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Review Article

Exploring the significance of control atmosphere of vegetables

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ABSTRACT

The development and production of vegetables are increasing in every corner of the globe. Besides fresh and quality vegetables, which are the central pillar of generating economies and business, there is also demand and requirement to differentiate and create post harvest storage, transport, publicity, and preparing the foundation to broaden the utilization of vegetables beyond rising seasons and localities. However, numerous Western nations have created vegetables appropriate for cold environments, including potatoes and tomatoes, to tackle the issue. The countries of tropical areas, like China, India, Brazil, Pan American nations, and nations of Africa, South-East Asia, and Central Asia, have an appropriate environment and assets to cultivate numerous kinds of vegetables. However, the present paper examines the significance of control the atmosphere storage of vegetables and how it affects various foodstuff quality and marketing. The study is based on secondary data. The study systematically reviews many articles, reports and books. The results reveal that the control atmosphere storage enhances the quality of the product that increases the product's suppy and demand. Furthermore, it shows that controlled atmosphere storage is the one most appropriate innovation that can guarantee long storage of vegetables that enhances the freshness and best marketing of the products. The vegetables are kept up through the utilization of explicit CA storage conditions to every product and control of the gas elements, temperature, and relative humidity of the climate. Notwithstanding these components, digestion changes of vegetables have been considered to set up the ideal storage conditions. This is enlarging the improvement of a quick storage system.

1. Introduction

The development and production of vegetables are increasing in every corner of the globe. Besides fresh and quality vegetables, which are the main pillar of generating economies and business, there is also demand and requirement to differentiate and create postharvest storage, transport, publicity, and preparing the foundation to broaden the utilization of vegetables beyond rising seasons and localities. However, numerous Western nations have created vegetables appropriate for cold environments, including potatoes and tomatoes, to tackle the issue. The countries of tropical areas, like China, India, Brazil, Pan American nations, and nations of Africa, South-East Asia, and Central Asia, have an appropriate environment and assets to cultivate numerous kinds of vegetables. However, these nations have made reasonable endeavours and have underlined to refining the agronomic practices and advancement of high yielding great quality vegetables for import and export market (Bishop, 1997).[1]

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2. Conceptualizing Control Atmosphere Storage in Vegetables (CAS)

The concept of Controlled Atmosphere (CA) storage is likely the best innovation created for foodstuffs engineering in the twentieth century. The Controlled Atmosphere (CA) storage frequently utilizes low oxygen (O2) levels and high carbon dioxide (CO2) levels in the storage atmosphere joined with refrigeration. Indeed, even early time, the storing practices may have used an altered environment improved with CO2 and exhausted O2 levels to broaden the capacity life of organic products, vegetables, oats, and different items (Dilley, 2006).

The procedure of adjustment of the environment encompassing fresh items is alluded to as CAS. In CAS, the environment is made preciously, and the gas arrangement is constantly checked and acclimated to keep up the ideal gas fixation. There are various sorts of controlled environment storage relying predominantly upon the technique or level of control of the gases. However, mostly two sorts of control atmosphere storage frameworks like "Static controlled air storage "and" Flushed controlled air storage" are most typically utilized. "Static" is the place where the item creates the atmosphere and "Flushed" is the place where the climate is provided from a streaming gas stream, which cleanses the store constantly.

Further, the new, highly sophisticated foodstuffs are the significant necessities for the global and regional food manufacturing level during the contemporary period. However, after reaping, especially for new and fresh vegetables, remain in the respiration cycle. Hence to sustain the quality, the respiration level must be decreased, mainly when the items are deposited for a prolonged period or transported to faraway marketplaces. An ideal approach to protect the quality and broaden the timeframe of realistic usability is by cooling, and another strategy used to expand the time span of usability is the change of the environment encompassing the item. Most items will in general, preserve longer in atmospheres that are great in carbon dioxide and low in oxygen. Further atmosphere change is typically utilized as a supplement for cooling (Dilley, 2006).

