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SM Journal of Nutrition and Metabolism

Research Article

Effect of Hydroponic Modified Atmosphere Storage (HMAS) on Cucumber Vegetable and Water Melon Fruit

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Article Information

Received date: Jun 20, 2018
Accepted date: Jul 17, 2018
Published date: Jul 20, 2018

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Keywords Hydroponic; Modified Atmosphere storage; Postharvest; Cucumber; Watermelon

Abstract

The Hydroponic Modified Atmospheric Storage (HMAS) was based on water creating humidifying atmosphere and polyethylene seal of porosity 0.05mm to allow gaseous exchange. Oxo-chlorate solution was used to inhibit microbial adhesion and cohesion. Carbon dioxide, oxygen, respiratory quotient, temperature and Relative Humidity (RH) percentage concentration results in hydroponic modified atmospheric storage containing clean water on cucumber were Carbon dioxide (Co_2 6-50%), oxygen (O_2 20-21%), RQ (-2 to 0.3), Temperature (T, 32-40°c) and Relative Humidity (RH, 36-58%). While those on sodium Oxo- chlorate (NaOCL) solution were (15-64%), oxygen (O_2, 20-21%), Respiratory Quotient (RQ,-3to0.7), Temperature (T, 28-38°C) and Relative Humidity (RH, 41-51%) respectively. The water melon (HMAS) chamber had carbon dioxide (CO_2, 15-69%), oxygen (O_2, 20-21%), Respiratory Quotient (RQ, -3.3 to 0.7), Temperature (T, 32-40°c) and Relative Humidity (RH, 42-65%) for clean water. While sodium oxo-chlorate (NaOCL) solution has (CO_2, 6-52%) carbondioxied (O_2, 20-21%) oxygen, (RQ, -2.4 to 0.3) Respiratory quotient, Temperature (T, 29-36°c) and Relative Humidity of (RH, 35-58%). Oxygen and carbon dioxide production rate which has direct influence on bio-material usage were relative and steadily enhanced, hence slowing down senescence and climactericson the cucumber and water melon that stayed for twenty four days. This approach minimized moisture loss, slow down respiration rate and inhibit the development of decay causing pathogens, at best temperature and relative humidity. The respiration rate, temperature, relative humidity, Respiratory Quotient (RQ) and storage durations results reveals that HMAS has the potential to benefit whole and fresh fruits and vegetables post-harvest shelf life. The applications of Hydroponic Modified Atmosphere Storage (HMAS) at simple technology could prolong shelf life of fresh fruits watermelon and cucumber vegetables. This could encourage commercial application of HMAS by fruit and vegetable retailers.

Introduction

The demand for fresh fruits and vegetables produce and products require by community, families and the industry is on the increase with less or no new and improved methods for maintaining fresh food quality and extending shelf life. Due to the complexities involved with produce that has varying respiration rates which are Relative Humidity (RH) and temperature dependents, different optimal storage temperatures for each commodity, water absorption, and by-products are many considerations in keeping horticultural produce safe. The principle involved is increased carbon dioxide, removing carbon dioxide, removing ethylene and other volatiles. A modified atmosphere is altering the normal composition of air to provide an optimum atmosphere for increasing the storage length and quality of food or produce [1]. This can be achieved by using controlled conditions which could be maintained throughout storage periods. Cucumber is a vegetable scientifically known as *Cucumissativus* belonging to the family of *Curcubitaceae;* this family includes all groups of melons and Cucumbers and had been familiarized to as vegetables but could be interchangeably referred to as fruits. The cucumber plant thrives naturally well in both tropical and temperate surroundings but will generally require temperatures between 15-33°C and as a result, the plant is native to many regions in the world. Watermelon (Citrulluslanatus) is of the cucurbitaceae family. As a member of the cucurbitaceae, watermelon is related to the cantaloupe, squash and pumpkin and other plants that grows on vines on the ground. Studies suggest that increased consumption of fruits and vegetables decreases the risks of obesity, diabetes, coronary heart diseases and while promoting healthy complexes, increased energy and overall weight reduction [2].

