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# Effect of Postharvest Changes on the Quality Attributes Of Cucumber from Maturity to Senescence

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**Abstract**

*The possible shelf-life of plant tissues after harvest has been demonstrated to be highly correlated with its rate of respiration. This study investigated the postharvest changes on the physicochemical, proximate, and vitamin compositions in Cucumber (Cucumis sativus) at ambient temperature from maturity to senescence. The results showed that pH increased gradually from 3.6 on day 0 to 6.6 by day 83, while Total Soluble Solids (TSS) rose from 0.901% to 3.36%, indicating the process of metabolic activity and carbohydrate breakdown. The weight of the fruit initially increased from 306.71 g to 693.64 g before a slight decline, with corresponding rise in volume (154,858 mm³ to 504,858 mm³) and specific gravity (0.999–1.131), which is an indication of structural expansion and water accumulation. Glucose levels rose from 0.194 mg/ml to 0.376 mg/ml, while titratable acidity declined from 0.348% to 0.244%, suggesting a shift toward decreased acidity and enhanced sweetness. Proximate analysis indicated rising moisture (74.49–86.91%), ash (0.72–1.71%), crude fibre (0.93–1.87%), lipids (0.166–0.283%), and protein (1.55–2.86%), concurrent with a decrease in carbohydrate content from 22.14% to 6.37%, expressing metabolic breakdown of stored sugars. Vitamins A, C, and E showed a significant increase (0.151–0.291 mg/100 g, 4.57–6.03 mg/100 g, and 15.45–16.69 mg/100 g, respectively), exhibiting retention and enhancement of antioxidant potential during storage.*

**Keywords:** Cucumber, Maturity, Postharvest Changes, Ripening, Senescence.

## Introduction

Fruits have played a vital role in the human diet, offering many arrays of quality attributes such as colors, shapes, flavors, aromas, and textures. The nutritional significance of fruits has been thoroughly studied due to growing awareness of food safety (Adeeko et al., 2020). Fruit consumption has been linked to a reduced risk of cancer, heart diseases, and other health benefits (Paulauskiene et al., 2020). Fruits have been broadly divided into climacteric and non-climacteric depending on the unique respiratory patterns they exhibit during the ripening process (Lichtenthaler, 2007). The presumable shelf-life of plant component after harvest has shown to be highly correlated with its rate of respiration (Kader, 2002). Climacteric fruits are regulated by ethylene production and continue to ripen even after harvested due to an increase in respiration at the beginning of the ripening process (Dallenbach et al., 2020). Also, fruit's ethylene production level and post-harvest deterioration are correlated (Nunes et al., 2000). Non-climacteric behavior may be caused by a negative ethylene feedback mechanism, whereas climacteric behavior during ripening may be caused by a positive ethylene feedback mechanism (Dita et al., 2018). During the process of ripening, fruits usually undergo significant metabolic changes, such as chlorophyll breakdown, cell wall degradation, accumulation of anthocyanin or carotenoid pigments and the synthesis of low-weight metabolites (including sugars, acids, and volatiles), all of which enhance their appeal to seed dispersers (Mpai et al., 2020). After fruits have been harvested and before they reach the final consumers, they undergo a stage called postharvest ripening or senescence. The length of this stage varies from days to weeks, and is majorly affected by the fruit's metabolism and ripening stage at the time of harvest (Lama et al., 2020). Preharvest and postharvest changes are known to affect the physiological and morphological attributes of fruit species (Yahaya et al., 2015). Main preharvest factors include genetics, environmental conditions (such as climate, cropping conditions, insolation, irrigation, and adequate plant nutrition), the use of agrochemicals, proper pollination, harvest methods, and the condition and physiological age of the fruit at harvest. In contrast, the major postharvest factor is storage, which requires associated physicochemical, biochemical, and microbiological changes (Adeeko et al., 2020). Volatiles, which is a complex group of chemical substances including aldehydes, alcohols, ketones, esters, lactones, and terpenes, significantly affect the sensory quality of both harvested and processed fruit products (Mustapha & Yahaya, 2006). The concentration of these volatiles in fruits varies, depending on various preharvest and postharvest factors (Yahaya et al., 2015). Cucumbers are known as a vegetable crop because they contain a lot of cucurbitacins and polyphenolics, which are substances with a diverse of biological uses. Ploetz (2015) asserted the activities of cucumbers to include analgesic, diuretic, antibacterial, anti-inflammatory, anti-carcinogenic, anti-hyaluronidase, anti-elastase, antioxidant, and anti-hyperglycemic properties. The aim of the present research is to understudy the effect of postharvest changes on the quality attributes of cucumber from maturity to senescence.

