooling treatment (T_2) demonstrated an extended shelf life of 8.67 days. However, T_1 showed the highest pH (6.38), ascorbic acid content (5.0%), and anthocyanin content (0.33 µg/g), while T_4 exhibited the highest titratable acidity (0.23%). On the other hand, storage condition S_2 (refrigerator storage) resulted in the longest shelf life (8.17 days), highest pH (6.45), titratable acidity (0.21%), ascorbic acid content (3.75%), and anthocyanin content (0.28 µg/g). The combined effects of hydrocooling treatments and storage conditions exerted significant influences on most studied parameters for up to 10 days of storage. The optimum combination, observed in T_2S_2, resulted in the maximum shelf life (9.33 days), the highest pH (6.50) at 10 days after storage, and the maximum anthocyanin content (0.26 µg/g) at the same point. Conversely, the highest titratable acidity (0.26%) and ascorbic acid content (5.01%) at 10 days after storage were found in T_4S_2 and T_1S_2, respectively. Consequently, it can be inferred that the optimal condition for enhancing most postharvest qualities of coriander leaves involves a 10-minute hydrocooling treatment (T_2), storage condition S_2 (refrigerator storage), and the sample treated with 10 minutes of hydrocooling and stored in the refrigerator (T_2S_2).

Key words: Coriander leaves, Hydrocooling, Postharvest quality, Shelf life, Storage condition

Introduction

Coriander, scientifically identified as *Coriandrum sativum* L., is an herbaceous plant with an annual life cycle and is categorized within the Apiaceae family. Widely recognized as "Dhonia" in Bangladesh, this plant holds a prominent place in Ayurvedic medicine. All parts of the coriander plant are utilized as a flavoring agent and traditional remedies for various disorders in folk medicine across different civilizations (Sahib *et al.*, 2012). The plant is entirely edible, with fresh leaves commonly used for garnishing and found in numerous dishes such as chutneys and salads. The seeds exhibit an almost oval and spherical shape, providing a gentle, sweet, slightly tangy citrus taste accompanied by a touch of sage. In Bangladesh, the annual production of coriander seeds in the 2020-21 fiscal year (FY) reached approximately 21,518.84 metric tons, while the leaf production was about 6,209.00 metric tons (BBS 2021). This highly aromatic plant has played a crucial role in maintaining human health and enhancing the quality of life for thousands of years (Dhankar*et al.*, 2011). The leaves of coriander are abundant in vitamins, minerals, and iron. They contain high amounts of vitamin C (up to 160 mg/100 g), vitamin A (up to 12 mg/100 g), thiamine, zinc, and dietary fiber (Girenko, 1982). Additionally, the plant is abundant in essential oils crucial for growth and proper brain function (Nadeem*et al.*, 2013). Furthermore, coriander is utilized in the treatment of various disorders, including digestive tract disorders, respiratory tract disorders, and urinary tract infections. Studies have highlighted its pharmacological activities, such as antioxidant (Darughe *et al*., 2012), anti-diabetic (Eidi *et al*., 2012), anti-mutagenic (Cortes *et al*., 2004), anti-lipidemic (Sunil *et al*., 2012), and anti-spasmodic (Alison and Peter, 1999) properties.

Transpiration, leading to water loss from leaves, results in qualitative and quantitative losses of vegetables (Finger and Vieira, 1997). Leafy vegetables like coriander are prone to water loss and wilting post-harvest, affecting color, appearance, metabolism, and nutritional quality. Given their perishable nature, various postharvest methods, including forced air, cold water, ice, and vacuum cooling, can be employed to enhance food conservation, prolonging longevity and quality (Teruel, 2008). Among these methods, rapid cooling is cost-effective and efficient, and hydrocooling, utilizing ice or cold water, stands out as a simple and practical conservation technique. This method expeditiously removes field heat from freshly harvested products, slowing metabolism and reducing product deterioration (Franca, 2015).Furthermore, the optimal preservation of fresh culinary herbs is achieved through low-temperature and high-humidity storage (Cantwell and Reid, 1993). Quality characteristics such as a fresh appearance, uniformity in leaf size, form, and color, characteristic aroma and flavor, and the absence of defects like decay or yellowing can be maintained through improved postharvest techniques (Cantwell and Reid, 1993). Coriander, as a leafy vegetable, undergoes rapid senescence at high temperatures post-harvest (Lipton, 1987; Paull, 1992).

While there are reports on the effect of hydrocooling on various leafy vegetables, including coriander, to reduce field heat, there is a lack of information on the synergistic effect of hydrocooled water and the impact of storage at low temperatures on the post-harvest quality and longevity of coriander leaves. Therefore, this study was designed to explore the impact of hydrocooling on the postharvest quality and shelf life of coriander leaves under different low-temperature storage conditions.

Materials and methods

The study took place at the Postharvest Laboratory within the Department of Horticulture at Patuakhali Science and Technology University. The experiment, featuring two factors, was organized using a Completely Randomized Design (CRD) and included five replications. Four hydro-cooling treatments (cool water at 5 ± 0.5 °C) were considered for factor A: T_1: Hydrocooling for 5 minutes (min), T_2: Hydrocooling for 10 min, T_3: Hydrocooling for 20 min, and T_4: Hydrocooling for 40 min; and two low-temperature storage treatments (at 4 ± 0.5 °C) were considered for factor B: S_1: Storage in a chiller and S_2: Storage in a refrigerator. The total number of treatment combinations was 4 (Factor A) × 2 (Factor B) × 5 (Replication) = 40.

Locally cultivated leaves of the hybrid coriander variety were obtained from a nearby farmer's field as experimental material. The temperature of the surrounding environment and coriander leaves during harvesting from the field was 19.0 °C and 17.9 °C, respectively. The collected leaves were initially wrapped in newspaper and then encased in polythene before being conveyed to the postharvest laboratory. Following that, the coriander leaves were diligently washed using running tap water to remove soil and other dust particles from their surfaces. Excess water from the leaves was removed by spreading them on a perforated tray at a room temperature of 19.5 °C with 83.0% relative humidity. A bundle of coriander leaves, weighing 50 g, was prepared by tying them together with a rubber band, and this served as an experimental unit.

