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Research Article

Influence of Poultry Manure Rates on Postharvest Quality and Shelf-Life of Green Pepper (*Capsicum Annum*) Fruits

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Abstract

The research investigated the impact of different poultry manure rates on the post-harvest quality and shelf-life of green pepper (*Capsicum annuum*) fruits. The experiment utilized a 3×1 factorial design, implemented within a Randomized Complete Block Design (RCBD) framework. The study included three replications to ensure statistical validity. The treatment details comprised: T^1 (0kg/ha, control), T^2 (1.2kg/ha poultry manure), and T^3 (2.4kg/ha poultry manure) with a common green pepper variety, California Wonder. Results indicated that poultry manure application significantly influenced postharvest parameters. The 2.4kg/ha poultry manure treatment exhibited the lowest weight loss and maintained the longest shelf-life and marketable quality after 12 days of storage. Additionally, fruits from this treatment demonstrated the highest vitamin C and crude fiber contents. In contrast, the 1.2kg/ha poultry manure treatment resulted in the highest chlorophyll content. The results of this study indicate that the application of poultry manure at a rate of 2.4kg/ha yields the most favorable outcomes for green pepper fruits. This specific rate appears to enhance post-harvest quality characteristics and prolong the shelf-life of the peppers.

Keywords: Chlorophyll; Crude fiber; Physiological weight loss; Treatments; Vitamin C

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Introduction

Green pepper (*Capsicum annuum*), also known as bell pepper, is valued for its nutritional value and culinary adaptability [1]. The peppers are a nutritional powerhouse containing a diverse array of essentials including minerals (potassium, calcium, phosphorus, and iron), vitamins (A, B, and C), and carbs, proteins, and lipids [2]. As the most prevalent antioxidant, vitamin C is recognized to help prevent cancer and other diseases linked to weakened immune systems in humans [3,4]. The quality and storability of green pepper fruits are significantly impacted by pre-harvest management practices, which may involve the use of organic fertilizers like poultry manure.

Poultry manure is a valuable organic fertilizer that increases crop productivity and soil fertility since it is high in potassium, phosphorus, and nitrogen [5,6]. In addition to improving soil structure and water-holding capacity, its application influences the biochemical composition and physiological responses of plants. This results in improved water uptake and decreased water stress in plants, which is reflected in firmer and more resilient fruits after harvest [7]. The rate at which green pepper plants are able to absorb nutrients from the soil is directly impacted by the amount of poultry manure applied to the soil. Nutrient deficits brought on by insufficient application rates may hinder plant growth and fruit development [8]. Conversely, high manure application rates can cause nutritional imbalances, contaminate the environment, and lower fruit quality because of nutrient toxicity or physiological issues [9,10]. In a study by Dlamini et al. [11], it was found that applying 80tons/ha of chicken manure led to an increase in number of leaves, leaf area, leaf area index, and fresh and dry shoot mass of Swiss chard compared to lower application rates of 10, 20, and 40t/ha. The researchers attributed the significant improvements in the parameters to the increased availability of plant nutrients in the soil, which resulted in higher manure application rates. Additionally, compost has been shown to improve soil fertility and promote beneficial microbial activity in vegetable production. Al-Kahtani et al. [12], demonstrated that soil amended with a combination of compost mixture and 40% sheep manure resulted in the highest plant height, fruit yield, leaf chlorophyll, and mineral content, as well as the highest fruit quality index compared to tomato plants grown in other combinations such as 5%, 10%, and 20% sheep manure, as well as a control using active NPK mineral.

The quality characteristics of green pepper fruits, such as firmness, color, flavor, nutritional value, and vitamin C, change during the postharvest period [13,14]. To optimize postharvest quality and storability, it is important to determine the appropriate rates of poultry manure application. This study hypothesizes that different rates of poultry manure application will significantly affect the postharvest quality and storability of green pepper fruits. Specifically, moderate rates are expected to enhance physiological weight retention, shelf-life, vitamin C content, chlorophyll levels, and crude fiber content, while low or excessive rates may reduce fruit quality and increase physiological stress. The focus will be on evaluating the impact of these varied poultry manure rates on physiological weight loss, shelf-life, and nutrient composition of green pepper fruits.

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Materials and Methods

Study Design

The flow chart in figure 1 illustrates the impact of different poultry manure rates on the postharvest quality and shelf-life of green pepper (*Capsicum annuum*) fruits. The process involved seeding, transplanting, applying poultry manure at rates of 0, 1.2, and 2.4kg/ha, harvesting after 9 weeks, and conducting a quality analysis.

