Conventional and Advanced Packaging and Storage Technology of “Chives” (Allium tuberosum): A Review

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Abstract: The perennial Chives (Allium tuberosum), belonging to the Liliaceae family is typically used as a condiment, vegetable, or spice, salads and soups. It is suitable to tropical and temperate climate. Of all the species of Allium, chives contain the highest amount of beta-carotene and vitamin C. The unique flavour and scent of chives are attributed to sulphur compounds, particularly diallyl disulfide and diallyl trisulfide, which have also been investigated for potential anti-inflammatory, anticancer effects and antioxidant properties that serves to prevent oxidative stress and support general health. Even at refrigerated temperatures, these leaves have a very short shelf life. Chives can be successfully preserved for up to 14 days at 0–5 °C. Packing significantly affects how much weight is lost and how much water is retained during storage and the best packaging found as per latest studies is the plastics. This species has the potential to be commercialized in order to augment the production of onions and garlic in various regions of India, particularly given the current unstable climate. This is because of the species broader adaptability and multifunctional usage.

Keywords: chives; allium; packaging; storage; shelf life; nutritional.

1. Introduction

The perennial Allium species, or chives, belongs to the Liliaceae family. They may reach a height of 30 to 50 cm. From the Arctic areas to Asia, Europe, and North America, wild chives are widely dispersed [1]. Because chives grow quickly and are incredibly versatile, they can be grown and harvested multiple times a year. They can withstand both extremes of temperature. Additionally, they are simple to multiply from seeds or from clump division over the entire year. The primary reason chives are grown is for their long, cylindrical leaves, which are used in cooking. Their blossoms are occasionally used as decorations and can also be utilized in salad dressings. [2]

Edible chives are mildly peppery and mildly onion-flavored leaves and blooms. They are frequently used as a culinary herb to enhance the flavor of a wide range of dishes. For their blossoms, chives can also be planted as ornamentals.

Around the world, chives are mostly farmed in four species:

1. Common chives: Allium shoenoprasum
2. Chinese Chives: Allium tuberosum
3. Massive chives from Siberia: Allium ledebourianum
4. Garlic chives from Siberia: Allium nutan

It is typically used as a condiment, vegetable, or spice. It can be consumed in salads and soups as well as raw, fresh, cooked, or boiled. This plant resembles regular grass. It appears to be a significant perennial that grows quickly, resists drought, and produces cash the quickest. Researchers has investigated the phytochemical screening, antibacterial activity, and gas chromatography-mass spectrometry (GC-MS) analysis of A. odorum L. grown in allover northeast...
India but primarily Manipur, given its numerous health advantages. The majority of the phytochemicals (OSC, Saponins, Flavonoids, 2-methyl-2-butenal, 2-methyl 2-pentenal, Methyl propyl disulphide, Dipropyl disulphide) with the exception of amino, are present in both the aqueous and methanolic extracts of *A. odorum* L., according to preliminary phytochemical screening. [3] It has been demonstrated that using packaging can lessen harm to a variety of crop varieties. Because each form of vegetable has a particular nature and set of requirements when it comes to the environment, different varieties of vegetables require different kinds of circumstances when it comes to appropriate packing. Consequently, more study on the kinds of packaging that can preserve quality must be done for chives.

2. Origin

According to Chen, Poulson, Singh et al. [2,4-5] Chives are the smallest species in the Alliaceae family. The sole native Allium species to both the Old and New Worlds (Europe and Asia) as well as the sub-Arctic area is the herbaceous perennial chive [6,7,1]. Most likely coming from Siberia, it travelled to Asia, Europe, and, during the later Ice Age, North America via the Beringian [8]. According to Nikolai Friesen's personal communication, Asian plant populations do not genetically differ from those of North American populations. Three subspecies from Iberia—*A. schoenoprasum* subsp. orostae, *A. schoenoprasum* subsp. latiori folium, and *A.schoenoprasum* subsp. schoenoprasum [10]—are the main wild relatives of chives. Two subspecies are native to Europe: *A. schoenoprasum* ssp. alpinum (DC) Celak and *A. schoenoprasum* L. ssp. schoenoprasum. The most significant change to the Allium classification was brought about by advances in molecular genetics, which have improved scientists comprehension of the taxonomy of the species and the classification of three evolutionary lineages [7]. From this point on, chives were categorised under the *Allium schoenoprasum* subgenus Cepa, section Schoenoprasum. Though evidence of its use in Asia dates back 4000 or 5000 years [11], the cultivation of chives began in Europe during the Middle Ages. According to Singh et al. (2018) [5], the crop is grown in the USA, Austria, Canada, China, Fennoscandinavia, France, Germany, the UK, Israel, Italy, The Netherlands, and elsewhere [10].