Initially, the hydrocooling machine was filled with fresh tap water, and it was allowed to reach a water temperature of 5 (±0.5) °C. Once the desired temperature was achieved, all 40 bundles of coriander leaf samples were immersed in the hydrocooled water to undergo the hydrocooling treatment. Subsequently, they were submerged in the hydro cooled water for the specified duration (5 minutes for 10 bundles, 10 minutes for 10 bundles, 20 minutes for 10 bundles, and 40 minutes for 10 bundles) to reduce the temperature of the bundle leaves to 5 (±0.5) °C. After the hydrocooling treatment, the bundle sheet samples were placed in food boxes (20 cm × 15 cm × 6 cm) and wrapped with transparent food-grade polythene sheets. The boxes containing coriander leaves were then transferred to both a chiller and a normal refrigerator for low-temperature storage treatments at 4 ± 0.5 °C.

Observations on the shelf life of coriander leaves were recorded through visual assessments. The shelf life was determined from the initiation of storage until any signs of decay or spots appeared on the fresh leaves, which were examined daily at 10 AM. The quality of the leaves was visually scored throughout the storage period using an evaluation index (scores) ranging from 9 to 1, following the modified criteria established by Singh *et al*. (1972).

Table 1. Evaluation index on shelf life of coriander leaf by visual observation (Singh *et al*., 1972)

Numerical rating	Descriptive rating	Visual observation
9	Excellent (maximum commercial value)	Field fresh, bright green appearance and free from defects
7	Good (commercial value)	Minor defects but not objectionable, green color is slightly bleached and dull, good retail sales appeal
5	Fair (limit of marketability)	Leaves showing slight yellowing and wilting, could be returned to acceptable condition with slight trimming
3	Poor (usable but unsalable)	Moderate yellowing, wilting and drying and other defects serious, would be eaten
1	Very poor (unusable)	Heavy yellowing, wilting and drying, other defects serious, would not be eaten

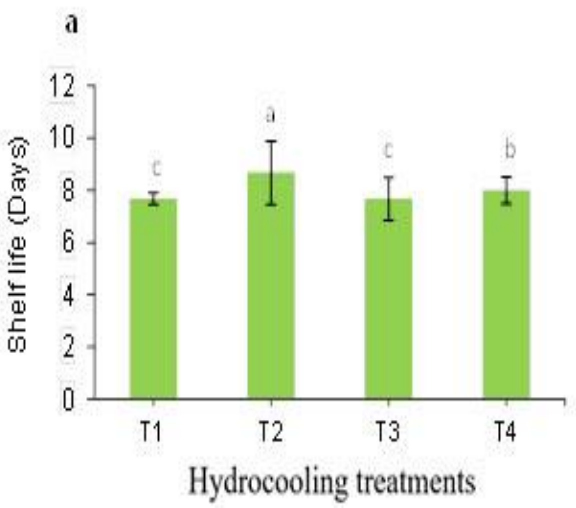
The pH was measured using a glass electrode pH meter (GLP 21, Crison, Barcelona, EEC). Titratable acidity (TA) and ascorbic acid (Vitamin C) were determined following the methods established by Rangana (1977) and Rangana (1979), respectively. The total anthocyanin content of the coriander leaf was determined according to the method described by Sims and Gamon (2002).The collected data on various parameters were statistically analyzed using Minitab Statistical software version 17 (Minitab lnc. State College, PA, USA); and the means were separated using Tukey at a 1% level of probability.

Results and discussion

Shelf life

Influence of hydrocooling treatments and storage conditions on the shelf life of coriander leaves

The shelf life of coriander leaves varied significantly (*p<0.01*) among hydrocooling treatments and storage conditions (Figure 1a and Figure 1b). Treatment T_2, involving hydrocooling for 10 minutes, exhibited the longest shelf life (8.67 days), while the shortest shelf life (7.67 days) was observed in treatments T_1 and T_3. This suggests that coriander leaves can be stored for an additional day when treated with 10-minute hydrocooling duration (T_2) compared to treatments T_1 and T_3. The findings imply that the shelf life of coriander leaves tends to increase with the duration of hydrocooling treatment up to a certain point, after which it decreases due to prolonged chilling effects. Fredericci *et al*. (2019) reported an increase in the shelf life of spring onions when hydrocooled for 10 minutes at 5 ^{0}C. In contrast to our findings, a previous study by Franca *et al*. (2015) reported an extended shelf life in butter lettuce when hydrocooled at 4 °C for 5 minutes, followed by storage at 5 °C. In our investigation, the maximum shelf life (8.17 days) for coriander leaves was recorded in storage condition S_2 (refrigerator storage), while the minimum shelf life (7.83 days) was recorded in S_1 (chiller storage) at 4 ± 0.5 °C.The shorter shelf life in the chiller storage condition may be attributed to increased vapor generation, leading to more rapid leaf deterioration. Patel *et al*. (2015) observed an increased shelf life of tomatoes when hydrocooled at 8 ^{0}C and stored in refrigerated condition.



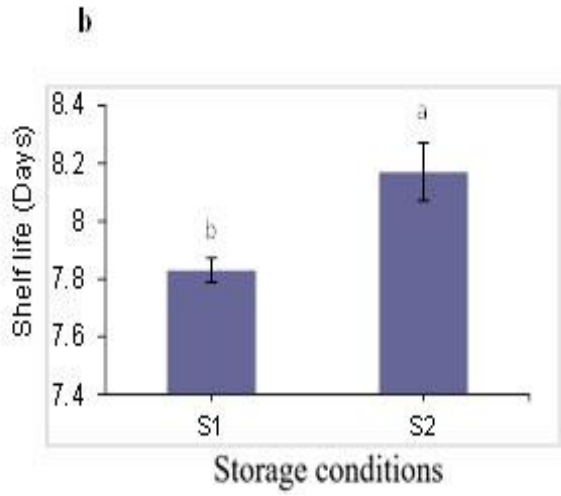


Figure 1. Effect of hydrocooling treatments (a) and storage conditions (b) on shelf life of coriander leaves

Here, T_1= hydrocooling for 5 minutes, T_2= hydrocooling for 10 minutes, T_3= hydrocooling for 20 minutes, T_4= hydrocooling for 40 minutes at 5 ± 0.5 °C; and S_1= storage at chiller, S_2= storage at refrigerator at 4 ± 0.5 °C. The vertical barsrepresentthe standard error of the mean (*n=5*). In a column, values having a different letter (s) differ significantly at a 1% level of probability analyzed by Tukey.