As it is evident that Controlled atmosphere storage is a framework for keeping vegetables in a climate that contrasts generously from ordinary air in regard to CO2 and O2 levels. The Controlled atmosphere storage alludes to the steady observing and change of the CO2 and O2 levels inside gas-tight compartments. The gas blend will continually vary because of the metabolic action of the store's respiring vegetables and the spillage of gases through entrances and walls. The gases are hence estimated occasionally and changed in accordance with the prearranged level by the opening of natural air or nitrogen or passing the store air from a biochemical to eliminate CO2 (Bodbodak, & Moshfeghifar, 2016).[2]

3. Brief Emergence and Development of Control Atmosphere Storage (CAS)

The first commercial utilization of the usage of the adapted gas atmosphere was for control atmosphere storage of fruits and vegetables. There are some evidence to recommend that the old Egyptians and Samarians in the subsequent century BC put away parts of their foodstuffs in fixed limestone graves to enlarge their life. Maybe even Joseph utilized these methods while planning for the seven years of starvation.

In 1929, Spencer Mount was the first person who investigated the commercial control atmosphere storage in UK. He effectively put away 30 tons of Bramley's Seedling apples in 10% carbon dioxide at his homestead in Canterbury. It is fascinating to take note that notwithstanding all the successive investigations, 10% carbon dioxide is as yet a suggested storage condition for this cultivar (Dilley,1990).[3,4]

Early advancements were mainly for the storage and transportation of mass food varieties. The scientific examinations on the impact of gases on broadening the time-span of usability of food varieties were led in 1930 on fresh meat. It was explored that a multiplying of the timeframe of realistic usability of refrigerated pork and sheep when these meats were put away in an atmosphere of 100% CO2.

Hence, Jacques Etienne Berard first investigated the Controlled Atmosphere (CA) storage in the mid-1800s in France (Dalrymple, 1969).[5] He saw that foodstuffs did not age in an air exhausted of O2 (Dalrymple, 1969). Further, various examinations too examined the impacts of low degrees of O2 and high degrees of CO2 on growing. However, the purpose of commercial usage of Controlled Atmosphere storage was set up by Kidd and West (1927), who considered the impacts of O2, CO2, and C2H4 on respiration and ripening in pome products and berries. Notwithstanding, after the 1950s, when CA innovation developed, its utilization turned out to be more regular. Furthermore, the enlargement and practical improvements during the 1990s extended its utilization around the world (Prange et al.[6], 2012).

In Controlled Atmosphere storage, inside a foodstuff space is the gas arrangement that is consistently observed and adjusted to keep up the ideal focus inside totally close resiliences. Since CA storage is principal concentrated and costly to work, it is more proper for those food varieties that are pleasant to long haul storage various fruits and vegetables. Moreover, the Controlled Atmosphere storage is valuable for lightening various storage issues, infections of foodstuff, while different problems might be intensified or initiated by controlled atmosphere storage. However, studies have explored the use of controlled atmosphere storage for different products, which prompted the commercial usage and suggestion of CA surroundings for the capacity of different natural products, vegetables, fresh-cut fruits, and vegetables. Additionally, controlled atmosphere storage

has explicit applications, for example, bug control and sanitization (Dumont et al., 2016).[7]

4. Method and Significance of Controlled Atmosphere in Vegetables

The characteristics of vegetables such as flavor, color, size, shape, and absence of external flaws eventually govern their acceptance by consumers. The development of these characteristics is the result of many chemical and biochemical changes that occur following harvesting and storage. Since harvesting vegetables at their correct stage of maturity is critical for the development of a highly acceptable product for the fresh market or for processing, it is vital to understand more fully what changes are taking place.

Controlled atmosphere (CA) storage of vegetables indicates to storge in the atmosphere with diminished degrees of oxygen and additionally moderately high carbon dioxide fixations, at low temperature and high relative humidity (RH). The adjusted climates are made in an impenetrable room, and they are ceaselessly observed and kept up all through the storage period. CA storing is a proper and fruitful innovation for enriching the lifespan of genuine usability and sustaining the worth of vegetables for an enormous scope (Thompson at el, 2018).[8]

Controlled atmosphere storing has been the subject of a tremendous number of biochemical, physiological and innovative investigations, despite which it is however, not known conclusively why it works. The real impacts that were fluctuating the degrees of O2 and CO2 in the atmosphere have on crops changes with such factors and reasons which are given below:

1. a) The types of yield or crops
2. b) The cultivars of crop
3. c) The absorption of the gases in the store
4. d) The harvest temperature
5. e) The condition of development of the crop at produce
6. f) The level of readiness of the climacteric vegetable
7. g) The developing conditions before reap
8. h) The presence of ethylene in the store

However, there are additionally various impacts of these two gases, so the impacts of the CO2 and O2 in broadening the storage life of a crop might be expanded when they are linked.

