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Post Harvest Effect Of Sunlight On Enzymatic Activity And Physicochemical Properties Of Some Selected Vegetables In The University Of Cape Coast Community

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Abstract
Sunlight plays a very significant role in the growth and proliferation of trees, including tree crops, fruits and vegetables. However, same cannot be said for it about its effect on vegetables postharvest. The objective of this study was to assess the postharvest effect of sunlight on cabbage, carrot and spring onion harvested from the University of Cape Coast Teaching and Research Farm, Ghana. Vegetables were sectioned into three groups; the control; samples exposed to ambient light and samples exposed to sunlight. Moisture content, titratable acidity, total soluble solids and polyphenol oxidase activity were assessed for the various exposure conditions. Moisture content for samples exposed to sunlight was 92.53±0.69% for cabbage, 93.08±0.10% for carrot and 93.08±0.10% for spring onion. Total soluble solids for samples exposed to sunlight were 2.05±0.35°Brix for cabbage, 2.85±0.07°Brix for carrot and 3.20±0.14°Brix for spring onion. Titratable acidity concentrations for samples exposed to the sun were 0.41±0.11% for cabbage, 0.40±0.06% for carrot and 0.54±0.05% for spring onion. Polyphenol oxidase activity (µmol/L/min) for samples exposed to the sun was 236±8.65 for cabbage, 92.01±5.31 for carrot and 83.76±0.44 for spring onion. The statistical analysis of the data revealed that titratable acidity and polyphenol oxidase activity showed significant differences for some samples between the storage conditions. Moisture Content and total soluble solids however revealed significant differences among the storage groups. It can be inferred from the results that exposing vegetables to sunlight postharvest farm produce for a prolonged time affects their moisture content, total soluble solids content, titratable acid concentration as well and polyphenol oxidase activity.
Keywords*: Sunlight, Enzymatic activity, Vegetable, Postharvest effect, physicochemical properties*

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I. Introduction

One essential part of a healthy diet is vegetables. This is because of their high content of vitamins (C and E), minerals, fibre, phytochemicals, β-carotene, and other antioxidants such as selenium, zinc, and flavonoids, which gives numerous health benefits. Vegetables in diet is associated with a decreased risk of developing cancer, cardiovascular disease, stroke, and other chronic ailments. However, exposing the vegetables to sunlight by drying or storing them can affect the nutritional content of the vegetable.

In Ghana, vegetables are mostly sold under the sun where there is little or no shed. Radiations from the sun affect the physicochemical properties and nutritional composition of the vegetables as well as their enzymatic activities. Generally, plants are exposed to the sun since they depend on sunlight to produce their food. Even though vegetables need sunlight to produce their food and grow, once they are harvested, they do not require too much amount of sunlight. Once vegetables are harvested, they are disconnected from the plant's vascular system, which means they no longer receive nutrients or water from the plant. Since photosynthesis requires live plant cells and chloroplasts, harvested vegetables no longer can undergo photosynthesis. However, even though harvested vegetables do not photosynthesize, they still require appropriate storage conditions to maintain their quality and nutritional value. Exposing the harvested vegetables to different radiations from the sun can affect the post-harvest lifespan of the vegetables. These radiations have some effect on the physiological and chemical processes of plants, most especially vegetables meant for human consumption. After harvesting, vegetables exposed to sunlight will undergo certain physicochemical and enzymatic changes depending on the duration of exposure. Examples of the properties that will be affected are colour, texture, pH, moisture content, total soluble solids content and polyphenol oxidase activity.

At the University of Cape Coast, most vegetable vendors usually set up their stalls in the sun exposing the vegetables to the sunlight. These vegetables tend to lose their characteristic attributes but not to the knowledge of the vendors. This study therefore aims to investigate the effect of sunlight on the enzymatic activities and the physicochemical properties of some selected vegetables at the University of Cape Coast.

II. Materials And Methods

Study Design

The research was grouped into two parts; exposure of freshly harvested vegetables to various conditions and then laboratory analysis. Titratable acidity, moisture content, total soluble solids and polyphenol oxidase activity of the vegetables were analysed to determine whether sunlight had effect on them.