Watermelons generally are none suited for very-long storage term. The ideal storage temperature is in the range of 10 to 15°C with approximately 90% Relative Humidity (RH) [3]. Watermelons' generally do not respond well to Controlled Atmosphere storage (CA) or to Modified Atmosphere Package (MAP). Studies have shown shrinkage on packaging of individual fruits as well as decay in (MAP) [4]. An effective method of fruit preservation ought to retain the original characteristics of fruit as convenient as possible. The main methods of fruit preservation includes; Modified Atmosphere Storage (MAS), Controlled Atmosphere Storage (CAS), use of preservatives,

OPEN ACCESS
ISSN: 2573-5462

How to cite this article Orede VO, Ogori AF, Adekonyini OO and Ajayi FF. Effect of Hydroponic Modified Atmosphere Storage (HMAS) on Cucumber Vegetable and Water Melon Fruit. SM J Nutr Metab. 2018; 4(1): 1025.

use of irradiation, use of heat, chilling and processing all of which extend the shelf life of fresh fruit produce. Modified atmosphere storage (MA) systems slow ripening and senescence processes in fruits and vegetables. It also reduces disorders and decay as a result of tissue physiological death as well as reduces ethylene sensitivity and improve flavor quality. Respiration rate and ethylene sensitivity are reduced. MA can also alleviate certain physiological disorders which may reduce decay indirectly or directly.

Hydroponic Modified Atmosphere Storage (HMAS) involves troughs suspended on water or clean or circulating water creating a Relative Humidity (RH) influenced by temperature conditions, suitably sealed to allow modified atmosphere system. This involves modifying the atmosphere condition of the package to store vegetables and fruits that could shelf longer, with stand unsuitable weather conditions and disease infestation and other micro conditions that might keep these produce impractically safe. This process might increases availability of fruits and vegetables all year round. Vegetables and fruits are known to undergo deterioration faster on post-harvest except with special mechanisms to prolong their shelf-life. The ripening and softening of fruits consequentially have effects on the quality on the food produce and are such are key traits that have an effect on the food supply, nutritional values and human health [5]. It is therefore essential to control post-harvest softening, ripening and discoloration in cucumber vegetable and water melon fruits which could lead to deterioration and probable loss of nutritional and micro nutrient values. Cucumber vegetables and water melon fruits after harvesting can only stay for few hours to days. In an unstable weather, the climacteric and senescence of our fruits and vegetables will be quick as never imagined. These problems must lead to fruit and vegetable nutrient inadequacy, shortages, seasonal supply and micro nutrient terrorism hence bioavailability problem [6]. There is need to promote increased local fabrication of storage structure for our farmers' for produce safety hence poverty alleviation. Hydroponic modified atmosphere storage structure will offer great opportunities to reduce Vegetable foods and micro nutrition terrorism; this could contribute to food security and safety. The research work employed hydroponic MA storage structures locally sourced to ascertain Storage shelf life approach of cucumbers, water melon via evaluating the produce post-harvest characteristics for human or for feed utilizations and market values that would enhance micro nutrients and food potentials and utilization.

Materials and Methods

Four Local cheap plastic storage structures were set up for these studies. About 0.05 N (2.5 NaOCL in 500cl) and 1.0NNaOCL (5ml NaOCL in 500cl) treated water with porous filtering rubber baskets submerged in a bowel (plastic) containing for the cucumber and water melon produce storage studies respectively. Another setup on

Figure 1: The setup of HMAS with oxygen and carbon dioxide readers enclosed during periodic Reading.

clean water Constructed as the former were set up for both cucumber and water melon. This was sealed using polyethylene covering films of 0.05mmporosity which issued to generate the modified atmosphere conditions.

$$NaOCL_{(L)} + H2O_{(L)} = NaOH_{(L)} + HOCL_{(L)}$$

Fresh cucumber vegetables and water melon fruits harvested from local farm in Gashua suburb was used. About twenty kilograms, 5-7 pieces of cucumber vegetables and 50 kilograms of water melon fruits (about 3pieces) were put in the netted suspended basked and set up under room temperature (±34°c). The Polyethylene covering films of 0.05mm porosity with a zip opener for periodic reading using the oxygen and carbon dioxide machine reader which were setup.

This system was based on water creating humidifying atmosphere and the Oxo-chlorate inhibiting microbial adhesion or cohesion: caustic soda, water, Oxo- chlorate, and polyethylene seal, all these materials help to equilibrate and the removal of CO_2/O_2 in the HMAS system (Figure 1).

Method of data analysis

Readings were taken after a three day interval for 24 days using oxygen meter (Model 803) and carbon dioxide logger (Co_2/Tem/RH Data logger model No;201707004365) The readings was taken for three weeks and reading were in percentage for oxygen and part per million (which were converted to percentage (%) for carbon dioxide . The readings were done twice and directly from the chambers and recorded in a tabular format. The meters were introduced into the chambers after each three days interval. It is allowed for (2-3) three minute before readings are logged out.

