

RESEARCH REGARDING THE STORAGE OF FRUITS AND VEGETABLES IN CONTROLLED ATMOSPHERE

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Abstract: *One factor as important as the automatic control of the humidity and temperature in the warehouses for fruits and vegetables is the automatic controlled composition atmosphere. This paper studies two different atmosphere composition control systems, one carbon dioxide generator and one nitrogen generator. Both enrich the atmosphere to 99% from the total gas mass. Using these control methods together with automatic adjustment systems used for controlling the climacteric factors increases significant the storage duration and at the same time reduces weight loss due to dehydration.*

Key words: *automatic systems, controlled atmosphere, nitrogen generator.*

1. Introduction

The main factor that influences maintaining fruits and vegetables in a fresh state is represented by the active natural immunity, respectively the metabolism specific to each particular kind. An important role has the passive immunity, which is determined by the traits that are specific to epicarp, by their structural and textural characteristics and by their maturity degree [1].

The atmosphere composition is influenced by the level of carbon dioxide, nitrogen, oxygen and ethylene the storing duration. A method of increasing it, is the oxygen content reduction and at the same time increasing the nitrogen or the carbon dioxide content. This operation has as effect the breathing intensity reduction so that the storage duration is extended.

The achievement of controlled atmosphere

is assured in two ways: by abiological methods, which decrease the oxygen concentration and increase the carbon dioxide concentration, are obtained independently from the biologic substrate participation, and by biological methods, when a specific gas composition is assured due to fruits' and vegetables' respiratory activities.

Another method is storing fruits and vegetables in oxygen and carbon dioxide impoverished environment, with the temperature and humidity values automatically controlled. By using modified atmosphere in warehouses where fruits and vegetables are refrigerated, the cooling capacity will be increased to reduce the vital activity of the vegetal organs, physiological disorders will be avoided, and in some measure the degradation phenomena will be reduced to a minimum.

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Storage conditions

Table 1

| Product | Temperature range | | % O ₂ range | % CO ₂ range |
|-----------------------|-------------------|----------------|------------------------|-------------------------|
| | ⁰ C | ⁰ F | | |
| Strawberry | 0-5 | 32-41 | 10 | 15-20 |
| Apple | 0-5 | 32-41 | 2-3 | 1-2 |
| Kiwifruit | 0-5 | 32-41 | 2 | 5 |
| Nuts and dried fruits | 0-25 | 32-77 | 0-1 | 0-100 |
| Bananas | 12-15 | 54-59 | 2-5 | 2-5 |
| Bananas | 12-15 | 54-59 | 2-5 | 2-5 |
| Lettuce | 0-5 | 32-41 | 2-5 | 0 |
| Tomatoes | 0-5 | 32-41 | 2-5 | 2-5 |
| Mature green | 12-20 | 54-68 | 3-5 | 0 |
| Partially-ripe | 8- 12 | 47-54 | 3-5 | 0 |

Table 1 presents the recommended values for temperature, oxygen and carbon dioxide content for high storage duration [2].

2. Material and Method

By storing fruits and vegetables in a controlled atmosphere conditions became a subject more and more important to researchers and manufactures for equipments used in this activity. That is why, lately many systems that are specialized in monitoring and controlling the atmosphere appeared. Figure 1 presents a system for

controlling the CO₂ level.

Where the notations have the following signification: *A* - evaporator; *Aa* - fan; *Ab* - coil; *Ac* - defrost; *B* - scrubber; *Ba* - slide; *Bb* - wire control for scrubber; *Bc* - lime; *C* - sprayed on polyurethane; *D* - collar with internal pipe flange; *E* - breather bag; *Ea* - gate valve; *F* - automatic relief valves; *G* - manual relief valve; *H* - differential pressure gauge; *I* - CO₂ purging system; *Ia* - CO₂ cylindre; *Ib* - metering valve; *Ic* - purge meter; *Id* - safety valve; *J* - sampling line; *K* - false floor; *Ka* - "2x4"; *Kb* - polyurethane floor; *Kc* - dunnage.

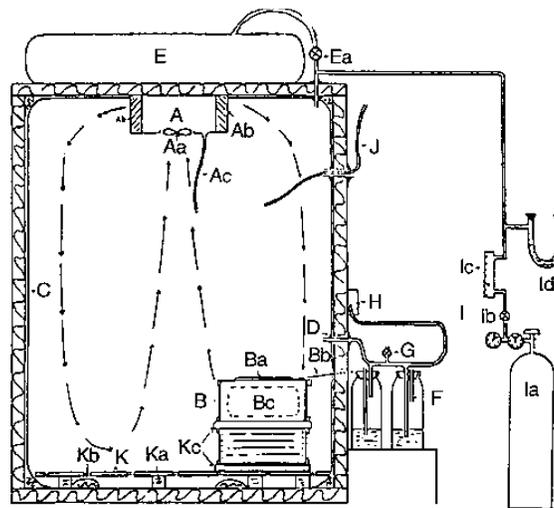


Fig. 1. Carbon dioxide generator [2]

Also in manipulating the atmosphere using CO₂, Carbon Dioxide Scrubbers which allows easy programming appered, CO₂ concentrations for peak performance scrub and purge times, background timing defaults, CO₂ scrub cycle history, log of CO₂ levels,

history of cycles per day in a room, scrubber capacity ratio and alarms. This system has a high efficiency rate because it assures a 99.9% gas purity, but unlike the system presented before, this one (Figure 2) decreases the CO₂ content to 2.5%.