Study Area

The study was carried out on carrots, cabbage and spring onion which were harvested at the University of Cape Coast Teaching and Research Farm. Samples were analysed at the Research Laboratories of the Department of Laboratory Technology and the Department of Biochemistry of the University of Cape Coast.

Sample Collection

Samples of vegetables were harvested and placed in sterile zip-lock bags, sealed, labelled and maintained in a closed dark box and transported to the laboratory for analysis. Samples were freshly harvested from the farm and it was ensured that they were mature enough, free from pests or infestations, fresh and possess a high degree of wholesomeness.

Sampling Technique

A purposive Sampling strategy was adopted in choosing the vegetables from the population.

Sample Treatment

Vegetables freshly harvested from the farm were divided into three different zip-lock bags and then placed in a dark box with each sample bag labelled as fresh from the farm, Sun and Room. The fresh-from-farm zip-lock bag was immediately worked on. The bag labelled "Sun" was then exposed to the sun for 8 hours at sunlight radiation of 400 W/m^2. The zip-lock bag labelled 'Room' was also exposed to ambient light in a room for 8 hours at 1.1 W/ m^2 to serve as control.

Sample Preparation

Freshly harvested carrots, spring onions and cabbages were thoroughly washed under running water to get rid of any soil, debris or foreign matter on their surface. To speed up the process, the vegetables were cut into smaller pieces and then ground using mortar and pestle to obtain a smooth consistency and homogenized sample. The ground samples were then kept in clean dry sample containers ready for analysis. For the vegetables set aside to be exposed to sunlight, they were washed thoroughly and exposed to the sun. After the exposure time, they were cut into smaller pieces and ground using a mortar and pestle and then sampled into clean dry sample containers and labelled. Vegetables to be kept under ambient light were first washed thoroughly under a running tap before being exposed. After the exposure time to the ambient light, they were cut into pieces and ground using a mortar and pestle to obtain a fine sample. They were then put into a clean dry sample container to be analysed.

Sample Analysis

To evaluate the post-harvest effect of sunlight on enzymatic and physicochemical properties of selected vegetables, various laboratory analysis was conducted. Titrimetry method, Refractometer analysis, Oven-dry method, and Gonzalez method with slight modifications was used to analyse titrable acidity, total soluble solids, moisture content, and polyphenol oxidase respectively.

Statistical Analysis

The values obtained from laboratory analysis were computed using Microsoft Excel to determine the respective concentrations for each parameter. These were presented in tables. Version 26.0 of Statistical Package for Social Sciences (SPSS) was used for the analysis of data for all parameters which are moisture content, titratable acidity, total soluble solids and polyphenol oxidase. One-way Analysis of Variance (ANOVA) was used to evaluate whether the values obtained before and after the exposure were statistically different at a 95% Confidence interval. The SPSS was also used to compute descriptive statistics which include the mean values and their respective standard deviation which was then used to develop analytical tables for the study.

III. RESULTS

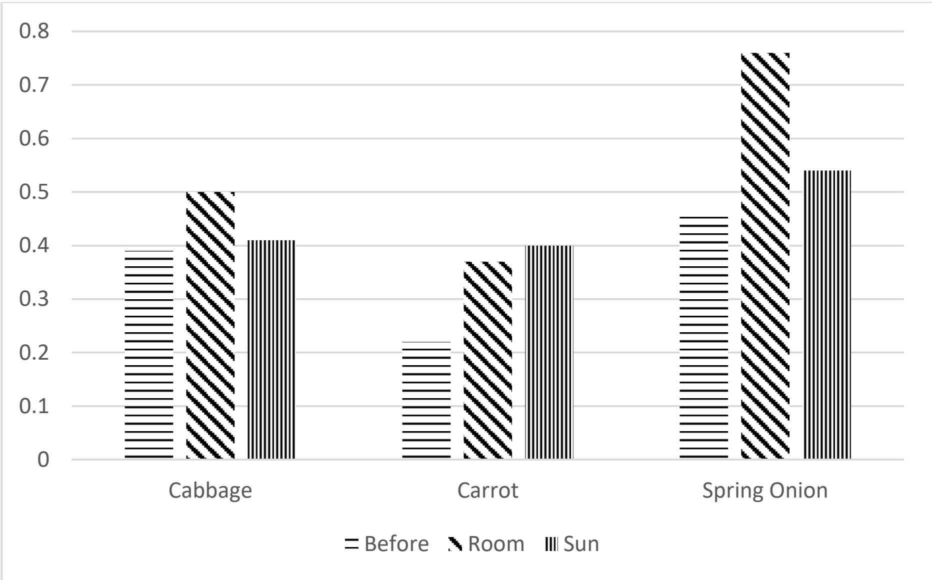
From Table 1, the titratable acidity concentration was determined for all three samples before and after exposure to ambient light and sunlight. For Cabbage, the acid concentration determined before exposure was