4.1. Method of control atmosphere in vegetables

The most established and most famous technique for extending out the time span of usability of vegetables is cold storage. This depends on the way that organic responses, like respiration and other metabolic cycles, as well as decomposition, rely upon temperature. The Van't Hoffrule shows that the speed of response reduces two to three-fold for each 10_C lessening in temperature. Consequently, the storage of vegetables at the smallest, however above freezing, would appear to be generally gainful regarding the highest storage time (Eskin, & Shahidi, 2012).[9]

5. Understanding the Necessities for Perfect Controlled Atmosphere Storage (CAS)

5.1. Controlled atmosphere storage room

A gas-tight room is a conspicuous necessary for accomplishing a decent controlled air storage structure. Therefore, it is vital to make room dividers gas-tight. To guarantee that the dividers are gas-tight to CA storage they are wrinkled with sheets of electrified steel.

Fig. 1: The left, pictured shows the Doors may be fixed on a sliding rail, and the right side picture shows the mounted to open vertically on overhead rails.

6. Temperature

Cold storing is the most utilized strategy for keeping up the nature of leafy foods. Lower temperatures lead to more slow breath rates and lessen other metabolic or debasement responses. Temperatures are typically kept somewhere in the range of 1 and 3 _C in CA storage, however, the exact ideal temperature. The principal method of safeguarding vegetables and meat in storage or during significant distance transport is by refrigeration, and controlled environments are viewed as an enrichment to expand or increase the impact of refrigeration. Further, CA storing is merely fruitful when functional at low temperatures. However, standard refrigeration units are thus essential parts of the CAS system. Moreover, temperature control is attained by taking pipes holding a refrigerant inside the storage. Therefore, ammonia or chlorofluorocarbons are standard refrigerants.

6.1. Humidity control

Most natural products, vegetables, and meats, which are kept in CA storage, necessitate a greater relative humidity, by and large, the nearer to immersion, the better, insofar as

dampness doesn't reduce on the food sources. The measure of heat consumed by the cooling loops of the refrigeration unit is identified with the temperature of the refrigerant they contain and the surface region of the coils. It is believed that if their refrigerant temperature is low contrasted with the store air temperature, water will consolidate on the evaporator. This exclusion of dampness from the store air, lessens its relative mugginess that consequence in the store food losing dampness by evaporation-transpiration. Thus, To lessen food dehydration the refrigerant temperature ought to be held near the store air temperature.

6.2. *Gas control*

The climate in an advanced CA store is continually examined for CO2 and O2 levels utilizing an Infrared gas analyzer to quantify the gas content in the store continually. Hence, there are likewise ethylene analyzers that ceaselessly measure ethylene focus in the store. Further, in the storage room where low ethylene is fundamental, instructions can be made that the ventilation and ethylene exclusion structures are working accurately (Fragoso, A. V., & Mújica-Paz, H. 2016 and Thompson at el, 2018).

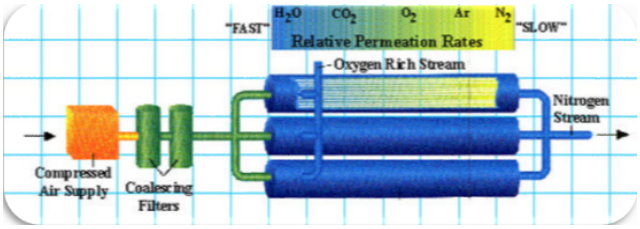

Fig. 2: Scrutinizing the vegetables storage under control atmosphere storge

The storage of vegetables is carefully associated with their respiration level, which is an outflow of metabolic action. Since high-impact respiration entails O2 and consequences in CO2 and heat discharge. Further, over 95% of the energy delivered is lost as heat. The temperature decline, in particular whenever assisted by adjustment of the atmosphere, led to a decrease in respiration rate, and accordingly to an increment store life in vegetables with climacteric respiration. However, the determination of the most reasonable atmosphere relies upon cultivars, phase of development, ecological and agriculture boundaries.

