Controlled atmospheric storage for enhancement shelf life and quality of apple

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Introduction

Apple (*Malus domestica*) is considered as an important temperate fruit, ranking fourth in the order after banana, orange and grape. Hierarchically, China is placed up the order as the largest producer and India with a share of 1/3rd of the total apple production, stands at ninth place. From the application perspective, 71% of the apples are consumed as fresh and 20% is processed and converted into value added products. The grading of the apples results in the generation of A, B and C grade apples. Price of apple varies as per quality and varieties. A grade and B grade apples are used as table purpose while C grade apples are sent to processing unit for processing. As a general rule, A grade apples are used to store in cold storages while B grade goes to market and C grade to processing industry. A and B grade apples are sold in box and carton. In industrial terminology, the apple juice concentrate (AJC) is preferred over apple cider, wine, apple purees, jams, Ready to Serve (RTS) apple juice, vermouth and dried apple products other products with the preference level of 65%. Apple cultivation is predominant and serves as the backbone of the rural economy of Jammu and Kashmir, Himachal Pradesh, North Eastern, Himalayan States and Uttarakhand. Jammu and Kashmir has a special distinction with 77.71% share percentage. However, it is pertinent to mention that Apple is a perishable fruit crop with high post-harvest loss percentage. As per one estimate, total Harvest and Post-harvest Losses (%) account for 12.26±1.05%. at National level. This loss is comparatively higher than other developed countries. The low damage percentage gave them a competitive advantage, thereby, providing a space to keep the market price as low as 10-25 rupees per kilogram. Therefore, it is imperative to involve latest post-

harvest processing techniques and technologies to reduce the losses and enhance its market value.

Developmental imbroglio and remedial measures: The state with the highest apple production lacks basic facilities: infrastructural vacuum, technological backwardness and market instability. The state has no proper setup in terms of infrastructure, grading, packing and storage structure, transportation and handling services. The absence results in an increase in the loss percentage at source and destination. The farmers are facing the stress and disappointment as their produce is unable to reach to the markets or stored at modern scientific storage facilities. The problem can be redressed with the involvement of controlled atmospheric storage to arrest the loss percentage and extend the shelf life of the apple without affecting its quality. The underlying fact behind the controlled atmospheric storage (CAS) is to lower down the oxygen and increase the concentration of carbon dioxide to decrease the respiratory metabolism or ethylene production. The levels are continuously monitored to maintain optimum concentration within the prescribed tolerances in order to check the fermentation and degradation of the quality of the stored apple. This can improve quality attributes such as physiological loss in weight, fruit firmness, rotting, scalding, juiciness, total soluble solids and acidity.

Critical requirements for Storage and transportation of apple:

1. Optimum Temperature and Relative Humidity (RH)
2. Optimum air movement
3. Optimum air movement
4. Optimum Stacking
5. Optimum Atmosphere conditions (oxygen, carbon dioxide and nitrogen)
6. Water vapor and condensation on product sanitation

The main components of controlled atmospheric storage that are essential to maintain temperature, relative humidity, gas and composition includes:

I. **Refrigeration equipment for cooling the produce**: This help to maintain the temperature of apple and lower the respiration rate

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II. **RH Humidifiers/ Coolers:** Evaporators/cooling machines assist in keeping a high RH, reducing water loss from the produce.

III. **Nitrogen generation:** PSA (pressure swing adsorption) Nitrogen technique is utilized in CA store to produce 99 percent pure nitrogen. To produce pure nitrogen, specially constructed molecular sieves are utilized to separate nitrogen from ambient air. The only necessary input is a compressor and ambient air. Low oxygen is achieved and maintained by flushing it into the storage containers/chambers.

IV. **Carbon dioxide scrubbers**: Scrubbers are used to remove surplus carbon dioxide from the storage space. They also remove a little amount of ethylene. Adsorbents in scrubbers include carbon molecular sieves and activated alumina.

V. **Instruments for monitoring, regulating, and recording:** Oxygen and carbon dioxide analyzers, instruments for precise control of oxygen and carbon dioxide recording and logging, and other equipment used for monitoring and regulating within the compartment.

VI. **Safety Arrangements**: These include sensors for avoiding injury to the produce due to freezing. Effect of toxicity due to the refrigerant (like ammonia) is avoided by selecting safe refrigerants.

Therefore, CAS help to reduce such as physiological disorders, flavor and off-flavor, acidity, C_2H_4 production, respiration rate, volatile compounds, phytochemical compounds, color, etc. This can help to enhance the storage life of apple and increase the livelihood of farmers in union territory of Jammu and Kashmir.