3. Botany

Perennial plants, chives are grown as biennials. Nonetheless, the cycle of productive development is often finished in a year. Chives are classified as belonging to the subgenus *Rhizideum* based on molecular evidence [12]. Oval in form, bulbs are frequently grouped closely. The skin of the bulbs has the feel of carton paper and is a greyish brown tone with hints of purple or yellow. The growth of extended rhizomes and false bulbs are examples of advanced character states, or synapomorphies. These plants are often clustered, ovoid-cylindric, and have a diameter of 0.5–1 cm. Their tunics are brown or yellow-tinted, papery, laciniate, and occasionally fibrous at the apex. The leaves are terete, fistulose, smooth or scabrous denticulate, and they grow in clumps of two to five, slightly shorter than the scape. (figure 1) Branching of chives originates from the site of lateral initiation subsequent to the growth of every two or three leaves [13], causing plants to produce clusters of offspring. Scape: 10–50 (60) cm, terete, smooth or scabrous-denticulate, 1/3–1/2 of its length covered in leaf sheaths [1].

![Figure 1: Pictorial depiction of Chives (*Allium tuberosum*) plant.](image)

Chives blossom the second year after sowing and every year after that. The cylindrical, hollow, and smooth flower scape is long and narrow. Sub globose umbels with many flowers. Spices that are polymorphous, with tepals twice as long as filaments and a perianth that ranges from purple-red to white (or light pink). Each of the six needle-shaped petals is the same height. There is no pistil protruding from the petals [1]. Pollen and viable seeds are rarely produced by the blooms. In general, chives are an out-crooser, and blooms are pollinated by insects, yet selfing also happens a lot [14]. Chives can be grown from divisions or from seeds.

4. Nutritive value

Due to their unique spicy flavor, Allium plants have been regarded as a healthful food source since ancient times. The flavor of chives is softer and more delicate than that of garlic and onions, which makes it easier for the palate to tolerate. In addition to being rich in vitamins and minerals, onions also contain flavonoid molecules, which act as antioxidants [14, 15]. Of all the species of Allium, chives contain the highest amount of beta-carotene and vitamin C. Numerous compounds found in abundance in chives may have positive effects on...
health. The unique flavor and scent of chives are attributed to sulphur compounds, particularly diallyl disulfide and diallyl trisulfide, which have also been investigated for potential anti-inflammatory and anticancer effects. Antioxidant and anti-inflammatory properties of phenolic substances, such as ferulic acid and caffeic acid, serve to prevent oxidative stress and support general health. Furthermore, flavonoids—a class of polyphenolic chemicals distinguished by their potent antioxidant capabilities—are present in chives. These can improve general well-being by scavenging damaging free radicals and possibly lowering the risk of chronic illnesses [2].

Minerals and vitamins A and C are also present in considerable concentrations in chives. Even at refrigerated temperatures, these leaves have a very short shelf life. Similar to other leafy vegetables, senescence is characterized by a decrease in chlorophyll and yellowing of the leaves. Senescence during harvest causes numerous additional substances, including lipids and ascorbate, which are critical for nutritional and sensory quality, to degrade together with proteins, releasing and accumulating amino acids [16]. Maintaining the freshness of fruits and vegetables presents two challenges: (i) Fresh produce keeps growing after it is harvested, and while it is being stored, numerous chemical and biological processes take place. If certain reactions aren't managed, the vegetable may age quickly. (ii) The possibility of microbial reducing or delaying contamination is important to preserve the product's ultimate quality and safety. [17]