Therefore, no kind of atmosphere is perfect for all crops; explicit recommendations and alarms should be resolved for each yield over the variety of storage temperature and times (Fragoso, A. V., & Mújica-Paz, H. 2016). [10]

eveals the recommended temperature, RH, and oxygen and carbon dioxide applications for the storage of some vegetables.

Table 1: ontrolled atmosphere conditions for some vegetables

Vegetables	T (_C)	RH (%)	O2 (%)	CO2 (%)
Asparagus	0–1.5	95–100	7	7
Beans, green	8	95	3	3
Bell peppers	7-14	90-95	2-3	5
Broccoli	0	95-100	1-2	5-10
Cauliflower	0	95-98	2	5
Celery	0	98-100	2-4	3-5
Cucumbers	10-13	95	3-5	10
Garlic	0	65-70	1-3	5-15
Jicama	13-18	65-70	0	5-10
Lettuce	0-5	98-100	1-3	7-10
Mushrooms	0	95-98	3	5-7
Onions	0	65-70	3	5-7
Peas	0	95-98	2-3	2-3
Radish	0	95-100	1-2	2-3
Tomatoes	13-15	90-95	4	5

Source:- (Fragoso, A. V., & Mújica-Paz, H. 2016)

6.3. *Storage of minimally processed vegetables*

The inclination by customers for vegetables in a 'prepared to cook and 'prepared to-eat helpful method has brought about the stock of vegetables in minimally processed method to the market. Such Minimally Processed (MP) produce has been effectively put away in a modified atmosphere package (MAP) with almost no trouble in their tactile, nourishing, and market quality. However, MAP utilizing polypropylene sacks with micro-perforations has been demonstrated to be a successful strategy for putting away MP vegetables. LO atmosphere is used to control decay microorganisms on cut spinach leaves for seven days. Further, a greater degree of O2 hinders detrimental fermentation responses, postpones carmelizing during preparing, and restrains microbial development during the storage of MP vegetables and fruits. MAP has been utilized monetarily to broaden the time span of usability of minimally processed mango furthermore, other serving of mixed greens, vegetables and leaves (Thompson, 1996, Hardenberg et al. [11],1986).

7. Understanding the Positives and Limitations of Controlled Atmosphere Storage on Vegetables.

7.1. *Positive impact of controlled atmosphere storage on vegetables*

The following positive impact of CAS as are given below:

1. a. A significant decline in respiratory rate, with a decrease in climacteric most extreme, combined by an extension of both pre-climacteric and post-climacteric periods.
2. b. A decrease in the impact of ethylene on digestion because of the connection of O2 with ethylene, with a subsequent postponement of appearance of senescence

side effects.

3. c. An increase storage life, which can even be multiplied, in as much as the over maturing is deferred.
4. d. The protection of a magnificent determination of tissue, because of the impact of CO2 focus on the enzymes performing on cellular membranes
5. e. A high turgidity is attained, with the goal that vegetables are more delicious and fresh
6. f. A more modest loss of acidity, sugars and vitamin C, therefore the nutritious and fleshly quality is higher.
7. g.Decrease in chlorophyll breakdown, with coming about higher shading strength
8. h. Decrease in enzymatic sautéing in cut produce, at whatever point low degrees of O2 are utilized.
9. i. Improvement in surface brought about by the activity of CO2 on proteins following up on cell layers.
10. j. Decrease in some physiological problems incited by C2H4, for example, singe of apples and pears and chilling injury of citrus organic products, avocado, stew pepper, and okra.
11. k.Decrease in microbial action, particularly shape

7.2. Negative impact of controlled atmosphere Storage on vegetables

Controlled atmosphere storage has additionally negative impacts, at O2 levels beneath 1%, without CO2, anaerobic conditions can triumph with the subsequent arrangement of liquor and physiological changes. Additionally, high CO2 and low O2 may cause irregular indigestion in vegetables.