Combined effect of hydrocooling treatments and storage conditions on the shelf life of coriander leaves

The combination of hydrocooling duration and storage condition had a significant impact (*p<0.01*) on the shelf life of coriander leaves (Table 2 and Figure 2). The coriander leaves treated with hydrocooling for 10 minutes followed by storage in the refrigerator (T_2S_2) exhibited the longest shelf life (9.33 days), whereas the sample treated with 20 minutes of hydrocooling followed by storage in the refrigerator (T_3S_2) had the shortest shelf life (7.33 days) at 4 ± 0.5 °C.

Table 2. Combined effect of hydrocooling treatments and storage conditions on the shelf life of coriander leaves

Hydrocooling treatment × Storage condition	Shelf life
T_1S_1	7.67 d
T_1S_2	7.67 d
T_2S_1	8.00 c
T_2S_2	9.33 a
T_3S_1	8.00 c
T_3S_2	7.33 e
T_4S_1	7.67 d
T_4S_2	8.33 b
Level of significance	**
CV (%)	9.88

Here, T_1= hydrocooling for 5 minutes, T_2= hydrocooling for 10 minutes, T_3= hydrocooling for 20 minutes, T_4= hydrocooling for 40 minutes at 5 ± 0.5 °C; S_1= Storage at chiller, S_2= Storage at refrigerator at 4 ± 0.5 °C. ** = Significant at 1% level of probability. In a column, values having a different letter (s) differ significantly at 1% level of probability analyzed by Tukey.

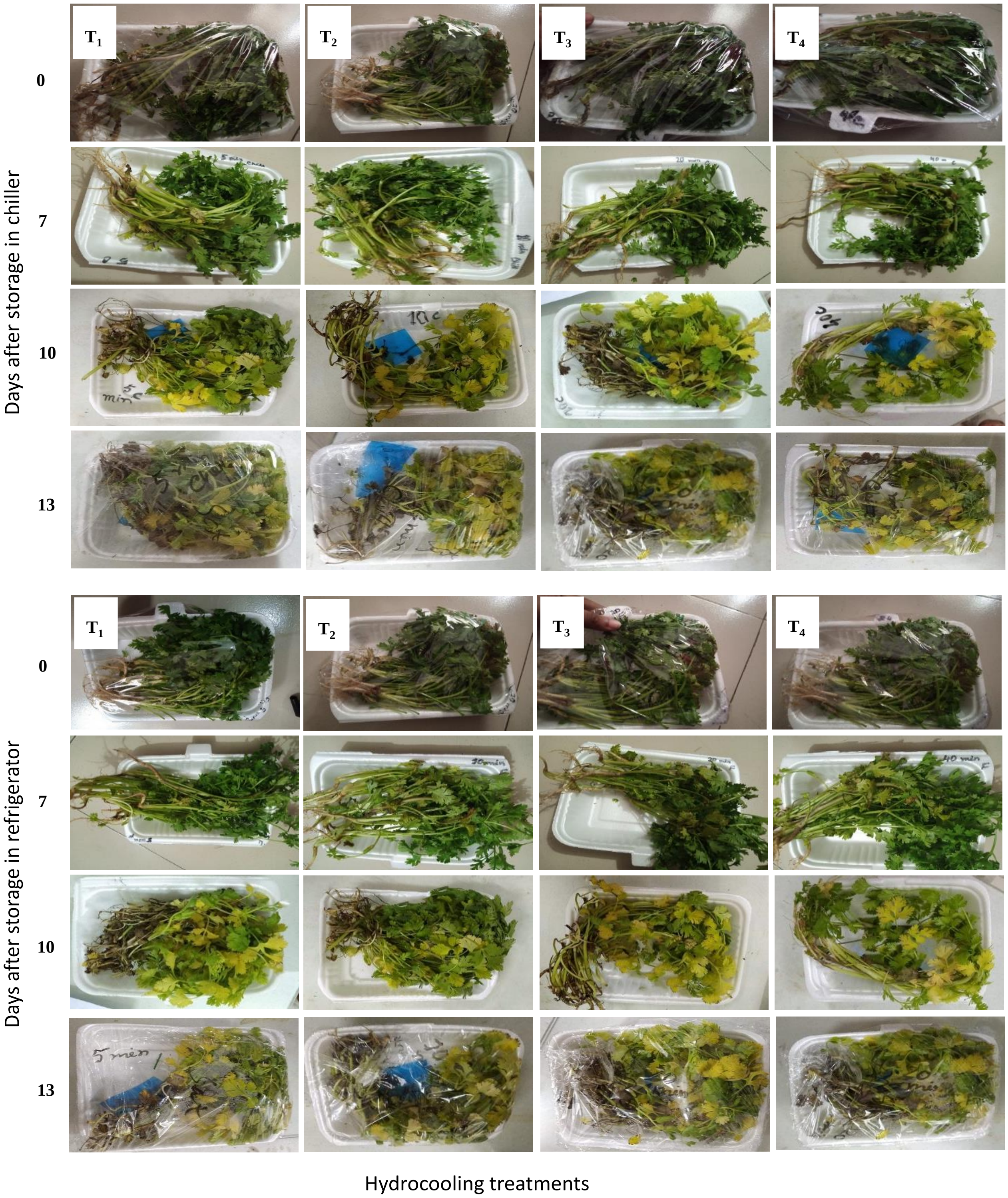


Figure 2. Hydrocooling treated samples: T_1 (5 min), T_2 (10 min), T_3 (20 min), and T_4 (40 min) in chiller and refrigerator in different days after storage (0, 7, 10 and 13).