0.39±0.06% which was not significantly different from that obtained for keeping the samples in a room (0.50±0.05) or under the sun (0.41±0.11). For Carrot, the acid concentration before exposure was determined to be 0.22±0.03% and was significantly lower than that obtained when the sample was kept in a room (0.37±0.04) or under the sun (0.40±0.06). For Spring Onion, the acid concentration before exposure was 0.46±0.11%. This value was significantly lower than the acid concentrations after exposure to ambient light (0.76±0.13%) but was similar to that obtained after keeping sample in sunlight (0.54±0.027).

Table 1: Shows titratable acidity concentration (%) of vegetables after exposure to ambient light and sunlight.

Sample(s)	Before(Control)	Room	Sun	*p*-value
Cabbage	0.39±0.06	0.50±0.05	0.41±0.11	0.266
Carrot	0.22±0.03[a]	0.37±0.04[b]	0.40±0.06[b]	0.005
Spring Onion	0.46±0.11[a]	0.76±0.13[b]	0.54±0.05[a]	0.027

Values are mean ± standard deviation and p-value. Mean values having the same superscripts along the rows are not significantly different while mean values with distinct superscripts along the rows are deemed significantly different.

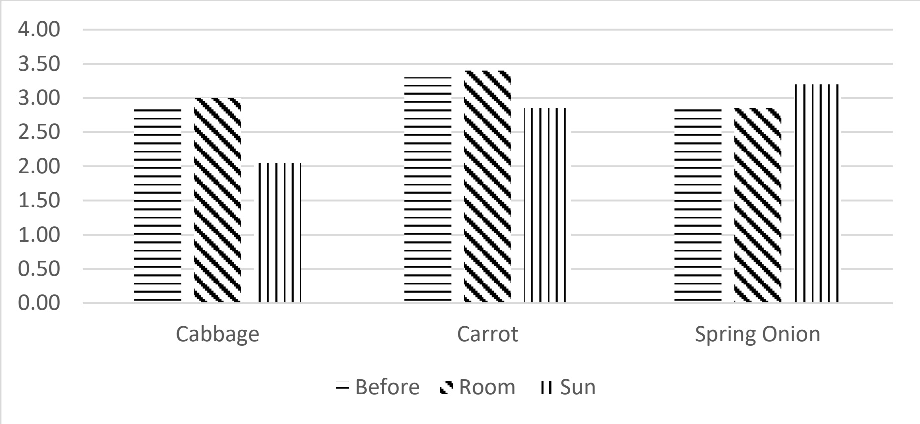


From Table 2, the total soluble solids content was determined for all three samples before and after exposure to ambient light and sunlight. For Cabbage, the total soluble solids content before exposure was determined to be 2.90±0.14°Brix which was not significantly different from that obtained for keeping the samples in a room (3.00±0.14) or under the sun (2.05±0.35). For Carrot, the total soluble solids content before exposure was determined to be 3.30±0.57°Brix which was not significantly different from that obtained for keeping the samples in a room (3.40±0.42) or under the sun (2.85±0.07). For Spring Onion, the total soluble solids content before exposure was determined to be 2.90±0.14°Brix which was not significantly different from that obtained for keeping samples in a room (2.85±0.07) or under the sun (3.20±0.14).

Table 2: Shows total soluble solids content (°Brix) content of vegetables before and after exposure to ambient light and sunlight.

Sample(s)	Before(Control)	Room	Sun	*p*-value
Cabbage	2.90±0.14	3.00±0.14	2.05±0.35	0.050
Carrot	3.30±0.57	3.40±0.42	2.85±0.07	0.459
Spring Onion	2.90±0.14	2.85±0.07	3.20±0.14	0.117

Values are mean ± standard deviation and the p-value.