Fig. 2. *Carbon dioxide scrubber*

Lately Nitrogen generators are gaining more and more field because they are an environmentally friendly substance and also a chemically non-reactive, colorless and odorless gas that comprises 79% of the Earth's atmosphere. Gaseous nitrogen is used in controlled and modified atmosphere fruits and vegetables storage and packaging to maintain the quality of fresh products by retarding oxygen-dependent ripening and decay processes. Controlled atmospheres are extensively used in the storage of apples and pears as to allow extended storage prior to sale without significant quality degradation. Controlled atmosphere storage rooms for apples and pears are typically maintained at 98-99% Nitrogen concentrations with balance controlled amounts of oxygen and carbon dioxide. Nitrogen can be provided

from vaporized liquid nitrogen (Figure 3), non-cryogenic generators (Figure 4), or combustion-based generators [5].

3. Results and Discussions

It is well known that anaerobic conditions promote astringency removal. Research shows that in CO₂ treated products, the removal of astringency was faster than in N₂ treated fruits and vegetables, but CO₂ treatment causes internal browning [3]. Weight loss is mainly due to losses of water through dehydration and carbon gases exchange. This weight loss is directly proportional to the gas type, its concentration and exposure duration. CO₂ application with high concentration, appreciatively 99% showed more reduction in weight loss than N₂ [4].



Fig. 3. Nitrogen generator from vaporized liquid nitrogen

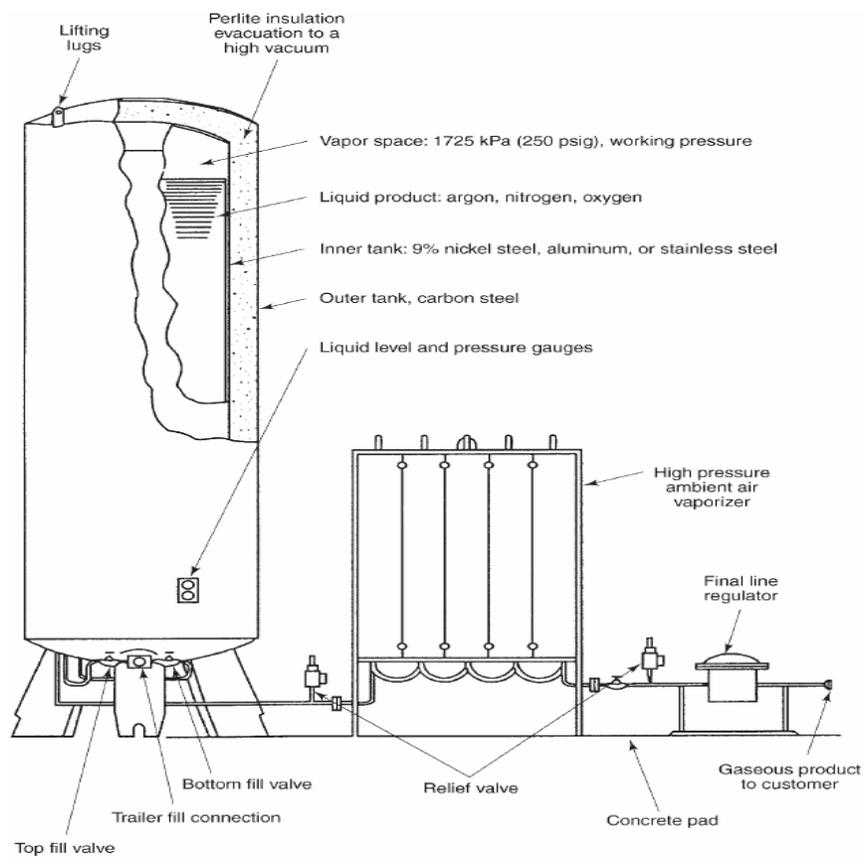


Fig. 4. Non-cryogenic generator

Breathing rate (CO_2 production) for fruits and vegetables stored in controlled atmosphere is directly influenced by the gas that was selected to enrich the atmosphere. So CO_2 maintains higher CO_2 production throughout the storage period, which indicates its effectiveness in removing astringency than N_2 applications, the means that CO_2 is more effective in removing astringency than N_2 .

Instead of storing fruits and vegetables in N_2 than in CO_2 keeps a higher vitamin C content, but in both cases the decrease of vitamin C content is insignificant. Also fruits and vegetables firmness and taste significantly decreases gradually towards the end of the storage period but as well as in the vitamin C case the products stored under N_2 atmosphere maintains its high quality and firmness longer than those stored in CO_2 .



Fig. 5. *Apples stored without using automatic systems*



Fig. 6. *Apples stored in automatic warehouses with controlled atmosphere*

In Figures 5 and 6 there are illustrations of apples, variety Red Delicious which were stored almost 200 days. The first lot of apples which are shown in Figure 5 had been stored in a warehouse without any controlling or adjustment system. In the other figure, a modern warehouse was used which had climacteric control and monitoring systems and also an efficient Carbon Dioxide Scrubber.

It is easy to see and understand the need for using advanced systems for humidity, temperature and atmosphere control. Only thus a quality product can be assured to consumers for a long period of time.

4. Conclusions

- Increasing the storage duration for fruits and vegetables is also possible by controlling and modifying the atmosphere inside the spaces used for this purpose. This increase is significant when in combination with these systems automatic temperature and humidity control and adjusting systems are used.
- Storing fruits and vegetables in nitrogen has the advantage that it preserves the product's taste and exterior aspect throughout storing duration and so the physical-chemical qualities are not affected.
- For certain species of fruits and vegetables the CO_2 generators assure a more effective storage because the weight losses are smaller than in nitrogen atmosphere storage, which leads to a greater profitability.

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