pH

Influence of hydrocooling treatments and storage conditions on the pH content of coriander leaves

A significant difference ($p<0.01$) in the pH of coriander leaves was evident across various hydrocooling treatments and storage conditions at intervals of 0, 7, and 10 days, as well as 10 and 13 days (Figure 3a and 3b). At 10 days, the highest pH (6.38) was observed for T_1 (hydrocooling for 5 minutes), which was statistically similar to T_2 and T_4, while the lowest pH (6.30) was recorded for T_3 (hydrocooling for 20 minutes). There was a slight increase in the pH of coriander leaves with different hydrocooling treatments as the storage period progressed. Ferreira *et al.* (2006) reported that hydrocooling resulted in superior strawberry quality, including improvements in pH. The pH of coriander leaves gradually increased with different storage conditions as the storage duration advanced. On the 13th day of storage, a greater pH value (6.45) was noted in S_2 (refrigerator storage), while a lower pH (6.39) was registered in S_1 (chiller). The findings indicate an upward trend in the pH of coriander leaves during the later stages of storage, with variations based on the storage condition.

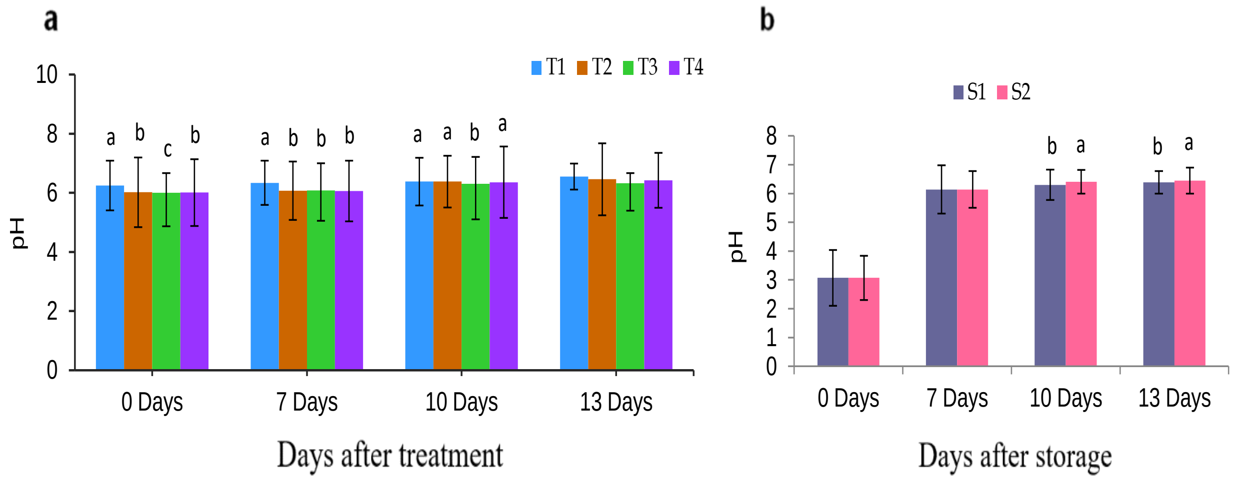


Figure 3. Effect of hydrocooling treatments (a) and storage conditions (b) on pH of coriander leaves
Here, T_1= hydrocooling for 5 minutes, T_2= hydrocooling for 10 minutes, T_3= hydrocooling for 20 minutes, T_4= hydrocooling for 40 minutes at 5 ± 0.5 °C. S_1= Storage at chiller, S_2= Storage at refrigerator at 4 ± 0.5 °C. The vertical barsrepresent the standard error of the mean (*n=5*). In a column, values having a different letter (s) differ significantly at 1% level of probability analyzed by Tukey.

Combined effect of hydrocooling treatments and storage conditions on the pH content of coriander leaves

There was a significant (*p<0.01*) variation in the combined effects of hydrocooling treatments and storage conditions on the pH content of coriander leaves at 7, 10, and 13 days after storage, whereas the combined was insignificant at the beginning (0 days) of the storage period (Table 3). At 13 days after storage, the highest pH (6.67) was recorded in T_1S_2, and the lowest pH (6.26) was observed in T_3S_2.

Table 3. Combined effect of hydrocooling treatments and storage conditions on pH of coriander leaves

Hydrocooling treatment × Storage condition	0 days	7 Days	10 Days	13 Days
T_1S_1	6.25	6.34 a	6.30 cd	6.42 cd
T_1S_2	6.25	6.34 a	6.45 a	6.67 a
T_2S_1	6.02	6.07 b	6.25 d	6.37 d
T_2S_2	6.02	6.06 b	6.50 a	6.54 b
T_3S_1	6.00	6.08 b	6.31 c	6.40 d
T_3S_2	6.00	6.08 b	6.30 cd	6.26 e
T_4S_1	6.01	6.06 b	6.35 bc	6.38 d
T_4S_2	6.01	6.06 b	6.38 b	6.47 c
Level of significance	NS	**	**	**
CV (%)	0.24	0.34	0.34	0.27

Here, T_1= hydrocooling for 5 minutes, T_2= hydrocooling for 10 minutes, T_3= hydrocooling for 20 minutes, T_4= hydrocooling for 40 minutes at 5 ± 0.5 °C; S_1= Storage at chiller, S_2= Storage at refrigerator at 4 ± 0.5 °C. ** = Significant at 1% level of probability. NS= non-significant. In a column, values having a different letter (s) differ significantly at 1% level of probability analyzed by Tukey.

Titratable acidity

Influence of hydrocooling treatments and storage conditions on the titratable acidity of coriander leaves

There was a significant (*p<0.01*) variation among hydrocooling treatments and storage conditions at 0, 7, and 10 days after storage concerning the titratable acidity of coriander leaves; however, at 13 days after storage, no significant difference was found (Figure 4a and 4b). On the 10th day following storage, T_4 exhibited the highest titratable acidity at 0.23%, while T_1 showed the lowest titratable acidity at 0.19%, with statistically similar to T_2 and T_3. Chepngeno *et al.* (2016) reported that hydrocooling contributed to a deceleration in the reduction of titratable acidity in vegetables. The titratable acidity of coriander leaves gradually decreased with the progression of the storage period with different hydrocooling treatments and storage conditions. On the other hand, at 10 days after storage, the higher titratable acidity (0.21%) of coriander leaves was observed when stored in the refrigerator (S_2), and the lower titratable acidity (0.19%) was recorded in the chiller (S_1). Barbara *et al.* (2000) observed a lesser decrease (8%) in titratable acidity when oranges were stored in the refrigerator, aligning with our own findings.