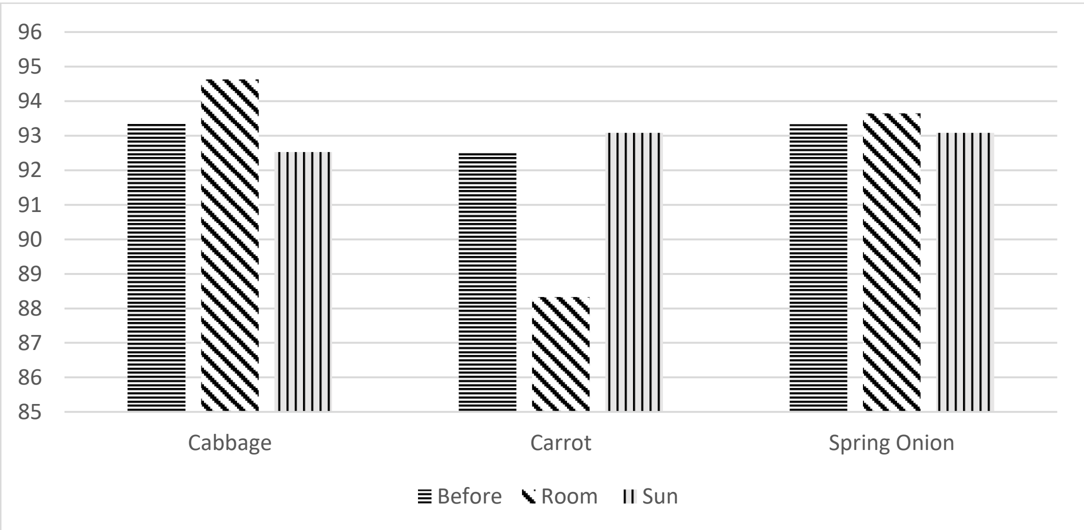


From Table 3, the moisture content was determined for all three samples before and after exposure to ambient light and sunlight. For Cabbage, the moisture content before exposure was determined to be 93.35±0.86% which was not significantly different from that obtained for keeping samples in a room (94.63±0.61) or under the sun (92.53±0.69). For Carrot, the moisture content before exposure was determined to be 92.53±0.69% which was not significantly different from that obtained for keeping samples in a room (88.33±2.79) or under the sun (93.08±0.10). For Spring Onion, the moisture content before exposure was determined to be 93.33±0.35% which was not significantly different from that obtained for keeping samples in a room (93.65±0.25) or under the sun (93.08±0.10).

Table 3: Shows moisture content (%) of vegetables before and after exposure to ambient light and sunlight.

Sample(s)	Before(Control)	Room	Sun	*p*-value
Cabbage	93.35±0.86	94.63±0.61	92.53±0.69	0.132
Carrot	92.53±0.69	88.33±2.79	93.08±0.10	0.218
Spring Onion	93.33±0.35	93.65±0.25	93.08±0.10	0.228

Values are mean ± standard deviations and the p-value.