5. Pharmacological property

*A. tuberosum* possesses the ability to fight harmful microorganisms. Garlic chives ethanolic extract was proven to be beneficial against the development of *Bacillus subtilis*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, and *Klebsiella pneumoniae*. When compared to other strains, *B. subtilis* showed the greatest inhibition. *A. tuberosum* extract shown a higher deadly impact against *S. aureus* and *B. subtilis*. Certain Gram-positive bacteria, including *Listeria monocytogenes*, *Salmonella typhimurium*, *Escherichia coli*, *Campylobacter jejuni*, and *S. aureus*, were susceptible to essential oil such as garlic chives diallyl disulfide. *A. tuberosum* has two types of thiosulfonates: S-methyl 2-propene-1-thiosulfinate and S-methyl methanethiosulfonate. Researchers demonstrated an antibacterial action on *Escherichia coli*. *A. tuberosum* thiosulfonates exhibited antifungal action against *Aspergillus fumigatus*, *Aspergillus niger*, and *Aspergillus flavus*. *Aspergillus oryzae* and *A. flavus* strains 3.2758 and 3.4408 were inhibited by allyltrisulfide, a primary essential oil present in *A. tuberosum*, at a minimum concentration of 250 ppm. The nematicidal properties of garlic chives, or *A. tuberosum*, are effective against root-knot nematodes, especially *Meloidogyne incognita* J2, a parasite that preys on plant vascular tissues. An in vitro study using a plant extract revealed a significant parasite death rate. *A. tuberosum* has the potential to be a fantastic source of colon cancer drugs. The plant's essential active ingredients are called thiosulfonates. The compounds exhibited a dose- and time-dependent inhibition of cancer cell growth.

6. Post harvest management of chives

Since chives are a highly perishable crop, they should be sold the day they are harvested. 48 hours may pass if refrigerated conditions are available. Storing at 95–100% relative humidity and 0–1°C may pass if refrigerated conditions are available. It may be stored for seven to fourteen days provided they are kept cold.

![Post harvest management of chives](image_url)
blanched, which decreased the amount of dry by 22%, vitamin C by 29%, beta carotene by 20%, chlorophylls by 21%, and nitrates by 26%. Nitrites, on the other hand, rose threefold. A further augmentation of losses was detected at a -20 °C storage temperature, following a year of frozen chive preservation, the amounts of vitamin C, beta carotene, chlorophylls, and nitrates that were retained varied from 11 to 66%, 37 to 65%, and 58 to 81%, respectively [20]. The demand for chives has risen year-round due to the growth of the catering industry and industrial production of ready-to-cook foods, most often pizza and au gratin dishes. The preservation of the vegetable as a dried or frozen product can satisfy this need. Chives can be added as a garnish or as a flavour to many different meals. Fish tastes especially better when infused with chives. Simply said, fish with chives is a really tasty Chinese meal. Numerous dishes, including pancakes, buns, dumplings, and cookies, might benefit from the addition of chives. It may also be found in a variety of meat and dairy products [2].

6.1. Harvesting and Minimal processing

It takes six to eight weeks from planting to harvest the full plant. Harvesting should always take place early in the morning to protect plants from heat stress. The leaves have to be tidy, crisp, and largely devoid of discoloration. Eliminate any damaged, diseased, pest-infested, or yellowed leaves. The origins have to be completely cleaned to get rid of any dirt particles. Next, the material needs to be weighed and knotted into the bunches required by the market, which are typically 0.45 kg (1 lb). Burn all post-harvest waste that has been contaminated by disease or pests. Wastes free of disease can be mulched for use with other crops. Due to the high perishability of these leaves, minimally processed and individually packed fresh-cut aromatic herbs did not experience the first success recorded for other fresh-cut goods [21]. However, because fresh fragrant herbs keep more of their fragrance than dried ones, they are obviously superior [22].

Minimal processing raises the vegetables respiratory rate, which might contribute to a more swiftly development of senescence indications on the fresh-cut leaves and subsequently loss of quality [17, 23]. Despite the fact that a number of studies have been conducted on the nutritional makeup and microbiological safety of fresh-cut aromatic herbs [24-26,17,21,27-29], data on their stability and nutritional quality throughout shelf-life are sparse [22]. Researchers examined the nutritional quality stability of minimally processed leaves of chives, coriander, parsley, and spearmint, which are among the most popular aromatic herbs in European cuisine [30, 25, 17, 28]. Nutritional analysis concentrated on how their vitamins, minerals, and macronutrient composition changed over time. The investigated plants antioxidant potential as well as their phenolic and flavonoid contents were evaluated. Due to refrigerated storage, a number of physicochemical parameters were observed, including pH, total soluble solids (TSS), total titratable acidity (TTA), and color. These parameters are more closely linked to the development of the leaves appearance and flavour. [32]