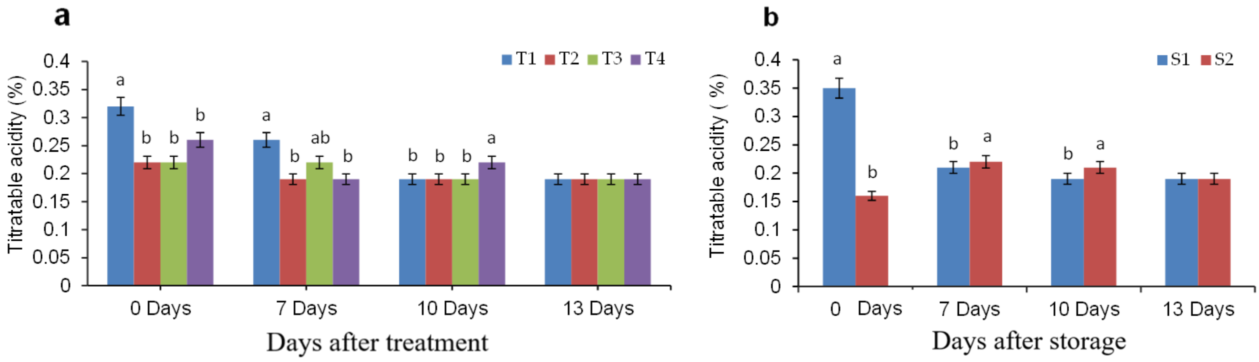


Figure 4. Effect of hydrocooling treatments (a) and storage conditions (b) on titratable acidity of coriander leaves
Here, T_1= hydrocooling for 5 minutes, T_2= hydrocooling for 10 minutes, T_3= hydrocooling for 20 minutes, T_4= hydrocooling for 40 minutes at 5 ± 0.5 °C.S_1= Storage at chiller, S_2= Storage at refrigerator at 4 ± 0.5 °C. The vertical barsrepresent the standard error of the mean (*n=5*). In a column, values having a different letter (s) differ significantly at 1% level of probability analyzed by Tukey.

Combined effect of hydrocooling treatments and storage conditions on the titratable acidity of coriander leaves

Significant differences ($p<0.01$) were observed in the combined effects between hydrocooling treatment and storage conditions at 0, 7, and 10 days post-storage, with no significant influence noted at 13 days post-storage (Table 4). On the 10th day of storage, T_4S_2 exhibited the highest titratable acidity at 0.26%, while all other treatments displayed the lowest titratable acidity at 0.19%.

Table 4. Combined effect of hydrocooling treatments and storage conditions on titratable acidity of coriander leaves

Hydrocooling treatment × Storage condition	0 Days	7 Days	10 Days	13 Days
T_1S_1	0.38 a	0.26 a	0.19 b	0.19
T_1S_2	0.26 c	0.26 a	0.19 b	0.19
T_2S_1	0.32 b	0.19 b	0.19 b	0.19
T_2S_2	0.13 d	0.19 b	0.19 b	0.19
T_3S_1	0.32 b	0.19 b	0.19 b	0.19
T_3S_2	0.13 d	0.26 a	0.19 b	0.19
T_4S_1	0.38 a	0.19 b	0.19 b	0.19
T_4S_2	0.13 d	0.19 b	0.26 a	0.19
Level of significance	**	**	**	NS
CV (%)	0.74	0.53	0.59	0.74

Here, T_1= hydrocooling for 5 minutes, T_2= hydrocooling for 10 minutes, T_3= hydrocooling for 20 minutes, T_4= hydrocooling for 40 minutes at 5 ± 0.5 °C; S_1= Storage at chiller, S_2= Storage at refrigerator at 4 ± 0.5 °C. ** = Significant at 1% level of probability. NS= non-significant. In a column, values having a different letter (s) differ significantly at 1% level of probability analyzed by Tukey.

Ascorbic acid content

Influence of hydrocooling treatments and storage conditions on the ascorbic acid content of coriander leaves

It is evident from Figure 4 that there was a significant ($p<0.01$) variation among different hydrocooling treatments at 0, 7, and 10 days after storage, and storage conditions showed significant differences at 10 days after storage in terms of the ascorbic acid content of coriander leaves. The ascorbic acid content of coriander leaves was non-significant at 10 days among different treatments, and in the case of storage conditions, it was also non-significant at 0, 7, and 13 days (Figure 5a and 5b). The ascorbic acid content in coriander leaves diminished progressively as the storage period advanced, considering various hydrocooling treatments and storage conditions. At 10 days, the highest ascorbic acid content (5.0%) was recorded in hydrocooling treatment T_1 (hydrocooled for 5 minutes), while the lowest (3.75%) was observed in T_2 (hydrocooled for 10 minutes). The findings revealed that coriander leaves exhibited 33.33% higher ascorbic acidity when hydrocooled for 5 minutes (T_1) compared to hydrocooling for 10 minutes (T_2). Rivera *et al*. (2006) noted a rise in ascorbic acid levels in leaf lettuce for a period of up to 7 days as a result of hydrocooling. In terms of storage conditions, higher ascorbic acid content (3.75%) was observed when coriander leaves were stored in the refrigerator (S_2), and the lower ascorbic acid content (2.81%) was recorded when coriander leaves were stored in the chiller (S_1). It means that storage of coriander leaves in the refrigerator (S_2) can conserve 33.45% higher ascorbic acid than that of the chiller (S_1). Yadav & Sehgal (1997) reported a reduced loss of ascorbic acid in leafy vegetables when stored in a refrigerator at 5 °C.