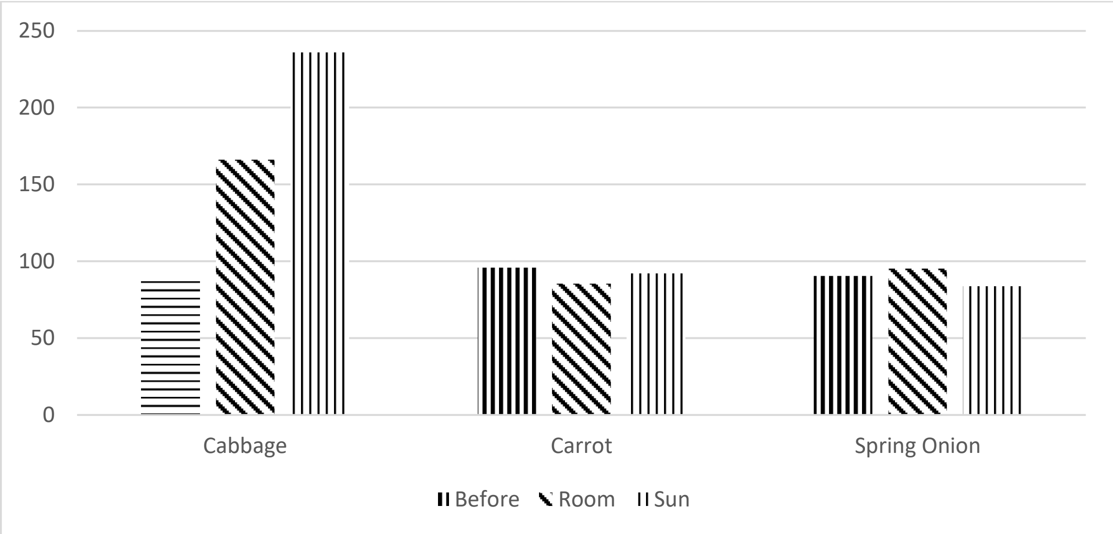


From Table 4.0, the polyphenol oxidase activity was determined for all three samples before and after exposure to ambient light and sunlight. For Cabbage, the polyphenol oxidase activity before exposure was determined to be 87.53±1.82µmol/L/min and was significantly lower than that obtained when the sample was kept in a room (166.01±4.45) or under the sun (236±8.65). For Carrot, the polyphenol oxidase activity before exposure was determined to be 95.83±2.62µmol/L/min. This value was significantly higher than the polyphenol oxidase activity after exposure to ambient light (85.45±1.84) but was similar to that obtained after keeping samples under the sun. For Spring Onion, the polyphenol oxidase activity before exposure was determined to be 90.53±4.44µmol/L/min which was not significantly different from that obtained for keeping samples in a room (90.53±4.44) or under the sun (83.76±0.44).

Table 4: Shows polyphenol oxidase activity (µmol/L/min) of vegetables before and after exposure to ambient light and sunlight.

Sample(s)	Before(Control)	Room	Sun	*p*-value
Cabbage	87.53±1.82[a]	166.01±4.45[b]	236±8.65[b]	0.000
Carrot	95.83±2.62[a]	85.45±1.84[b]	92.01±5.31[a]	0.032
Spring Onion	90.53±4.44	95.27±8.47	83.76±0.44	0.109

Values are mean ± standard deviations and the p-value. Mean values having the same superscripts along the rows are not significantly different while mean values having different superscripts along the rows are significantly different.



IV. Discussion

Titratable acidity, total soluble solids content, moisture content and polyphenol oxidase activity are key parameters to assess in determining the overall quality of vegetables. Exposing vegetables to sunlight for longer durations in one way or another may affect these quality parameters of the vegetables. The aim of this study was to assess the effect of sunlight on the aforementioned parameters of the selected vegetables.

Titratable Acidity

Titratable acidity in vegetables is a key parameter used to assess the acidity level and the overall flavour profile of vegetables. Titratable acidity plays a crucial role in determining the flavour balance of vegetables. It contributes to the overall taste perception by providing a desirable level of acidity, which is essential for a refreshing and balanced flavour profile. The data from this study (Table 1.0) revealed that there was no significant difference in cabbage before and after exposure to room temperature and sunlight. Cabbage is a vegetable with a moderate level of acidity. Cabbage showed an increase in the acid content after it was exposed to sunlight and ambient light. The sample exposed in the room recorded a higher acid content as compared to the sample exposed to the sun. Cabbage showed a mean acid content of 0.39±0.06% before exposure, 0.50±0.05 when exposed to ambient light and 0.41±0.11% when exposed to sunlight. Even though there was an increase in acid content after exposure, there was no significant difference among the values. The increase in the acid content of cabbage in a cool dry place away from direct sunlight is due to the breakdown of cells by the natural enzymes in the cabbage. The cool dry environment helps to preserve these enzymes, which allows them to break down the cell walls and release acids. The increase in the acidity level will make the cabbage taste sourer.

Carrot however showed a very significant difference, (*p*-value= 0.005), in its acid content after exposure to the sunlight for eight hours and also when kept in the room under ambient light. There was an increase in the acid content after the carrot was exposed to the sun and also to ambient light. This increase could impact the tangy taste of the carrot instead of the usual sweet taste it possesses. Carrots naturally are very low acid-level vegetables. The increase in the acid content of the carrot could be due to sunlight breaking down the cell walls, releasing acids that were previously bound up in the cells.