Result and Discussion

Table 1 showed characteristic storage condition on cucumber and water melon in HMAS systems. Respiration rate had variation in Co_2;

Table 1: Characteristics and storage conditions of whole cucumber and watermelon in HMAS.

			Respiration Rate			
Commodity	CO_2 (%)	O_2 (%)	RQ Storage	Temp ˚c	RH%	Storage Period
Cucumber (In clean water)	6-50	20-21	0.3-2.3	32-40	36-58	3-24 days
Cucumber (2.5ml NaoCL water)	15-64	20-21	0.7-3	28-38	41-51	3-24 days
Watermelon (Clean water)	15-69	20-21	0.7-3.3	29-36	42-65	3-24 days
Watermelon (5ml NaoCL water)	6-52	20-21	0.3-2.4	32-40	35-58	3-24 days

Figure 2: HMAS setup of clean and Oxo chlorate hydroponic chambers.

this also varied in O_2 .HMA storage system on clean water for Co_2 had (6-50) % respiratory percentage this was low compared to the Oxo chlorate chamber of (15-64) % respiratory percentage. The values on oxygen gas were equal for both chambers at (20-21) % respectively. Kader [7] asserts that atmospheric modification of low oxygen and or elevated carbon dioxide concentration are useful when supported at proper temperature and relative humidity in maintaining postharvest quality of some fruit-vegetables, such as tomato and muskmelons, this was observed in the HMAS system storage.

According to Fallikand Aharoni [8] the rate of deterioration of harvested commodities is generally proportional to the respiration rate. These might be the reasons for the unusual long storage period of 24 days safe storage observed during these studies. High-oxygen atmosphere favor high activities of PG, PE enzymes for sweet cherries and [9,10] on strawberries. Both imputed that high oxygen atmosphere retards the decrease in firmness in grapes which coincided with higher retention of cell wall polysaccharides.

The RQ of (0.3-3) from the table above, agreed with values recorded by Irtwange [11]. He assumed that it could be one but could range from 0.7 to 1.3 on metabolic variations for RQ.

Relative humidity of (36-65) % was observed during the whole storage days. About 90-95 % RH was observable as optimum for cucumber, soft-rind squash fruit-vegetables [12] but pumpkin and hard-rind squash was 60–70 %. Storage period between (3-24) days far exceeded that reported by El Ramady et al., [12] for both cucumber (10-14) days and water melon (14-21) days (Figures 2 and 3).

Temperature fluctuations during storage in HMAS

Figure 4 indicates that temperature variations during the storage

Figure 3: Watermelon fruit (up) and cucumber vegetables (below) at the end of twenty four days storage experiment.

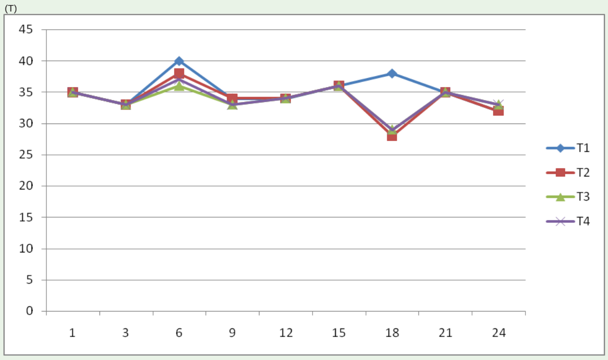

Figure 4: Temperature variation in HMAS with storage days.

Key: T1= Temperature of chamber with cucumber on clean water

T2=Temperature of chamber with cucumber on 2.5ml NaOCL

T3=Temperature of chamber with water melon on clean water

T4=Temperature of chamber with water melon on 5ml NaOCL

days had slight variation with approximate range of (27-40 °c). The relative temperature observed in the chamber throughout the long stay of both cucumber and water melon might have come from the water as a convective current as well as droplet evaporation in the chamber would have allowed this low rage of temperature.

Temperature and relative humidity values with storage in HMAS

Figure 5 indicates that the relative humidity variations during the storage days had slight variation with approximate range of (40-65) %. The relativity at relative humidity and observed in the chamber throughout the long stay of both cucumber and water melon might have come from the water as a humidifying substrate for the chamber.