## Materials and Methods

Cucumber was harvested at maturity from a local farm in Jos Plateau for immediate quality study. High quality laboratory chemicals for physicochemical properties, proximate and vitamin compositions were sourced from both domestic and foreign analytical store. Matured cucumber was sorted and graded for uniformity and wholesomeness and thereafter, at room temperature, subjected to evaluation for physicochemical properties, proximate and vitamins compositions from maturity to senescence. The physicochemical properties, proximate and vitamin compositions were carried out according to the methods described by Association of Official Analytical Chemists (AOAC., 2005).

## Statistical Analyses

Data obtained from the experiment were subjected to completely randomized experimental design and statistical analysis using Microsoft excel version 2010, SPSS version 20 and Mini Tab version 17

## Results and Discussion

### Effect of Postharvest Changes on the Physicochemical Properties of Cucumber from Maturity to Senescence

The postharvest changes observed in cucumber fruits stored under ambient conditions, as shown in Figures 1 to 5, demonstrated gradual physiological and biochemical changes from maturity to senescence. Throughout the 83-day storage period, parameters such as pH, total soluble solids (TSS), glucose, weight, volume, and specific gravity increased steadily, while titratable acidity (TA), length, and width showed gradual declines. These trends indicate the metabolic changes associated with continous ripening and senescence under ambient conditions, where respiration and enzymatic activity remain high. The significant increase in pH from 3.6 to 6.6, accompanied by a corresponding decrease in titratable acidity from 0.348% to 0.244%, which is an indication of progressive utilization of organic acids as respiratory substrates. Organic acids like citric and malic acid are metabolized through the tricarboxylic acid (TCA) cycle to produce energy for ongoing metabolic processes (Kays & Paull, 2004). Similar increases in pH and decreases in acidity during ambient storage have been reported in cucumber (Díaz-Pérez, 2019) and other non-climacteric fruits such as zucchini and bell pepper (Silva et al., 2015). The decrease in acidity shows the change from synthetic to degradative metabolism as the fruit tilts toward senescence. An increase in Total Soluble Solids (0.90% to 3.36%) and glucose concentration (0.194 to 0.376 mg/ml) further supports enhanced metabolic activity and carbohydrate breakdown. This accumulation of soluble sugars arises from hydrolysis of polysaccharides and structural carbohydrates into simpler sugars during ripening (Chien et al., 2007). Sugars also accumulate due to water loss–induced concentration effects (Mahajan et al., 2017). Significant increase in Total Soluble Solids and sugar content contribute to the perceived sweetness and are often used as indicators of ripeness and quality in cucumbers and related cucurbits.

Changes in the physical parameters particularly the consistent increase in fruit weight, volume, and specific gravity were notable. The increase in apparent weight and volume could be attributed to water absorption and cell enlargement during the early storage phase, followed by metabolic water production through respiration (Wills et al., 2016). Specific gravity increased from 0.999 to 1.137, reflecting a denser fruit tissue composition, possibly linked to solute accumulation. However, the gradual decrease in width and length toward the later storage period suggests shrinkage and cellular collapse due to moisture loss and cell wall degradation as senescence progressed (Vicente et al., 2007). This structural breakdown is typical of tissues undergoing enzymatic softening and loss of turgor pressure. Overall, the trends indicate that cucumbers, when stored at room temperature without postharvest treatments, experience accelerated biochemical and physical changes that compromise long-term quality. The cumulative rise in pH and TSS, coupled with declining acidity and slight morphological shrinkage, are signatures of advanced senescence. These results agree with previous findings that cucumbers are highly perishable and undergo rapid deterioration when stored under non-refrigerated conditions (Ismail et al., 2014; Kader, 2013). Postharvest cooling or controlled-atmosphere storage is therefore essential to slow respiration and enzymatic degradation, thereby extending shelf life and maintaining market quality.

In this study, fruit pH increased (from 3.6 to 6.6) while titratable acidity (TA) decreased (0.348% → 0.244%). Concurrently, total soluble solids (TSS) increased (~0.901% → ~3.38%) and glucose concentration rose (~0.194 mg/ml → ~0.369 mg/ml). These patterns suggest active metabolic acid consumption, sugar conversion or concentration effects, and biochemical shifts typical of postharvest physiology. Kays & Paull (2004) described the mechanism by which harvested fruits consume organic acids via the TCA (tricarboxylic acid) cycle, leading to decreased acidity and raised pH. In the specific case of cucumber, the review by Bao et al., (2023) underscores that ambient storage accelerates such physicochemical transformations, often compromising quality. The present dataset supports this: the rising TSS and glucose reflect sugar mobilization as carbohydrate reserves are utilized or hydrolysed during storage. For morphological and dimensional changes: the increase in weight, volume and specific gravity during the early to mid storage period in our data may seem counterintuitive, but they align with reports of solute accumulation, moisture redistribution, and respiration derived metabolic water in stored produce (Wills et al., 2016). However, the gradual decline in width and length in later days indicates shrinkage and structural collapse, consistent with senescence and moisture loss patterns similar to those observed by Bao et al., (2023) in greenhouse cultivated cucumbers, where firmness decline and textural disorder emerged 13 days into storage. Thus, the interplay of accumulation and degradation processes is evident in our data and matches established literature.