The acid content of the carrot before exposure to the sun and after exposure to the sun revealed a significant difference. The control had an acid content of 0.22±0.03%, the sample exposed to ambient light in a room recorded an acid content of 0.37±0.04% and the sample exposed to the sun recorded an acid content of 0.40±0.06%. High titratable acid content affects flavour and overall taste in vegetables so an increase in acid content after exposure means the taste and flavour will be affected. The increase in the titratable acid content of the carrot will affect the taste of the carrot.

With regards to spring onion, there was an increase in acid content after exposure to ambient light and then sunlight. The acid content of the spring onion before exposure was 0.46±0.11%, the acid content of the sample exposed to ambient light was 0.76±0.13% and the acid content of the sample exposed to the sun was 0.54±0.05%. A significant difference however existed between the sample before exposure and the sample exposed to ambient light. Spring onions are generally considered low in titratable acid so an increase in the acid content after exposure could be due to environmental conditions such as temperature and light exposure can impact the titratable acidity of vegetables. An increased light exposure can generally stimulate the synthesis of organic acids in certain vegetables. An increase in the acid content could affect the overall taste of the spring onion making it taste sour preventing its usage in culinary practices.

Total Soluble Solids

Total soluble solids (TSS) are a critical physicochemical property of vegetables that refers to the total concentration of dissolved solids, primarily sugars, organic acids, and other soluble compounds present in the vegetable juice or extract. TSS is closely associated with the sweetness and flavour perception of vegetables. Higher TSS levels generally indicate a sweeter taste and better flavour profile in vegetables. Results from the study (Table 2.0) indicated that there was no significant difference between all controls and their respective samples after exposure (p-value =0.050) or higher which is the same as or higher than the confidence level and therefore not significant.

Cabbage before exposure recorded a TSS level of 2.90±0.14°Brix, 3.00±0.14°Brix (Table 2.0) after exposure to ambient light and 2.05±0.35°Brix after exposure to the sun. The TSS level of the control and the sample exposed to ambient light showed a slight difference and this could be because it was stored in a shaded environment and therefore less likely to be affected by sunlight-induced changes. However, comparing the control to the sample exposed to the sun it could be deduced that the total soluble solids content reduced after exposure to sun. Cabbage generally has low total soluble solids content which explains why all the mean values obtained are relatively low. The decrease in the TSS level after exposure to the sun could be due to photodegradation which breaks down sugars thereby reducing the TSS level. Higher TSS levels gives vegetable their sweet taste therefore a decrease in their levels can impart an undesirable taste to vegetables.

Carrot revealed a p-value of 0.459 from Table 2.0. The p-value is also greater than the confidence level of 0.05 so there is no significant difference between the control and any of the exposed samples. The sample before exposure revealed a TSS level of 3.30±0.57°Brix, the sample exposed to the ambient light showed a TSS level of 3.40±0.42°Brix and the sample exposed to the sun showed a TSS level of 2.85±0.07°Brix. Carrot generally has higher TSS content and is considered sweet. The values obtained were relatively low because the carrots were not fully matured. The sample before exposure and the sample exposed to ambient light have values closer while the sample exposed to the sun has a lower TSS content. The decrease in TSS content after exposure to the sun could be due to photodegradation or enzymatic reactions which potentially reduce the level of total soluble solids. Excessive exposure to sunlight post-harvest for extended periods can cause the breakdown of sugars. The TSS content after exposure to ambient light did not deviate from the value obtained before exposure because the samples were exposed in a shaded environment therefore less likely to be affected by sunlight-induced changes in TSS compared to the sample exposed to direct sunlight.

