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Research Article
Preharvest Management of Early Blight using Aqueous Ginger (*Zingiber officinale*) Extract Enhances Postharvest Storage Life of Tomato (*Solanum lycopersicum* L.) Fruits

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Abstract

Background and Objective: Tomato (*Solanum lycopersicum* L.) is highly susceptible to postharvest deterioration because of its high water content, while early blight infection during production can further reduce the storage life of harvested fruits. This study evaluated the influence of preharvest early blight management using different concentrations of aqueous ginger (*Zingiber officinale*) extract on the postharvest storage life of tomato fruits. **Materials and Methods:** Tomato plants were treated with 0%, 5%, 10%, 15% and 20% v/v aqueous ginger extract, with Redforce fungicide (active ingredients: Metalaxyl 12%+Copper(I) oxide 60% WP) used as the standard control. Fruits harvested from the treated plants were evaluated under storage conditions using a Completely Randomized Design (CRD) with three replications. Percentage fruit decay and shelf life were determined during storage. Data were subjected to analysis of variance (ANOVA) at the 5% significance level and significantly different treatment means were separated using Fisher's Least Significant Difference (F-LSD) test at $p = 0.05$. The ginger extracts were also characterized for total phenolic content, total flavonoid content and 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical-scavenging activity. **Results:** Aqueous ginger extract contained phenolic compounds and flavonoids, with higher extract concentrations showing higher total phenolic content, total flavonoid content and DPPH radical-scavenging activity. Preharvest treatments significantly ($p<0.01$) influenced the postharvest storage life of tomato fruits. Fruits harvested from untreated plants recorded the highest decay (86.70%) and shortest shelf life (3.33 days). In contrast, fruits from plants treated with 10%, 15% and 20% v/v aqueous ginger extract recorded significantly lower decay of 56.70%, 43.30% and 43.30%, respectively and longer shelf lives of 6.33, 7.00 and 7.00 days, respectively. These treatments performed statistically at par with the Redforce fungicide treatment. **Conclusion:** Preharvest application of aqueous ginger extract at 10%, 15% and 20% v/v for early blight management improved the postharvest storage life of tomato fruits. Aqueous ginger extract therefore represents a promising botanical alternative for reducing postharvest losses and improving tomato fruit quality and storage potential.

Key words: *Alternaria solani*, botanical extract, early blight, postharvest losses, shelf life, tomato

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is one of the most important vegetable crops cultivated worldwide because of its nutritional, economic and industrial value[1]. The fruit is an important source of vitamins, minerals, carotenoids, particularly lycopene and other bioactive compounds associated with human nutrition[2,3]. Tomato production provides income and livelihood opportunities for millions of smallholder farmers. However, tomato production and utilization are constrained by several factors, including fungal diseases that reduce fruit quality and market value. Among these diseases, early blight caused mainly by *Alternaria solani* is one of the most destructive diseases affecting tomato production[4]. The pathogen infects leaves, stems and fruits, causing necrotic lesions, premature defoliation, reduced photosynthetic activity and deterioration of fruit quality. Its ability to survive in crop residues, produce abundant conidia and spread rapidly under warm and humid conditions contributes to its persistence in tomato production systems mostly in tropical and subtropical regions[5].

Globally, food losses between harvest and retail is a major challenge, with fruits and vegetables being the most affected because of their short shelf life and sensitivity to handling, storage conditions and environmental factors[6]. In developing regions, inadequate storage facilities, limited cold-chain infrastructure and inefficient transportation systems increase postharvest losses[7]. Postharvest deterioration is a major limitation to tomato production. The fruit is highly perishable due to its high moisture content, active metabolism, climacteric ripening behaviour and susceptibility to mechanical injury and microbial infection. These characteristics contribute to rapid softening, physiological deterioration, fungal decay and reduction in market quality after harvest[8]. Studies have shown that postharvest losses within the tomato value chain are associated with fungal decay, mechanical damage, poor packaging, transportation stress and unsuitable storage conditions[9]. Reported losses vary among production environments, but losses ranging from 20% to 40% have been documented in poorly developed tomato value chains where postharvest management systems are inadequate[6,8-10]. These losses reduce farmer income and limit market availability. Postharvest losses in tomato value chain are particularly pronounced in Sub-Saharan Africa, where vegetable supply chains are affected by inadequate storage facilities, weak transportation networks, limited processing capacity and limited access to appropriate postharvest technologies[7]. In Nigeria, one of the Africa's major tomato-producing countries, substantial quantities of harvested fruits are lost before reaching consumers because of rapid deterioration, fungal infection, transportation damage and inadequate handling practices[11]. These losses affect farmer profitability, market supply and food system efficiency[11,12]. Postharvest storage life of fruits are influenced not only by storage conditions and handling practices but also by the physiological condition and pathogen status of the fruits at harvest[13-15]. Several microorganisms responsible for postharvest fruit decay can establish infections during crop growth and remain quiescent until ripening and senescence create favourable conditions for disease development[8]. Therefore, management practices applied during crop production influence postharvest storage life of fruits by affecting fruit quality, pathogen load and susceptibility to deterioration.