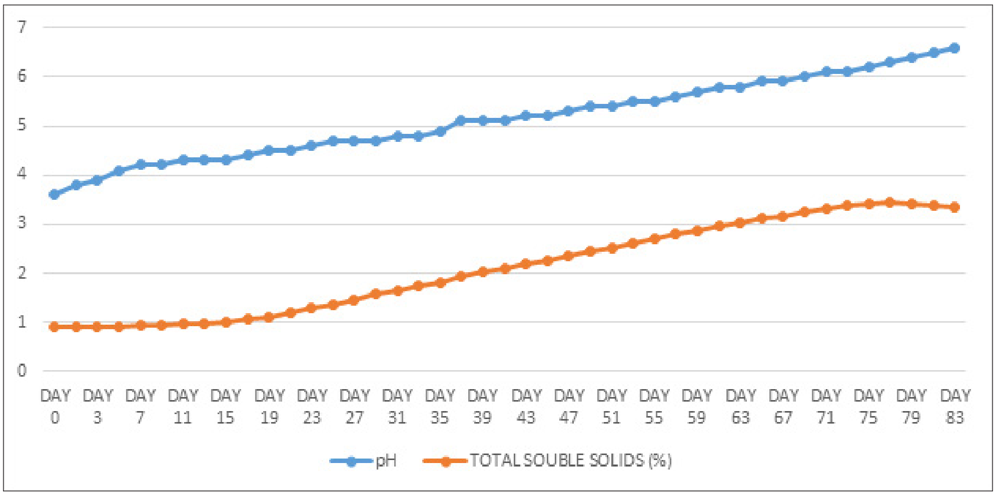

**Figure 1:** Effect of Postharvest Changes on the pH and Total Soluble Solids in Cucumber from Maturity to Senescence

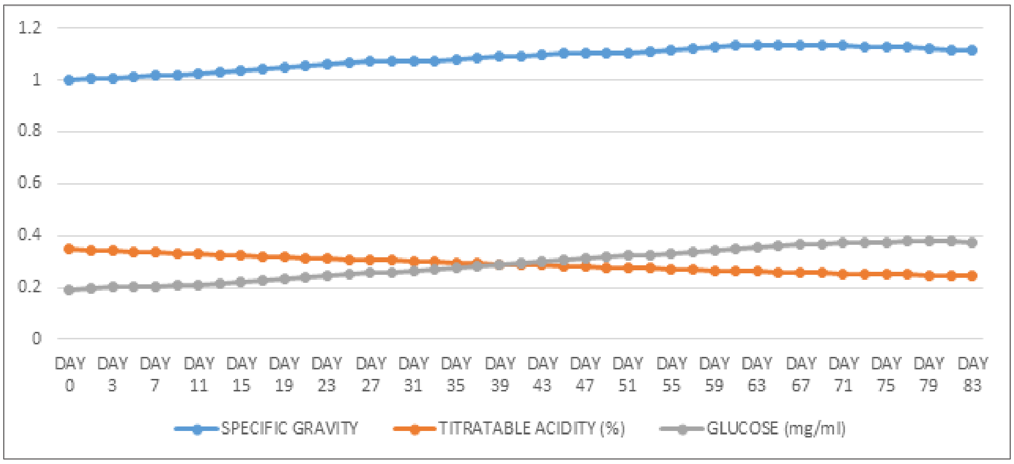

**Figure 2:** Effect of Postharvest Changes on the Specific Gravity, Titratable Acidity and Glucose in Cucumber from Maturity to Senescence