Spring Onion also recorded a p-value of 0.117 (from Table 2.0) which is greater than the confidence level of 0.05 thereby implying that there was no significant difference between the values. The TSS content before exposure was 2.90±0.14°Brix, 2.85±0.07 after exposure to ambient light and 3.20±0.14°Brix after exposure to sunlight. Generally, spring onions have relatively low TSS content which explains the fact that mean values obtained in Table 2.0 are low. The TSS content before exposure and after exposure to ambient light has a small difference but is quite close. The sample exposed to ambient light was done in a shaded environment which makes it less likely to be affected by sunlight-induced changes in TSS compared to those exposed to direct sunlight. The sample exposed to sunlight however gave a higher TSS content as compared to the control and the one exposed to the ambient light. The increase in TSS content could be due to the temperature. Amount of sunlight exposure that vegetables receive will also affect the total soluble solids content. Vegetables that receive more sunlight will typically have higher levels of total soluble solids than those that receive less sunlight. Higher temperatures often associated with sunlight exposure, can accelerate metabolic processes, including the conversion of starches to sugars, which can increase the TSS content.

Moisture Content

Moisture Content is a critical physicochemical property of vegetables that refers to the amount of water present in the vegetable tissue. The texture, shelf life, and overall quality of vegetables are notably influenced by water. Moisture content greatly influences the texture of vegetables. High moisture content contributes to crispness, juiciness, and succulence, which are desirable sensory attributes. On the other hand, low moisture content can result in dryness and undesirable texture. Leafy vegetables generally have higher moisture content compared to root vegetables. Analysis of data from Table 3.0 revealed that there was no significant difference among the values. The high values obtained for moisture contents from Table 3.0 show that all samples used are juicy, succulent, and fresh.

Cabbage had a p-value of 0.132 which is higher than the confidence level of 0.05 and implies that there is no significant difference among all the samples. The moisture content (Table 3.0) obtained for the cabbage before exposure was 93.35±0.86%, 94.63±0.61% was obtained after exposure to ambient light and 92.53±0.69% was obtained after exposure to sunlight. The values obtained were close to each other and showed no significant difference. Leafy vegetables have higher moisture content, and this explains why the cabbage possesses a high amount of moisture. The value obtained after the exposure to ambient light was slightly higher than the control. This could be because the room in which the cabbage was exposed was highly humid. The value obtained after exposure to sunlight was lower than the moisture content of the control. The reduction in the moisture content could be due to the high temperature in the atmosphere which accelerates moisture loss through evaporation.

Carrot showed a p-value of 0.218 which is very high as compared with the confidence level of 0.05. This implies that the samples had no significant difference before and after exposure statistically. The moisture contents obtained were 92.53±0.69% before exposure, 88.33±2.79% after exposure to ambient light and 93.08±0.10% after exposure to sunlight. The sample exposed to ambient light experienced significant reduction in its moisture content which could be due to osmosis by the carrot. When vegetables are exposed to ambient light, the water in the vegetables can move to the surrounding air, which has a lower water concentration. This can lead to a decrease in the moisture content of vegetables. If the room in which the carrot was stored had a temperature rise, the humidity would decrease thereby causing the samples to lose water. The sample exposed to sunlight however experienced a slight increase in moisture content when compared to the control.

Spring Onion also revealed a p-value of 0.228 which is higher than the confidence level of 0.05 implying that there is no significant difference among the values before and after exposure. The moisture contents obtained were 93.33±0.35% before exposure, 93.65±0.25% after exposure to ambient light and 93.08±0.228% after exposure to sunlight. It can be deduced that the spring onion relatively maintained its moisture content before and after exposure. The value obtained for the sample exposed under ambient light is a little higher than the control and this could be because water vapour can condense on the surface of the vegetables leading to an increase in moisture content when the surrounding air is humid. The value obtained for the sample exposed to the sunlight was a little lower than the control and this could be due to evaporation due to the high temperature of the direct sunlight which can accelerate moisture loss.

Polyphenol Oxidase

One important group of enzymes in vegetables is polyphenol oxidase (PPO). PPO catalyses the oxidation of phenolic compounds, leading to enzymatic browning in vegetables. Enzymatic browning can negatively impact the visual appeal and flavour of vegetables, reducing their market value and shelf life. Phenolic compounds exhibit antioxidant properties and are crucial in plant defence mechanisms against various environmental stresses.