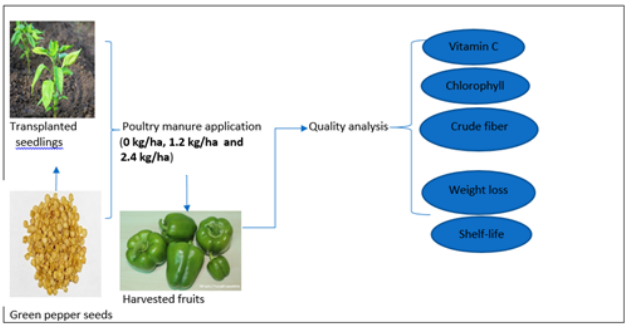

Figure 1: Flow chart of different poultry manure rates on the postharvest quality and shelf-life of green pepper (*Capsicum annuum*) fruits.

Experimental Site

The experiment was conducted at the Postharvest Department of the Kumasi Institute of Tropical Agriculture in Kumasi. This site is situated at 6°40'26'' North latitude and 10°35'' West longitude, with an elevation of about 260 meters. The region experiences a tropical maritime climate, featuring distinct wet and dry seasons and a bimodal rainfall pattern. The primary rainy period spans March to September, peaking in June and August. November to March marks the main dry season. Annual rainfall averages 1300mm, with a mean temperature of 28°C. The study took place during the dry season, spanning April to June 2024.

Soil and Manure Analysis

The soil and manure underwent analysis before cultivation. Total nitrogen was measured using the Kjeldahl method, while available phosphorus was quantified colorimetrically using a spectrophotometer. An Atomic Absorption Spectrophotometer (AAS) determined calcium and iron levels in soil, manure, and plant tissues. Soil pH was assessed with a pH meter. All tests were performed at Crop Science Laboratory-KNUST.

Experimental Design and Treatments

The study employed a 3×1 factorial arrangement within a Randomized Complete Block Design (RCBD), with three replications. In all, there were 9 plots with sizes of 1.5m × 1.2m comprising an experimental field of 16.20m^2. Paths of 0.5m width separated both the replications and the treatments. The poultry manure treatments used include: T_1: Control (0kg/ha), T_2: Poultry manure (8t/ha=1.2kg/ha) and T_3: Poultry manure (16t/ha=2.4kg/ha). The selection of the application rates creates a gradient to evaluate plant responses, enabling the identification of the optimal rate for cultivating green peppers. California Wonder green pepper seeds were used for the experiment. The seeds were obtained from a Chinese-owned agrochemical shop in Kumasi. The cultivar was chosen due to its popularity among local vegetable growers and consumers. Initially, seeds were nursery-sown and after three weeks, transplanted to the field. Robust seedlings were selected and planted at 30cm × 30cm intervals, with 20 plants per plot. Regular watering and standard cultural practices were maintained throughout the growing period. The peppers were harvested at the green, fully mature stage after a total growth period of 9 weeks, including nursery time.

Sample Collection and Processing

After a 9-week growth period (including nursery time), the green peppers were harvested at full maturity. Six fruits (6) from each plot's center were collected, placed in separate sterile polyethylene bags, and transported on ice to the laboratory. Quality analysis was performed at 3-day intervals (0, 3, 6, 9, and 12 days post-harvest), measuring vitamin C (mg/g), chlorophyll (mg/g), and crude fiber (%). Shelf-life evaluation was conducted over 12 days, while physiological weight loss (g) was monitored for 14 days.

Fruit Quality Attributes

Physiological Weight Loss

Physiological weight loss was measured by observing changes in the sampled fruits' weights throughout the storage period. An electronic balance was used to measure the initial and subsequent weights of pepper fruits daily. The percentage loss in weight was calculated using the method described by Haile with the following formula:

$$\text{PLW (\%)} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100$$

Vitamin C

Vitamin C content was quantified by titrating 3g of blended pulp homogenized with 50mL of 12% oxalic acid. The titrant used was 2, 6-dichlorophenolindophenol sodium salt solution. Results were expressed as mg of ascorbic acid per 100g of pulp, following the method described by Abu-Zahra et al. [15].

Chlorophyll

Chlorophyll extraction was performed using 99.9% methanol as the solvent. Samples were stored overnight in a dark cold room at 4°C. Following extraction, leaf pigments were promptly analyzed. Absorbance was measured at 665.2, 652.4, and 470 nm. Chlorophyll content in fresh fruit was determined according to the method described by Khaleghi et al. [16].