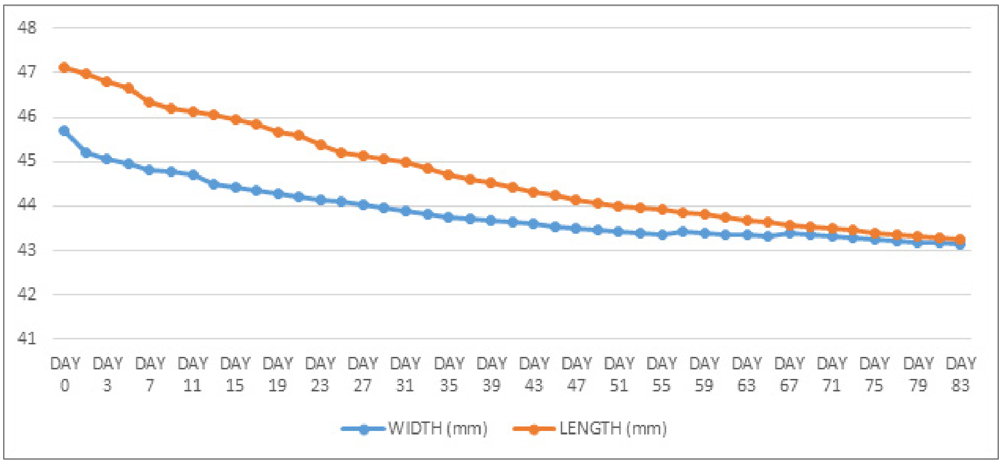

**Figure 3:** Effect of Postharvest Changes on the Width and Length of Cucumber from Maturity to Senescence

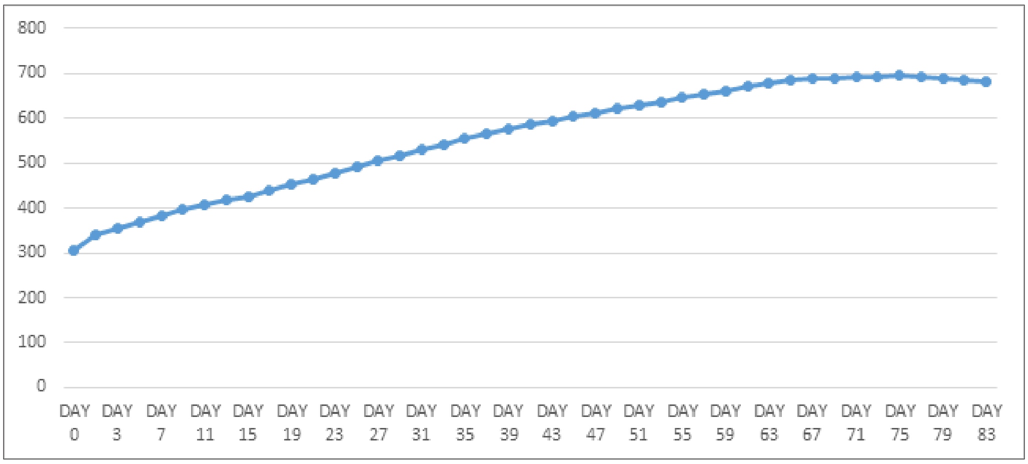

**Figure 4:** Effect of Postharvest Changes on the Weight of Cucumber from Maturity to Senescence

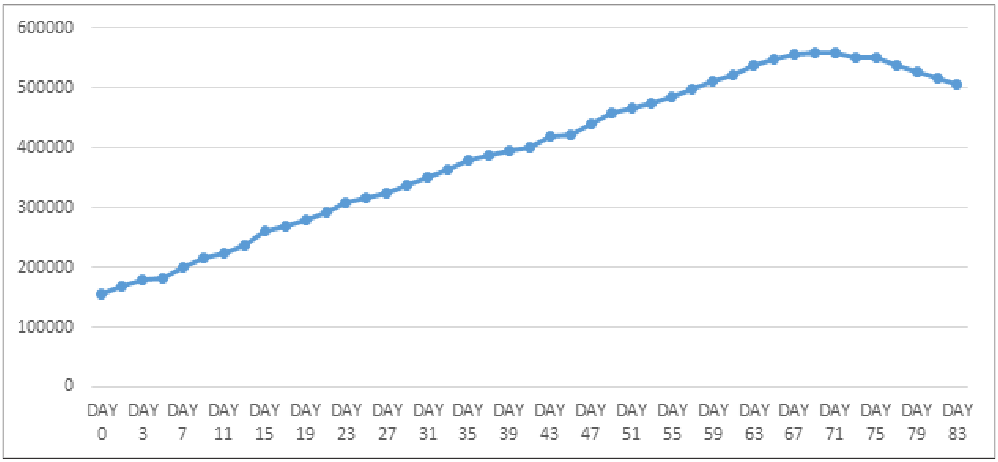

**Figure 5:** Effect of Postharvest Changes on the Volume of Cucumber from Maturity to Senescence

### Effect of Postharvest Changes on the Proximate Compositions of Cucumber from Maturity to Senescence

Proximate composition analysis, as shown in Figures 6 to 8, revealed progressive alterations in the biochemical constituents of cucumber fruits throughout the 83-day storage period. The results demonstrated a continuous increase in moisture, ash, crude fibre, lipids, and protein, while carbohydrate content showed a marked decline. These changes further illustrate the ongoing metabolic processes and compositional shifts occurring during postharvest maturation and senescence under ambient conditions. The steady increase in moisture content from 74.49% to 86.91 % may be attributed to metabolic water production during respiration and catabolic reactions (Wills et al., 2016). Additionally, ambient humidity can contribute to passive water absorption by cucumber tissues, which are highly permeable and hygroscopic (Díaz-Pérez, 2019). However, as senescence advances, this elevated water content may also reflect tissue softening and loss of structural integrity, which reduce the fruit's ability to regulate internal water balance (Kays & Paull, 2004). The observed increase in ash content (0.72 % to 1.71 %) suggests a relative accumulation of mineral constituents due to the concurrent decline in dry matter, particularly carbohydrates. Similar trends have been reported in other cucurbits such as squash and bottle gourd during postharvest storage (Singh et al., 2020). The rising crude fibre content (0.93 % to 1.87 %) could be associated with lignification and cell wall modification as tissues age, processes commonly linked to senescence and loss of tenderness (Vicente et al., 2007). Enhanced lipid and protein levels may result from the concentration effect due to moisture increase, as well as metabolic changes involving synthesis of stress-related proteins and membrane lipids (Mahajan et al., 2017). Conversely, carbohydrate content decreased markedly from 22.14 % to 6.37 %. This sharp