Cabbage showed a p-value of 0.000 (Table 4.0) which is lesser than the confidence level of 0.050 implying that the values obtained by cabbage after the analysis are extremely significant. Cabbage showed a PPO activity of 87.53±1.82µmol/L/min before the exposure, 166.01±4.45µmol/L/min after exposure to ambient light and 236±8.65µmol/L/min after exposure to sunlight. Comparing both values obtained after exposure to ambient light and exposure to sunlight to the control, it can be deduced that there was a huge increase in the enzymatic activity. The value obtained after exposure to ambient light was almost twice the value before exposure while the value obtained after exposure to sunlight was almost three times the value obtained before the exposure. The increase in enzymatic activity in the samples could be due to the sunlight intensity and duration of exposure. Also, temperature can affect the response of vegetables to sunlight post-harvest. Higher temperatures often accelerate metabolic processes, including the activation of enzymes like PPO. This explains why the samples exposed under the sun have a more pronounced increase in PPO activity. Sunlight can cause the activation of PPO, an enzyme that catalyses the oxidation of phenolic compounds. This can lead to browning of vegetables. Phenolic compounds play a vital role as defence mechanisms against various environmental stresses in vegetables, the higher the PPO activity the more the phenolic compounds are degraded making vegetables susceptible to damage.

Carrot also revealed a p-value of 0.032 which is lesser than the confidence level implying that the values obtained were statistically significant. Carrot from Table 4.0 showed a PPO activity of 95.83±2.62µmol/L/min before exposure, 85.45±1.84µmol/L/min after exposure to ambient light and 92.01±5.31µmol/L/min after exposure to sunlight. From the statistical analysis, there was a significant difference between the value obtained before exposure and the value obtained after exposure to ambient light while there was no significant difference between the value obtained before the exposure and after the exposure to the sun. The value obtained before exposure was higher than the value obtained after exposure to ambient light. The decrease in the enzymatic activity after exposure to ambient light could be because the sample was kept in a shaded environment with protection against excessive light exposure. This could also be due to the low temperature of the room since lower temperatures slow down enzymatic activity vegetables are often stored in cool environments to prevent browning. The decrease in the enzyme activity (Table 4.0) of the sample (carrot) exposed to sunlight was relatively small and not statistically significant to the value obtained before exposure.

Spring Onion revealed a p-value of 0.109 (Table 4.0) which is greater than the confidence level of 0.05 implying that there is no significant difference between the values obtained after the statistical analysis.

Spring onion showed a PPO activity of 90.53±4.44μmol/L/min before exposure, 95.27±8.47μmol/L/min after exposure to ambient light and 83.76±0.44μmol/L/min after exposure to sunlight. From the statistical analysis, the values obtained had no significant difference. However, the values obtained after the exposure to ambient light were higher than the values obtained before the exposure. The increase in enzymatic activity of the sample exposed to ambient light could be due to the high temperature in the shaded room thereby accelerating enzymatic activity. Higher temperatures can also activate PPO. Also, the values obtained for the samples exposed to the sunlight were lower than the values obtained for the control. The decrease in the enzymatic activity of the sample exposed to sunlight could be due to high temperatures leading to the inactivation of enzymes like PPO. This is because excessively high temperatures can also lead to damage and degradation of enzymes.

V. Conclusion

This study intended to evaluate the postharvest effect of sunlight on cabbage, carrot and spring onion by assessing the titratable acidity concentration, total soluble solids content, moisture content and polyphenol oxidase activity before and after exposure to the sun. The study revealed that the titratable acidity concentration of all three samples increased after exposure to sunlight. It was deduced from the study that sunlight synthesized the release of acids due to the high temperature thereby imparting a sour taste onto vegetables.

The study also revealed that the total soluble solids content of all three samples before and after exposure to sunlight was statistically not significant. The p-values obtained for all samples were higher than the confidence level of 0.05. This means that sunlight has no significant effect on the total soluble solids content of cabbage, carrot, and spring onion. The study also revealed a decrease in the moisture content of all cabbage and spring onions after exposure to sunlight. However, carrots had a slight increase in moisture content after exposure to sunlight. The increase however was statistically not significant since the p-value obtained was higher than the confidence level of 0.05. The polyphenol oxidase activity from this study revealed significant differences in cabbage and carrot since they revealed a p-value lesser than 0.05. This means that sunlight affected the polyphenol oxidase activity of cabbage and carrots. Future research should be done on different enzymatic activities and physicochemical properties of vegetables exposed to sunlight.

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