Effect of Oxygen (O_2) level on respiratory rate of produce in clean water in HMAS storage system

Here O_2 level remained fairly constant while Co_2 was gradually reducing. The concentration of oxygen (O_2) in HMAS package was however not slow but steady (about 21-20%), aerobic respiration occur here, which may result in tissue turgidity and the non-production of

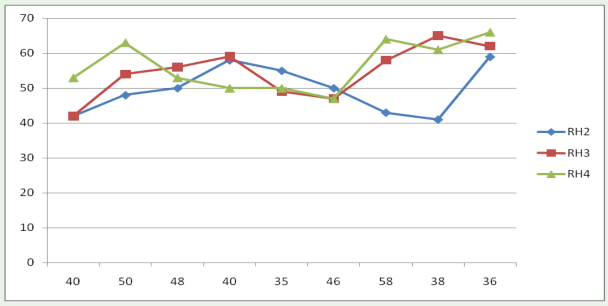

Figure 5: Relative humidity in HMAS with storage days.

Key: RH1=Relative humidity of chamber with cucumber on clean water

RH2=Relative humidity of chamber with cucumber on 2.5ml NaOCL

RH3=Relative humidity of chamber with watermelon on clean water

RH4= Relative humidity of chamber with water melon on 5ml NaOCL

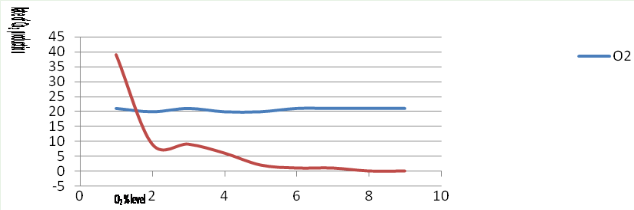

Figure 6: Effect of O_2 level on respiratory rate of cucumber in clean water in HMAS storage system.

Keys: Oxygen (O_2), (X axis graph) = Aerobic respiration rate graph

Relative carbon dioxide (Co2), (Y axis graph) = Relative rate of Co_2 production (Anaerobic respiration rate)

substances that contribute to off-flavors a, as well as the potential for low growth of food borne pathogens [13]. This high O_2 level in stored produce may cause oxidative breakdown of the complex substrates which making up the produce evidence in shelf life. Here, O_2 concentration may have increased the production of ethylene, a key component of the ripening and maturation process ripening of the produce may be enhanced. Therefore, the recommended percentage of O_2 in the Hydroponic modified atmosphere storage for water melon fruits and cucumber vegetables for both safety and quality did not falls between 1 and 5 as recommended [5] (Figure 6).

Effect of carbon dioxide Co_2 level on respiratory rate of produce in clean water in HMAS storage system

The level of Co_2 sinusoid between 55-40% and gradually reduced as day goes by with oxygen content in the HMAS packing tilting toward the Co_2 graph. HMAS system had high tolerance level for oxygen and carbon-dioxide. When storage is done in high Co_2 its results in reduced loss of chlorophyll as well as reduced accumulation of other pigments including anthocyanin, lycopene, xanthophyll and carotenoids [14]. Within the tolerance range of O_2 and CO_2 levels, reduced development of browning may also occur [15]. Outside the tolerance range, specifically for CO_2, browning may be intensified. Undesirable changes in texture are often reduced by high CO_2 and or low O_2 within the tolerance range. The produce had reduced softening as well as reduced development of toughness after the storage period of 34 days. This change agreed with Lougheed and Dewey [16]. Outside the tolerance range, processes of softening may be accelerated [17]. HMAS however might have reduced the use of carbohydrates and titratable acids resulting in slower acid and sugar loss during storage. The loss possibility would have been enhanced by anaerobic conditions develop within the package (Figure 7).

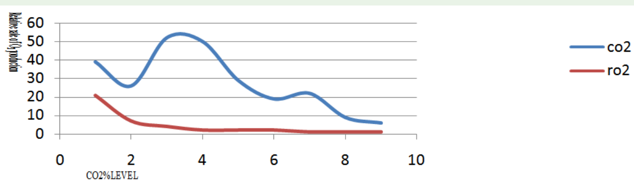

Figure 7: Effect of Co_2 level on respiratory rat of cucumber in clean water in HMAS storage system.

Keys: $\%O_2$, (X axis graph) = Relative oxygen (O_2) consumption

%Co2, (Y axis graph) = Acetaldehyde and ethanol production

Conclusion

Respiration rate, temperature, relative humidity, RQ and storage durations results reveals that HMAS has the potential to benefit whole and fresh fruits and vegetables post-harvest shelf life. Hydroponic modified atmosphere storage HMAS and its local technology can be used in postharvest handling and shelving of fresh fruit water melon and vegetables cucumber at elevated and moderate temperatures and relative humidity conditions with good storage days. Hence, need for commercial application of the technology by processors and fresh fruit and vegetable produce retailers because of it setback effect on senescence and climacterics of these fruits and vegetables.

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