Crude Fiber

Crude fiber content was determined using the methods described by Abu-Zahra et al. [17], with results expressed as a percentage.

Shelf-Life (Days)

The produce shelf-life was determined by counting the number of days green pepper fruits were stored up to marketable or acceptable quality. The fruits were monitored for signs of wrinkling, shrinkage, spoilage and rot. The harvested fruits were placed on trays and stored at room temperature for 12 days while observing the changes critically daily.

Data Analysis

Statistical analysis was conducted using Origin-Pro 9.2 software (Origin Lab Corporation, Northampton, MA, USA). All experiments

Sample	Organic content (%)	Organic matter (%)	Total N (%)	Ca^{2+} (cmol/k)	Mg^{+} (Cmol/k)	Fe (mg/kg)	Available P (Mg/kg)	pH
Soil	1.596	2.75	1.04	3.0955	0.6430	16.68	2.11	6.14
Manure	14.96	25.79	2.10	8.40	2.68	11.24	2.48	8.22

Table 1: Soil and manure analysis.

were replicated for reliability. Results are presented as mean values with standard deviations. To identify statistically significant differences between means, Analysis of Variance (ANOVA) was performed, followed by Tukey's comparison tests. The significance level was set at 0.05%.

Results and Discussion

Soil and Manure Analysis

Table 1 presents the pre-planting nutrient analysis of the soil and manure. Results indicate that the manure was alkaline, with a pH of 8.22, while the soil was mildly acidic with a pH of 6.14. The soil showed deficiencies in several key components: organic content, organic matter, total nitrogen, calcium, and magnesium.

Weight Loss

Postharvest weight loss in fruits and vegetables is largely attributed to continuous respiration by harvested produce. The study found no significant differences ($p>0.05$) in weight loss among green peppers from various treatments on days 0, 2, 5, 6, and 9. However, significant differences ($p<0.05$) were observed on days 1, 3, 7, 8, 10, 11, 12, 13, and 14. By day 14, peppers from untreated plants (0kg/ha poultry manure) showed the highest weight loss (68.7%), while those from plants treated with 2.4kg/ha poultry manure exhibited the lowest (52.0%). No significant differences ($p>0.05$) in weight loss were observed between peppers from plants treated with 1.2kg/ha and 2.4kg/ha of poultry manure. However, both these treatments resulted in significantly lower ($p<0.05$) weight loss compared to the control group (0kg/ha manure), as illustrated in figure 2 .The decrease in weight loss observed in peppers from plants treated with 2.4kg/ha of fertilizer may be due to increased calcium availability. Calcium enhances fruit firmness and lowers respiration rates, which is linked to lower weight loss [18,19]. In a study by Angelletti et al. [20], it was discovered that calcium-treated blueberries had less softening and weight loss than control fruits. The fruits might have developed thicker pericarps, enhancing protection against moisture loss and physical damage, thus minimizing storage weight loss. Conversely, Addo et al. [21], suggested that high storage weight loss percentages may result from low biomass accumulation.

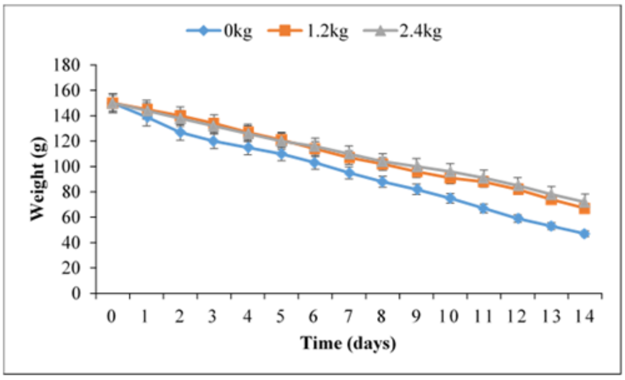

Figure 2: Effect of poultry manure rates on weight loss of green pepper fruits after harvest and during storage.