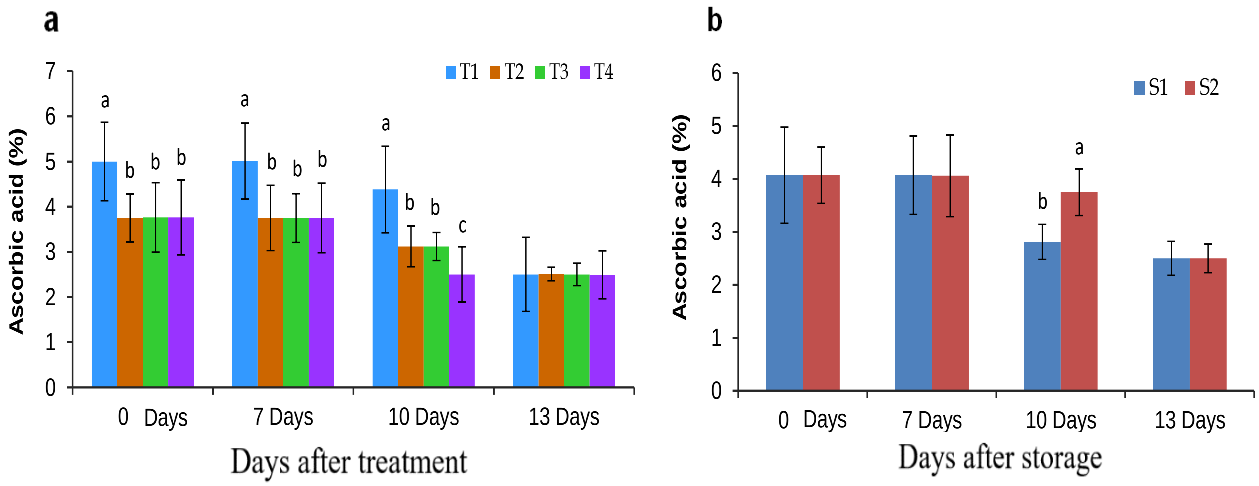


Figure 5. Effect of hydrocooling treatments (a) and storage conditions (b) on ascorbic acid content of coriander leaves
Here, T_1= hydrocooling for 5 minutes, T_2= hydrocooling for 10 minutes, T_3= hydrocooling for 20 minutes, T_4= hydrocooling for 40 minutes at 5 ± 0.5 °C. S_1= Storage at chiller, S_2= Storage at refrigerator at 4 ± 0.5 °C. The vertical bars represent the standard error of the mean (*n=5*). In a column, values having a different letter (s) differ significantly at 1% level of probability analyzed by Tukey.

Combined effect of hydrocooling treatments and storage conditions on the ascorbic acid content of coriander leaves

The combined effect showed significant (*p<0.01*) differences at 0, 7, and 10 days in respect to the ascorbic acid content of coriander leaves, whereas a non-significant difference was observed at 13 days after storage (Table 4). At 10 days after storage, the highest ascorbic acid content of coriander leaves (5.01%) was recorded from T_1S_2, whereas the lowest (2.50%) was recorded in T_2S_1, T_3S_1, T_4S_1, and T_4S_2.

Table 5. Combined effect of hydrocooling treatments and storage conditions on ascorbic acid content of coriander leaves

Hydrocooling treatment x **Storage Condition**	**0 Days**	**7 Days**	**10 Days**	**13 Days**
T_1S_1	5.00 a	5.01 a	3.75 b	2.50
T_1S_2	5.00 a	5.00 a	5.01 a	2.50
T_2S_1	3.75 b	3.75 b	2.50 c	2.50
T_2S_2	3.75 b	3.75 b	3.75 b	2.51
T_3S_1	3.76 b	3.76 b	2.50 c	2.50
T_3S_2	3.76 b	3.74 b	3.75 b	2.50
T_4S_1	3.76 b	3.75 b	2.50 c	2.50
T_4S_2	3.76 b	3.75 b	2.50 c	2.49
Level of significance	**	**	**	NS
CV (%)	0.68	1.01	0.46	0.63

Here, T_1= hydrocooling for 5 minutes, T_2= hydrocooling for 10 minutes, T_3= hydrocooling for 20 minutes, T_4= hydrocooling for 40 minutes at 5 ± 0.5 °C; S_1= Storage at chiller, S_2= Storage at refrigerator at 4 ± 0.5 °C. ** = Significant at 1% level of probability. NS= non-significant. In a column, values having a different letter (s) differ significantly at 1% level of probability analyzed by Tukey.

Anthocyanin content

Influence of hydrocooling treatments and storage conditions on the anthocyanin content of coriander leaves

A significant (*p<0.01*) difference in anthocyanin content of coriander leaves was observed after 7 days of treatments and storage. For both hydrocooling treatments and storage conditions, anthocyanin content remained insignificant at 0, 10, and 13 days (Figure 6a and 6b). After 7 days of storage, treatment T_1 showed the highest anthocyanin content (0.33 µg/g), while the lowest anthocyanin content (0.19 µg/g) was observed in treatment T_4. This indicates that coriander leaves hydrocooled for 10 minutes (T_1) exhibited 73.68% more anthocyanin content than those hydrocooled for 40 minutes (T_4). Sena *et al.* (2019) documented a higher preservation of anthocyanins in cashew apples when subjected to hydrocooling. Additionally, after 7 days of storage, significantly higher anthocyanin content (0.28 µg/g) was recorded in S_2, while a lower content (0.25 µg/g) was observed in S_1. The results suggest that coriander leaves stored in the refrigerator (S_2) exhibited a 12% higher anthocyanin content compared to those stored in the chiller (S_1). Crifo *et al.* (2012) noted an increase in anthocyanin content in blood oranges with short-term cold storage at 4 °C.