decline reflects the consumption of soluble sugars and polysaccharides during respiration and enzymatic degradation, which provide the energy required to sustain postharvest metabolism (Kader, 2013). The depletion of carbohydrates is a key factor driving textural softening and eventual senescence in fresh produce (Wills et al., 2016). Similar carbohydrate reduction trends have been observed in cucumbers stored at room temperature (Ismail et al., 2014) and in other vegetables such as okra and zucchini (Silva et al., 2015). Taken together, the compositional changes recorded during the storage period confirm that cucumbers continue active metabolic and physiological processes after harvest. The increasing moisture, ash, protein, and lipid fractions, coupled with declining carbohydrate reserves, reflect an overall deterioration of nutritive quality as the fruit progresses from maturity to senescence. These findings highlight the perishability of cucumber and emphasize the importance of adopting appropriate postharvest management strategies—particularly refrigeration or modified atmosphere storage—to retard metabolic activity and preserve nutritional quality over time.

In this study, there were marked increases in moisture content (74.49% → 86.91%), ash, crude fibre, lipids, and protein, while carbohydrate content declined drastically (22.14% → 6.37%). The increase in moisture content may reflect both passive water uptake under humid ambient conditions and internal water production (via respiration) or relative concentration effects as dry mass is lost. Similar observations of increased moisture—or relative water content—during early postharvest metabolism have been cited in general produce physiology (Kader, 2013). The rise in ash (inorganic content) likely reflects concentration of minerals as other constituents are lost or metabolized; Singh et al. (2020) reported rising mineral proportions in cucurbits under prolonged storage. The increase in crude fibre is consistent with cell wall modifications or lignification in senescing tissue (Vicente et al., 2007). Meanwhile, the sharp decline in carbohydrates underscores the depletion of reserves as respiration and other metabolic processes continue unabated—a pattern widely reported for vegetables stored at non optimal conditions. For example, Silva et al. (2015) found significant carbohydrate depletion in zucchini and bell pepper under ambient storage.