Vitamin C

Vitamin C, an essential nutrient and powerful antioxidant in both plants and humans, was analyzed in stored pepper fruits. No significant differences ($p>0.05$) in vitamin C content were observed on day 6 of storage. However, significant variations emerged on days 0, 3, 9, and 12 across treatments. By day 12, fruits from plots treated with 2.4kg/ha poultry manure exhibited the highest vitamin C content (17.89mg/g), while those from untreated plots had the lowest (9.11mg/g). Interestingly, there were no significant differences ($p>0.05$) between the control and other treatments at day 12. The observation that green peppers treated with 2.4kg/ha of poultry manure had the highest vitamin C content after harvest and storage suggests that this application rate, combined with the prevailing light and temperature conditions, created an optimal environment for nutrient uptake and vitamin C synthesis. (Figure 3). This finding aligns with Ansah and Woke's [22], study, which reported higher vitamin C content in cayenne peppers treated with 20 t/ha manure compared to lower rates or no treatment. They concluded that increased poultry manure application correlates with higher vitamin C concentrations. Shafeek et al. [23], noted that optimal organic fertilizer rates can boost fruit vitamin C accumulation, while insufficient rates may lead to nutritional deficiencies, hindering plant growth and vitamin C synthesis. A gradual decrease in ascorbic acid content was observed over the storage period, potentially due to exposure to excessive light, temperature fluctuations, physical damage, and low relative humidity, as claimed by Asanda et al. [24] and Lee and Kader [25].

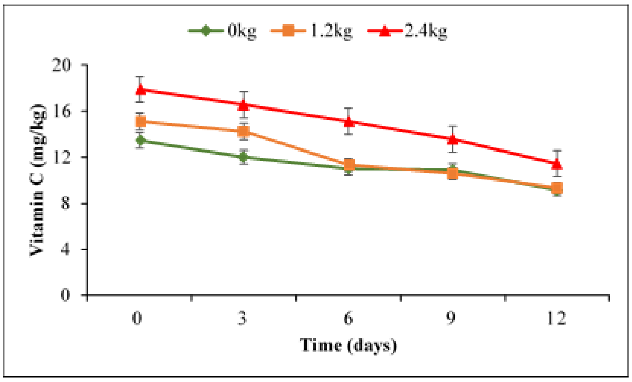

Figure 3: Effect of poultry manure rates on the Vitamin C content in green pepper fruits after harvest and during storage.

Chlorophy ll

The chlorophyll content of green pepper plants treated with different manure rates showed no significant differences ($p>0.05$) at day 0 and 12. However, the results showed significant differences ($p<0.05$)

among treatments on chlorophyll content in the pepper fruits at days 3, 6 and 9. The highest initial value (0.246mg/g) of chlorophyll content after harvest was obtained by fruits treated with 1.2kg/ha of poultry manure and the lowest from plots treated with no manure (0.111mg/g). After storage, fruits from plots amended with 1.2kg/ha manure retained the highest chlorophyll content (0.103mg/g) whiles fruits treated with no manure had the lowest chlorophyll content (0.076mg/g) (Figure 4). The higher chlorophyll content in fruits treated with 1.2kg/ha of poultry manure may be attributed to a balanced nutrient supply, particularly nitrogen, in the manure. Excessive nutrients can lead to toxicity and reduced chlorophyll synthesis. Moreover, the fruits appeared to regulate their physiological processes better under varying environmental conditions such as temperature, light intensity, and water availability, leading to higher chlorophyll content throughout the storage period. However, these findings contradict the results of Okonwu and Mensah [26], who suggested applying poultry manure at a higher rate of 400kg/ha. They observed that this higher rate resulted in high chlorophyll content, influenced by nitrogen levels.

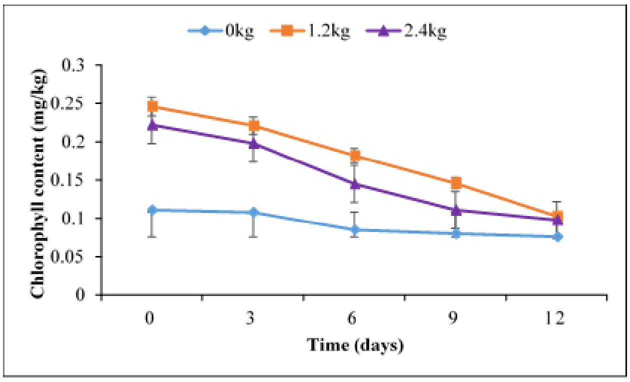

Figure 4: Effect of poultry manure rates on the Chlorophyll content in green pepper fruits after harvest and during storage.