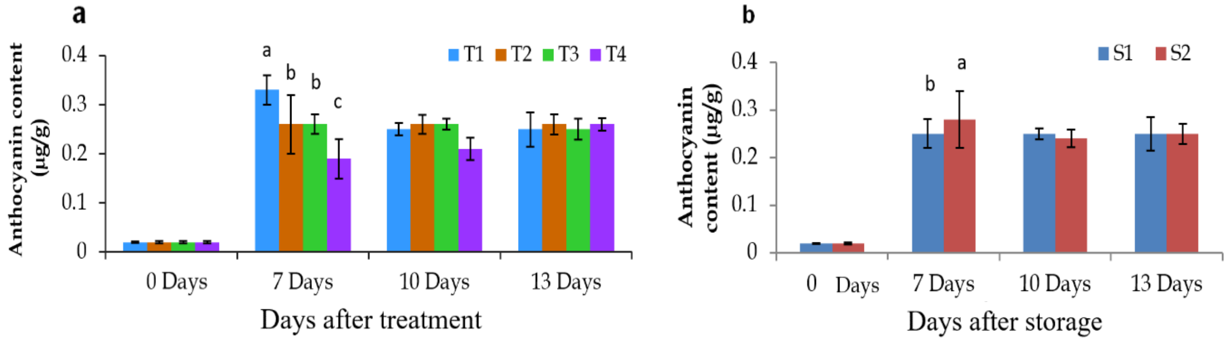


Figure 6. Effect of hydrocooling treatments (a) and storage conditions (b) on anthocyanin content of coriander leaves
Here, T_1= hydrocooling for 5 minutes, T_2= hydrocooling for 10 minutes, T_3= hydrocooling for 20 minutes, T_4= hydrocooling for 40 minutes at 5 ± 0.5 °C. S_1= Storage at chiller, S_2= Storage at refrigerator at 4 ± 0.5 °C. The vertical barsrepresent the standard error of the mean (*n=5*). In a column, values having a different letter (s) differ significantly at 1% level of probability analyzed by Tukey.

Combined effect of hydrocooling treatments and storage conditions on the anthocyanin content of coriander leaves

The combined effect of different hydrocooling treatments and storage conditions showed a significant ($p<0.01$) variation in anthocyanin content of coriander leaves at 7 and 10 days after storage, whereas a non-significant difference was observed at 0 and 13 days (Table 5). At 10 days after storage, higher anthocyanin content (0.26 µg/g) was recorded in T_2S_1 and T_2S_2, while lower anthocyanin content (0.19 µg/g) was observed in T_4S_2.

Table 6. Combined effect of hydrocooling treatments and storage conditions on anthocyanin content of coriander leaves

Hydrocooling treatment x Storage Condition	0 Days	7 Days	10 Days	13 Days
T_1S_1	0.02	0.27 b	0.25 ab	0.26
T_1S_2	0.02	0.39 a	0.23 ab	0.25
T_2S_1	0.02	0.26 b	0.26 a	0.25
T_2S_2	0.02	0.26 b	0.26 a	0.26
T_3S_1	0.02	0.26 b	0.25 ab	0.26
T_3S_2	0.02	0.26 b	0.26 ab	0.26
T_4S_1	0.02	0.19 c	0.22 ab	0.26
T_4S_2	0.02	0.19 c	0.19 b	0.26
Level of significance	NS	**	**	NS
CV (%)	9.75	0.70	0.75	0.62

Here, T_1= hydrocooling for 5 minutes, T_2= hydrocooling for 10 minutes, T_3= hydrocooling for 20 minutes, T_4= hydrocooling for 40 minutes at 5 ± 0.5 °C; S_1= Storage at chiller, S_2= Storage at refrigerator at 4 ± 0.5 °C. ** = Significant at 1% level of probability. NS= non-significant. In a column, values having a different letter (s) differ significantly at 1% level of probability analyzed by Tukey.

Conclusion:

In conclusion, the study underscores the importance of hydrocooling treatments and storage conditions in influencing the shelf life and quality attributes of coriander leaves. Optimal hydrocooling for 10 minutes significantly extended shelf life, emphasizing the need for precise post-harvest handling. Refrigerator storage outperformed the chiller, highlighting the critical role of storage conditions. The investigation revealed fluctuations in pH, titratable acidity, ascorbic acid, and anthocyanin content, providing a comprehensive understanding of post-harvest dynamics. The longest shelf life was achieved through optimal hydrocooling for 10 minutes, followed by storage in the refrigerator, indicating a significant combined effect. However, fluctuations were observed in pH, titratable acidity, ascorbic acid, and anthocyanin content. These findings offer practical insights for enhancing the freshness and nutritional value of coriander leaves, benefiting both producers and consumers in the agricultural chain.

References

Alison, M. G., & Peter, R. F. (1999). Insulin releasing and insulin-like activity of the traditional anti-diabetic plant *Coriander sativum* (coriander). *British Journal of Nutrition*, 81(3), 203–209.

BBS (2021) Yearbook of Agricultural Statistics (2019). Bangladesh Bureau of Statistics. Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka, pp. 157–158.

Barbara, M., Cortez, L., Leal, P., & Filho, L. (2000). Post-harvest characterization of 'Baianinha' oranges subjected to refrigerated storage and environmental conditions. *Horticultura Brasileira*, 18, 46–48. https://doi.org/10.1590/S0102-05362000000100010.

Cantwell, M., & Reid, M. (1993). Postharvest physiology and handling of fresh culinary herbs. *Journal of Herbs, Spices & Medicinal Plants*, 1(3), 93–125.

Chepngeno, J., Owino, W., Kinyuru, J., & Nenguwo, N. (2016). Effect of Calcium Chloride and

Hydrocooling on Postharvest Quality of Selected Vegetables. *Journal of Field Robotics*, 5, 23–40. https://doi.org/10.5539/JFR.V5N2P23.

Chowdhury, A. K., Srinives, P., Tongpamnak, P., & Saksoong, P. (2002). RAPD markers linked to resistance to downy mildew disease in soybean. *Euphytica*, 128(1), 55–60.

Cortes-Eslava, J., Gomez-Arroyo, S., & Villalobos-Pietrini, R. (2004). Antimutagenicity of coriander (*Coriandrumsativum*) juice on the mutagenesis produced by plant metabolites of aromatic amines. *Journal of Toxicology Letters*, 153, 283–292.