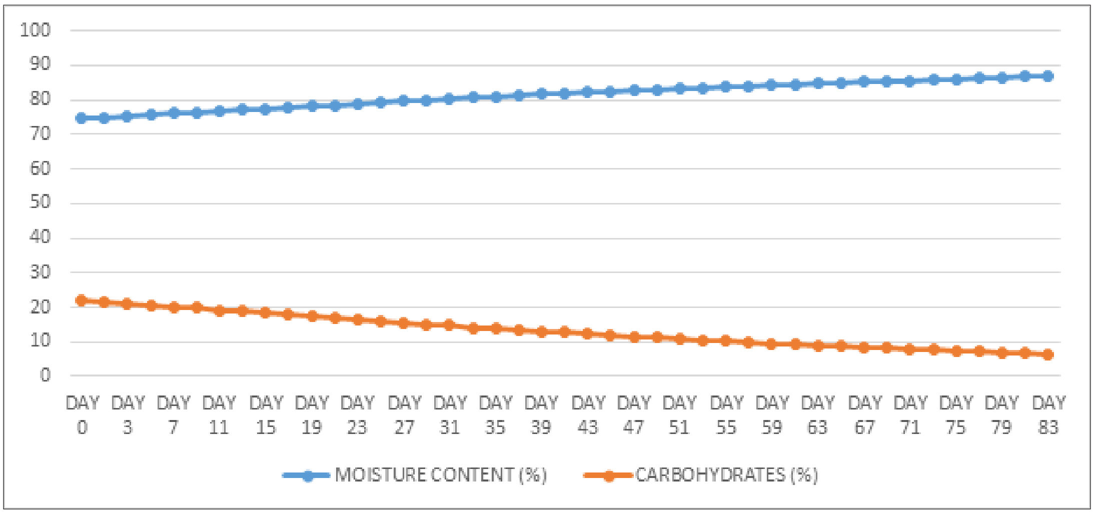

**Figure 6:** Effect of Postharvest Changes on the Moisture Content and Carbohydrates in Cucumber from Maturity to Senescence

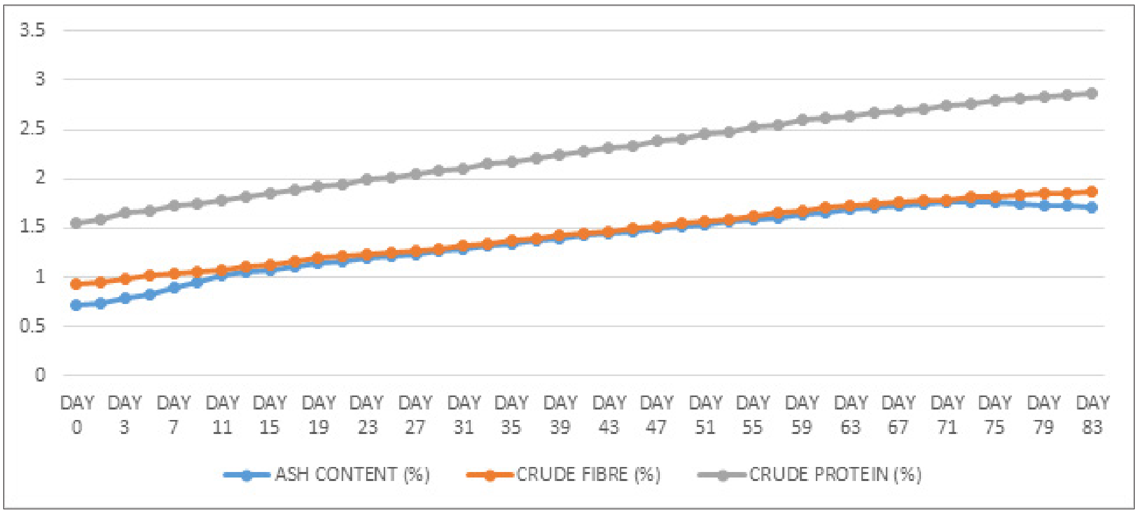

**Figure 7:** Effect of Postharvest Changes on the Ash Content, Crude Fibre and Crude Protein in Cucumber from Maturity to Senescence