6.2. Shelf life and storage

Due to the delicate nature of the leaves and their rapid deterioration, chives are an extremely perishable product. As such, its perishable nature makes it difficult to store, particularly in the heat. Similar to other leafy vegetables, senescence is characterized by a decrease in chlorophyll and yellowing of the leaves. Senescence during harvest causes numerous additional substances, including lipids and ascorbate, which are crucial for nutritional and sensory quality, to degrade together with proteins, releasing and accumulating amino acids [16]. The maturity of the leaves at harvest, storage temperature, composition of the environment, and length of storage are some of the variables that affect the pace of senescence. According to Ishii et.al (1984) [35], chives can be successfully preserved for up to 14 days in the air at 0–5 °C. Still, in actuality, postharvest treatment may not preserve such a low storage temperature. (Table 1) [2]

<table>
<thead>
<tr>
<th>Storage</th>
<th>Temperature</th>
<th>Shelf life</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Room temperature (+ 10, 20 or 30% CO₂)</td>
<td>20°C</td>
<td>7 days</td>
<td>[31]</td>
</tr>
<tr>
<td>2. Refrigerated storage</td>
<td>3 ± 1 °C</td>
<td>10 days</td>
<td>[32]</td>
</tr>
<tr>
<td>3. Refrigerated storage</td>
<td>0°C</td>
<td>13 days</td>
<td>[33]</td>
</tr>
<tr>
<td>4. Room temperature</td>
<td>20°C</td>
<td>5 days</td>
<td>[34]</td>
</tr>
<tr>
<td>5. Low temperature</td>
<td>3°C</td>
<td>20 days</td>
<td>[34]</td>
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</table>

Table 1: Different storage temperature and the shelf life of chives

6.3 Conventional and advanced packaging

It has been demonstrated that using packaging can lessen damage to a variety of vegetables, including

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green mustard, okra, cabbage, and chilli. Due to their varied qualities and environmental needs, different vegetable varieties require different kinds of packing as well as appropriate conditions for storage. Therefore, additional research on packaging options that preserve the quality of chives is required. There are three kinds of plastic packaging: wrapping plastic, PE (polyethylene), and PP (polypropylene). Chives that are packaged should be kept in storage for 14 days. Water content, color alterations, texture changes, and weight decrease were all noted. Anova (Analysis of Variance) was used to analyze weight loss and water content data, whereas a quantitative descriptive method was used to analyze physical test data (color and texture changes). According to this study, packing significantly affects how much weight is lost and how much water is retained during storage (Table 2) [39].

<table>
<thead>
<tr>
<th>Packaging</th>
<th>Shelf life</th>
<th>Temperature</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. LDPE</td>
<td>3 weeks</td>
<td>4-5°C</td>
<td>[36]</td>
</tr>
<tr>
<td>2. HDPE</td>
<td>3 weeks</td>
<td>4-5°C</td>
<td>[36]</td>
</tr>
<tr>
<td>3. Oriented Poly Propylene film</td>
<td>3 days</td>
<td>20°C</td>
<td>[37]</td>
</tr>
<tr>
<td>4. PVC</td>
<td>17 days</td>
<td>0-4°C</td>
<td>[33]</td>
</tr>
<tr>
<td>5. Inner HDPE film</td>
<td>21 days</td>
<td>5°C</td>
<td>[38]</td>
</tr>
</tbody>
</table>

Table 2: Different packaging and shelf life of chives.

However, there is not much research on the advanced storage of chives till now.

7. Future prospects

In India’s western and eastern Himalayan areas, Chinese chives (Allium tuberosum Rottler ex Sprengel) are a lesser-known vegetable that is grown. The species under consideration has the potential to be commercialized in order to augment the production of onions and garlic in various regions of India, particularly given the current unstable climate. Owing to the species’ versatility and vast range of uses, future focus in India will be on collecting and conservation initiatives. The focus of Chinese chives (Allium tuberosum Rottler ex Sprengel) in India going forward will be on collecting and conservation initiatives, according to ResearchGate. This is because of the species broader adaptability and multifunctional usage.

Because they are abundant in healthy nutrients and low in calories, chives are nutrient-dense. They are low in calories and fats and high in vitamins A, C, and K. Compounds like Sulphur found in chives may potentially aid in the prevention or treatment of cancer. The greatest application for chives is fresh; dried chives lose color and flavor. Although they are frequently used as a garnish, a person would need to consume a lot of them to receive a considerable amount of nutrients. They grow well after harvesting and are simple to cultivate and care for. Aphids are repelled by the natural oils in chives blades, while bees and other pollinators are drawn to the blooms.

8. Acknowledgement

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9. Conflict of interest

There is no conflict of interest.

10. Reference


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