Crifo, T., Petrone, G., Cicero, L., & Piero, A. (2012). Short cold storage enhances the anthocyanin contents and level of transcripts related to their biosynthesis in blood oranges. *Journal of agricultural and food chemistry*, 60 1, 476–81. https://doi.org/10.1021/jf203891e.

Darughe, F., Barzegar, M., & Sahari, M. A. (2012). Antioxidant and antifungal activity of Coriander (*Coriandrumsativum* L.) essential oil in cake. *International food research Journal*, 19(3), 1253–1260.

Dhankar, S., Kaur, R., Ruhil, S., Balhara, M., Dhankhar, S., &Chhillar, A. K. (2011). A review on *Justiciaadhatoda* A potential source of natural medicine. *African Journal of Plant Science*, 5(11), 620–627.

Eidi, M., Eidi, A., Saeidi, A., Molanaei, S., Sadeghipour, A., Bahar, M., & Bahar, K. (2012). Effect of coriander seed (*Coriandrumsativum* L) ethanol extract on insulin release from pancreatic beta cells in streptozotocin-induced diabetic rats. *Journal of Phytotherapy Research*, 23(3), 404–406.

Ferreira, M., Brecht, J., Sargent, S., & Chandler, C. 2006, 'Hydrocooling as an Alternative to Forced-air Cooling for Maintaining Fresh-market Strawberry Quality', *Horticultural Technology*, 16, 659–666. https://doi.org/10.21273/HORTTECH.16.4.0659

Finger, F. L., & Vieira, G. (1997). Control of post-harvest water loss in horticultural products. Viçosa: UFV. (Educational Notebook, 19). 29p.

Franca, C. F. M., Ribeiro, W. S., Silva, F. C., Costa, L. C., Rêgo, E. R., & Finger, F. L. (2015). Hydrocooling on postharvest conservation of butter lettuce. *Horticultural Brasileira*, 33, 383–387. DOI: http://dx.doi.org/10.1590/S0102-053620150000300018.

Fredericci, T., Fracarolli, J., Betin, P., Peixoto, L., &Fukasawa, L. (2019). Effects of hydrocooling on the post-harvest conservation and quality of spring onion. *Journal of Scientific Initiation Works at UNICAMP*,(26). https://doi.org/10.20396/REVPIBIC2620181275.

Freitas, B., Almeida, R., &Simplício, J. (2019). Coriander storage (*Coriandrumsativum* L) as an alternative to minimize postharvest damages. *Amazonian Journal of Plant Research*, 3(3), 383-390. https://doi.org/10.26545/ajpr.2019.b00047x.

Girenko, M. M. (1982). Initial material and basic trends in breeding of some uncommon species of vegetables. John Bull. VIR im. Vavilova, 120, 33–37.

Lipton, W. J. (1987). Senescence of leafy vegetables. *Horticultural Science*, 22, 854–859.

Nadeem, M., Anjum, F. M., Khan, M. I., Tehseen, S., El-Ghorab, A., & Sultan, J. I. (2013). Nutritional and medicinal aspects of coriander (*Coriandrumsativum* L.). *British Food Journal*, 115(5), 743–755.

Patel, B., Sutar, R., & Khanbarad, S. (2015). Extension of shelf life of pre-cooled tomato fruit under refrigerated transport condition storage. *Journal of Progressive Agriculture*, 6, 1–8.

Paull, R. E. (1992). Postharvest senescence and physiology of leafy vegetables. *Postharvest News Information*, 3(1), 11–20.

Ranganna, S. (1977). Manual of Analysis of Fruit and Vegetable Products. Tata McGraw-Hill, New York.

Ranganna, S. (1979). Manual of Analysis of Fruits and Vegetables Products. Tata McGraw - Hill Pub. Co. Ltd., New Delhi, 102–140.

Rivera, J., Stone, M., Stushnoff, C., Pilon-Smits, E., & Kendall, P. (2006). Effects of Ascorbic Acid Applied by Two Hydrocooling Methods on Physical and Chemical Properties of Green Leaf Lettuce Stored at 5°C. *Journal of Food Science*, 71(3), S270-S276.https://doi.org/10.1111/J.1365-2621.2006.TB15653.X.

Sahib, N. G., Anwar, F., Gilani, A. H., Hamid, A. A., Saari, A., &Alkharfy, K. M. (2012). Coriander (*Coriandrumsativum* L.): A potential source of high-value components for functional foods and nutraceuticals - A Review. *Journal of Phytotherapy Research*, 27(9), 1439–1456. doi10.1002/ptr.4897.

Sena, E., Silva, P., Batista, M., Sargent, S., Junior, L., Pagani, A., & Carnelossi, M. (2019). Calcium application via hydrocooling and edible coating for the conservation and quality of cashew apples. *Scientia Horticulturae*, 256, 108531. https://doi.org/10.1016/J.SCIENTA.2019.05.058.

Sims, D. A, Gamon, J. A. (2002). Relationships between leaf pigment content and spectral reflectance across a wide range of species, leaf structures and developmental stages. *Remote Sensing of Environment*, 81(2–3): 337–354. https://doi.org/10.1016/S0034-4257(02)00010-X

Singh, B., Yang, C. C., Salunkhe, D. K., & Rahman, A. R. (1972). Controlled Atmosphere Storage of Lettuce. 1. Effects on Quality and the Respiration Rate of Lettuce Heads. *Journal of Food Science*, 37(1), 48–50.

Sunil, C., Agastian, P., Kumarappan, C., & Ignacimuthu, S. (2012), 'In vitro antioxidant, antidiabetic and antilipidemic activities of *Symplocoscochin chinensis* (Lour.) S. Moore bark', *Journal of Food and Chemical Toxicology*, 50(5), 1547–1553.

Teruel, B. J. M. (2008). Cooling technologies for fruits and vegetables. *Current Agricultural Science and Technology*, 14(2), 199–220.

Yadav, S., & Sehgal, S. (1997). Effect of home processing and storage on ascorbic acid and β-carotene content of bathua (*Chenopodium album*) and fenugreek (*Trigonellafoenumgraecum*) leaves. *Plant Foods for Human Nutrition*, 50, 239–247. https://doi.org/10.1007/BF02436060.