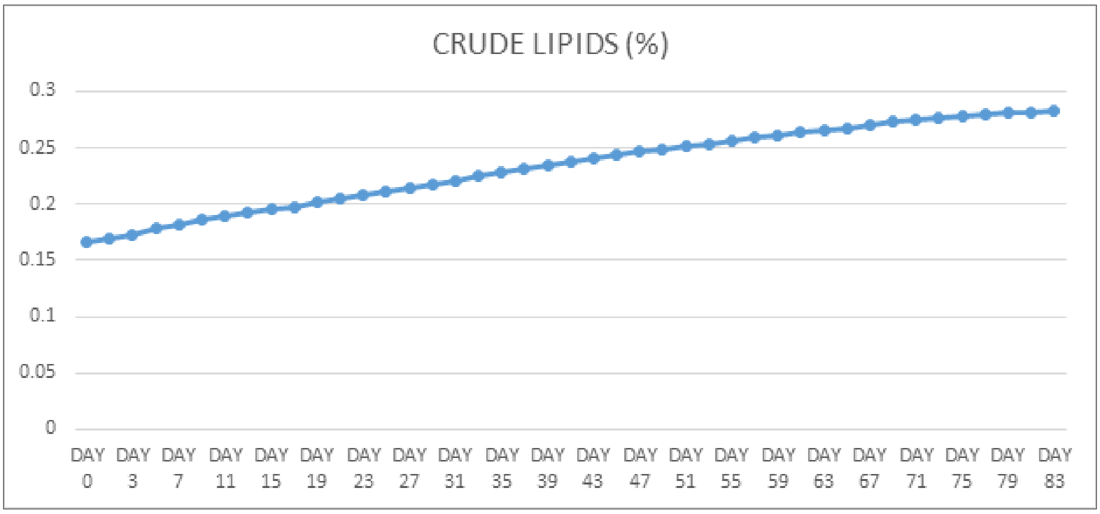

**Figure 8:** Effect of Postharvest Changes on the Crude Lipids in Cucumber from Maturity to Senescence

## Effect of Postharvest Changes on the Vitamin Composition of Cucumber from Maturity to Senescence

The vitamin composition of cucumber in Figures 9 and 10 showed a steady and consistent increase in the levels of vitamins A, C, and E throughout the 83-day storage period. Vitamin A content rose from 0.151 mg/100 g to 0.291 mg/100 g, vitamin C from 4.57 mg/100 g to 6.03 mg/100 g, and vitamin E from 15.45 mg/100 g to 16.69 mg/100 g. These gradual increases suggest that, under ambient storage, cucumbers continue to undergo biochemical reactions that enhance antioxidant compound accumulation before senescence sets in. The rise in vitamin A likely results from the ongoing conversion of carotenoid precursors, such as β-carotene, during postharvest ripening. Similar increases in carotenoid content have been reported in cucurbits and other green vegetables as chlorophyll degrades and carotenoid synthesis continues (Santos & Silva, 2015). Vitamin C (ascorbic acid) is a key antioxidant involved in oxidative stress regulation; its progressive increase may be attributed to enhanced synthesis in response to postharvest oxidative metabolism (Lee & Kader, 2000). However, while moderate rises are often observed during early storage, extended exposure to room temperature can eventually lead to its degradation—though in this study, the period before decline may not have been reached. The increase in vitamin E (α-tocopherol) suggests an adaptive antioxidative response to elevated reactive oxygen species generated during respiration and senescence (Barros et al., 2018). Tocopherols stabilize membrane lipids and protect cellular integrity, which is crucial in maintaining cucumber tissue viability during storage. This trend aligns with findings by Mahajan et al. (2017), who reported similar antioxidant accumulation in fresh produce under ambient stress conditions. Collectively, the progressive enrichment of vitamins A, C, and E underscores the complex balance between degradation and compensatory biosynthetic activity in postharvest cucumbers. Although these increases may temporarily enhance the fruit's nutritional and antioxidant profile, they occur concurrently with structural softening and compositional deterioration, indicating that biochemical ripening continues despite harvest. Effective storage interventions such as refrigeration or modified-atmosphere packaging would be required to stabilize these nutrients and extend shelf life (Kader, 2013; Wills et al., 2016).

The results showed steady increases in vitamins A (0.151 → 0.291 mg/100 g), C (4.57 → 6.03 mg/100 g) and E (15.45 → 16.69 mg/100 g) during storage. These increasing trends are somewhat unexpected given that many studies report vitamin C and other antioxidants decline with storage time. For instance, in the coating treated cucumber study by Chien et al. (2007), ascorbic acid declined under ambient storage. However, the recent review by Bao et al. (2023) observes that cucumber postharvest nutrient dynamics may include initial accumulation of antioxidant compounds as a response to oxidative stress before eventual decline. This suggests that in our samples, antioxidant pathways (for vitamins C and E) may have been up regulated in response to the increasing metabolic/oxidative stress during storage, thus temporarily increasing vitamin levels. The vitamin A increase may reflect conversion of carotenoid precursors as chlorophyll degrades (Santos & Silva, 2015). While our data do not show a subsequent decline within the 83 day frame, it is plausible that with extended storage or under more stressful conditions (e.g., high temperature, high humidity) vitamin degradation would ensue—a point supported by Lee & Kader (2000) in their work on vitamin C stability in produce storage.