Crude Fiber

The crude fiber content was not significantly (p>0.05) affected by the different manure rates at day 0, 3 and 6. However, the results showed significant (p<0.05) differences on crude fiber contents at days 9 and 12. At day 12, fruits from plots treated with 2.4 kg/ha poultry manure had the highest crude fiber content (2.09%) whiles those treated with 0 kg/ha poultry manure had the lowest crude fiber content (1.21%) at the end of storage (Figure 5). There were no significant (p>0.05) differences in the crude fiber content produced by green pepper treated with 1.2kg/ha and 2.4kg/ha poultry manure although at day 12, but both were significantly (p<0.05) higher than fruits treated with 0kg/ha manure. The higher initial and final values of crude fiber contents recorded in pepper fruits treated with poultry manure rate of 2.4kg/ha may be attributable to the increased availability of nitrogen in the manure stimulating cell division and elongation, resulting in higher crude fiber content in the pepper fruits [27]. In a study by Rehman et al. [28] and Khan et al. [29], it was revealed that nitrogen is crucial for the synthesis of amino acids, proteins, and chlorophyll. These compounds contribute to increased biomass and fiber production in plants.

Shelf-Life

The shelf-life of green peppers refers to the length of time the pepper fruits can be stored while maintaining a marketable or acceptable

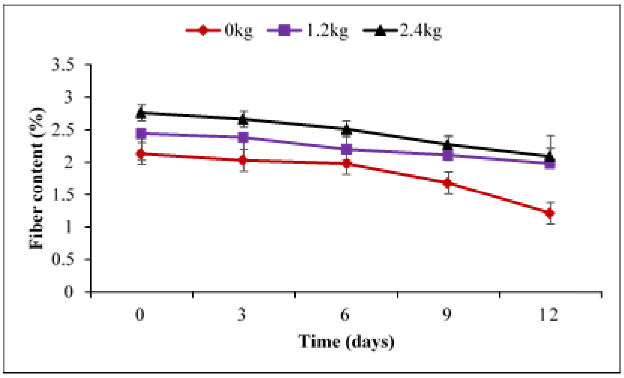

Figure 5: Effect of poultry manure rates on the Crude fiber content in green pepper fruits after harvest and during storage.

quality. The storage of green pepper fruits was significantly (p≤0.05) affected by the different application rates of poultry manure. The longest storage life of 10 days was observed in fruits from plots amended with 2.4 kg/ha of poultry manure, whereas fruits from plots with no amendment (control) had the shortest storage life of 7 days (Table 2). The peppers began wilting and shriveling on the 4th and 5th days after storage with signs of darkening, browning, and rottenness, which marked the end of the shelf-life of the fruits being observed on days 7, 8, and 10 for the 0 (control), 1.2 and 2.4kg/ha poultry manure rates, respectively. The ability of 2.4kg/ha poultry manure fields producing fruits with the longest shelf life may be due to relatively high and readily available calcium levels in the manure rate having the propensity to extend fruit shelf-life. Santhosh et al. [30], reported that calcium (Ca) has the potential to reduce fruit softening and postharvest decay, delay fruit ripening, delay fruit senescence, and extend storage life of fruits. Similarly, longer storage life can be adduced to lower respiration rates by the produce since high respiration activity leads to loss of food reserves, loss of water and produce senescence Mangaraj and Goswami [31], Nayik and Muzaffar [32]. The extended shelf life of green peppers, resulting from optimal poultry manure application, offers significant economic benefits for farmers and retailers. For farmers, a longer shelf life means reduced postharvest losses. Green peppers can maintain marketable quality for up to 10 days instead of just 7, allowing farmers to take advantage of a wider market window. This enables better timing of sales, potentially leading to higher prices as they can sell when demand is high, rather than being forced to sell quickly to avoid spoilage.

Treatments	Shelf-life (days)
0kg/ha pm	7.0[a]
1.2kg/ha pm	8.0[ab]
2.4kg/ha pm	10.0[b]

Table 2: Effects of poultry manure rates on shelf-life of green pepper fruits at storage.

Conclusion

This research elucidates the significant impact of poultry manure application on the postharvest attributes of green pepper (*Capsicum annuum* L.) fruits. The 2.4kg/ha treatment consistently outperformed other treatments in key postharvest parameters, including weight retention, storage longevity, and nutrient content (vitamin C and crude fiber). However, the 1.2kg/ha treatment yielded the highest chlorophyll content post-storage. Based on these results, we recommend applying 2.4kg/ha of poultry manure enhances the quality of green pepper after harvest and extends their storage life. This study has important implications for sustainable farming and the use of organic fertilizers. Research shows that specific levels of poultry manure can enhance the nutritional and storage qualities of green peppers, supporting the use of organic fertilizers in crop management for better food security and increased market value for farmers.

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Conflict of Interest

The authors have no conflict of interest to declare.

Data Availability

The research article contains all the data that was created and analyzed.

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