7.3. Examining the controlled or modified atmosphere storage

Controlled or modified atmosphere storage can be utilized as a supplement to legitimate temperature and relative humidity management.

Controlled atmosphere storage alludes to a persistently controlled gas atmosphere, while modified atmosphere storage alludes to a gas arrangement that is primarily changed or modified. However, the gas piece inside modified atmosphere storage will change over a long period because of the respiration pace of food items and the absorptivity of the packaging encompassing the food items. Further, the essential advantage of bringing down O2 and expanding CO2 encompassing the food is its impact on bringing down the respiration or metabolic pace of the product, which led to the slow down of the normal senescence practice. Thus, various impacts of adjusted O2 and CO2 levels are summed up in the below Table (Dumont et al., 2016; Thompson, 1998 and Kader, 1992). [12]

From the above table, it is perceived that careful consideration should be taken to keep a decent control on the exact degrees of adjusted gases since too significant degrees of CO2 or O2 will probably harm vegetables.

Table 2: ome impact of modified O_2 and CO_2 level on crops

Modified O_2 Levels	**Modified CO_2 Levels**
Reduced respiration rate	Declined discoloration levels
Reduced substrate oxidation	Declined synthetic reaction in climacteric fruits
Delayed ripening of climacteric fruits	Inhibition of some enzymatic reactions
Prolonged storage life	Declined production of some organic volatiles
Reduced rate of production of ethylene	Modified metabolism of some organic acids
Reduced degradation rate of soluble pectin	Inhibition of the effects of ethylene
Formation of undesirable odors and flavors	Retarded fungal growth
Altered texture	Production of off-flavors
Development of physiological disorders	Development of physiological disorders

Sources:- (Thompson, 1998 and Dumont et al., 2016)

Therefore, the significant advantage of controlled atmosphere storage is identified with the decrease of food decay from nuisances and infections. Meanwhile, higher CO2 levels usually have adversely affected the progress and improvement of microorganisms. Subsequently, putting vegetables under a controlled environment may fundamentally decrease the measure of postharvest synthetic substances utilized for their assurance against bugs and microorganisms (Dumont et al.[13], 2016 and Thompson, 1998). [14,15]

8. Conclusion

It is concluded that controlled atmosphere storage is the one most appropriate innovation that can guarantee long storage of vegetables that enhanced the freshness and best marketing of the products. The vegetables are kept up through the utilization of explicit CA storage conditions to every product and control of the gas elements, temperature, and relative humidity of the climate. Notwithstanding these components, digestion changes of vegetables have been considered to set up the ideal storage conditions. This is enlarging the improvement of the quick storage system.

It also enhances the quality of the product that increases the supply and demand of the product. Further, the essential advantage of bringing down O2 and expanding CO2 encompassing the food is its impact on bringing down the respiration or metabolic pace of the product, which led to the slow down of the regular senescence practice. Controlled or modified atmosphere storage can be utilized as a supplement to legitimate temperature and relative humidity management.

It is the most established and most famous technique for extending out the time span of usability of vegetables is cold storage. This depends on how organic responses, like respiration and other metabolic cycles, as well as

decomposition, rely upon temperature. Since CA storage is principal concentrated and costly to work, it is more proper for those food varieties that are pleasant to long haul storage various fruits and vegetables. Moreover, the Controlled Atmosphere storage is valuable for lightening various storage issues, infections of foodstuff, while different problems might be intensified or initiated by controlled atmosphere storage. However, studies have explored the use of controlled atmosphere storage for different products, which prompted the commercial usage and suggestion of CA surroundings for the capacity of different natural products, vegetables, fresh-cut fruits, and vegetables. Additionally, controlled atmosphere storage has explicit applications, for example, bug control and sanitization.

However, Controlled atmosphere storage has additionally negative impacts, at O2 levels beneath 1%, without CO2, anaerobic conditions can triumph with the subsequent arrangement of liquor and physiological changes. Additionally, high CO2 and low O2 may cause irregular indigestion in vegetables.

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10. Conflict of Interest

None.

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