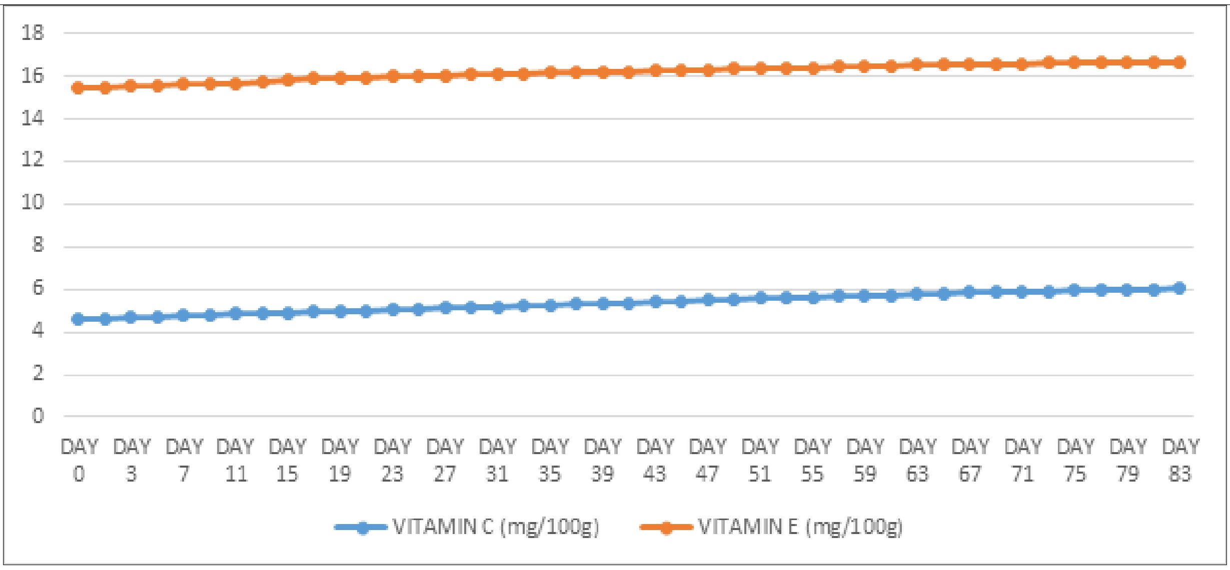

**Figure 9:** Effect of Postharvest Changes on the Vitamins C and E in Cucumber from Maturity to Senescence

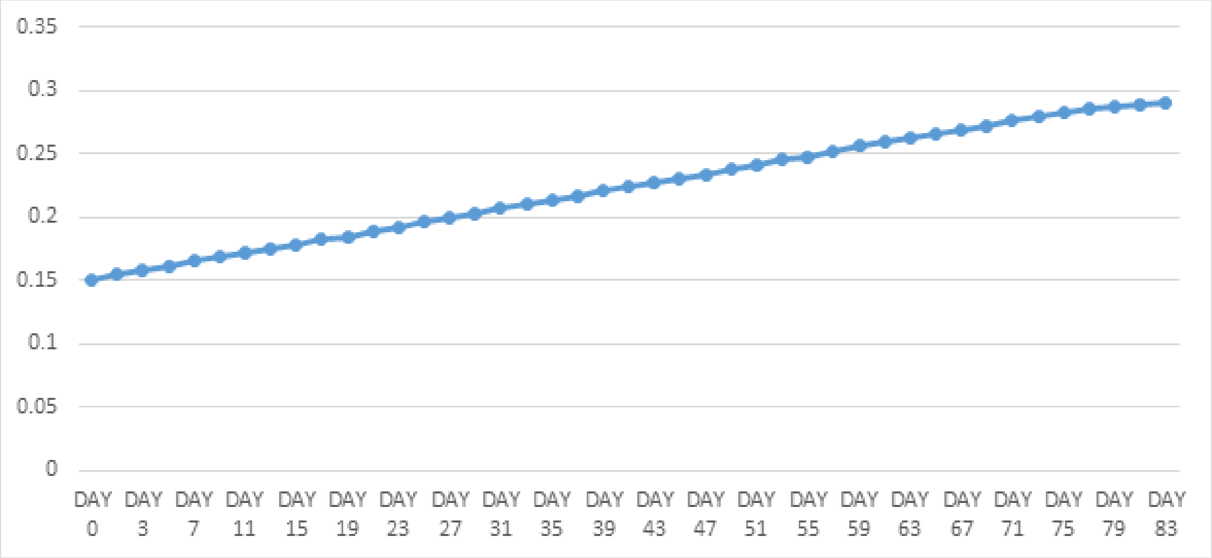

**Figure 10:** Effect of Postharvest Changes on the Vitamin A in Cucumber from Maturity to Senescence

## Conclusion

This study demonstrates that cucumbers undergo continuous metabolic and structural changes during ambient storage from maturity to senescence. Progressive increases in pH, total soluble solids, glucose, moisture, and selected vitamins were accompanied by declines in titratable acidity and carbohydrate content, indicating active respiration and substrate utilization after harvest. Physical alterations, including dimensional shrinkage at later stages, further reflect advancing tissue senescence. Although antioxidant vitamins (A, C, and E) showed temporary increases, these occurred alongside compositional depletion and structural deterioration. The findings confirm that Cucumis sativus remains physiologically active during postharvest, and storage at ambient temperature which accelerates quality degradation. Appropriate postharvest management strategies are therefore essential to preserve nutritional and market quality and to extend shelf life.

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