In recent time, botanical extract is receiving increasing attention as sustainable approach to crop protection due to the presence of bioactive compounds with antimicrobial, antioxidant and defence-inducing properties in it[16-19]. Phenolic compounds and flavonoids found in some botanical extract contribute to plant defence mechanism through reinforcement of structural barriers, regulation of oxidative processes and activation of resistance mechanisms against pathogens[20,21]. Botanical extract from ginger (*Zingiber officinale*) is rich in phytochemical such as gingerols, shogaols, phenolic compounds and flavonoids, which possess antimicrobial and antioxidant activities associated with inhibition of microorganisms and protection against oxidative deterioration[20,21]. With the antimicrobial potential of ginger extract, most studies have focused on laboratory antimicrobial assays or direct treatment of harvested fruits in efforts to provide botanical approach to management of postharvest losses in tomato value chain. There is dearth of information on whether application of ginger extracts to tomato plants to manage early blight during production can influence the storage life of the harvested fruits. Thus, the study was conducted to evaluate the influence of different concentrations of aqueous ginger (*Zingiber officinale*) extract applied to tomato plants under field conditions for early blight management on the postharvest storage life of the fruits. The findings provide insight into the potential of aqueous ginger extract treatment as sustainable components of early blight management in tomato production, with beneficial effects on postharvest storage life of the fruits.

MATERIALS AND METHODS

Study area and duration: The experiment was conducted from September to November 2025 at the Research and Demonstration Farm of Enugu State Polytechnic, Iwollo, Nigeria (07°16.834 E, 06°16.834 N; 252 m above sea level),

during the rainy season. The area has a hot, humid climate with high rainfall and a history of early blight occurrence in tomato fields.

Source of materials: Fresh rhizomes of ginger (*Zingiber officinale*) variety Taffin Giwa (Yellow UG1), characterized by its pungent properties, were used for the preparation of the aqueous ginger extract. The rhizomes were purchased from a local market in Enugu, Nigeria. Redforce fungicide (a.i. Metalaxyl 12%+Copper (I) oxide 60% WP), used as the standard positive control in the field experiment, was obtained from an agro-allied dealer in Enugu, Nigeria. Tomato cultivar Roma VF, commonly cultivated in the study area was used for the study and was also obtained from an agro-allied dealer in Enugu, Nigeria.

Preparation of aqueous ginger extract: The aqueous ginger extract was prepared according to the method described by Choudhary *et al.*[16], which is suitable for adoption by smallholder farmers. Fresh ginger rhizomes with a moisture content of 79.4% were thoroughly washed, weighed and homogenized with an equal volume of sterile water (1:1 w/v). The homogenate was heated in a water bath at 80°C for 10 min and filtered through a double layer of muslin cloth followed by Whatman No. 1 filter paper to obtain a 100% stock extract. The working concentrations were prepared by diluting the stock extract with distilled water as follows:

- 0% (v/v) = 100% water (negative control)
- 5% (v/v) = 1 part of extract: 19 parts of water
- 10% (v/v) = 1 part of extract: 9 parts of water
- 15% (v/v) = 3 parts of extract: 17 parts of water
- 20% (v/v) = 1 part of extract: 4 parts of water

Characterization of aqueous ginger extract: The aqueous ginger extract was qualitatively screened for selected phytochemicals as follows:

- **Phenolic compounds:** A 1 mL of stock extract was mixed with 2 drops of 5% ferric chloride solution following the procedure described by Harborne[22]
- **Flavonoids:** A 1 mL of stock extract was mixed with 1 mL of 10% aluminum chloride solution and 1 mL of 1 M potassium acetate and incubated at room temperature for 30 min following the procedure described by Harborne[22]

Determination of Total Phenolic Content (TPC): The total phenolic content (TPC) of the different concentrations of aqueous ginger extract was determined using the method described by Ozturk *et al.*[23] with slight modification. The ginger aqueous concentrations were further dilute 1:10 with distilled water. A 1 mL of the diluted sample extract was mixed with 0.5 mL of Folin-Ciocalteu reagent and allowed to react. After 5 min, 2 mL of 7.5% sodium carbonate solution was added to neutralize the mixture before it was incubated at room temperature in the dark for 30 minutes. The absorbance was subsequently measured at 765 nm using a spectrophotometer against a reagent blank. A standard calibration curve was prepared using gallic acid at 0, 10, 20, 40, 60, 80 and 100 mg/L. The linear regression equation obtained from the standard curve in was used to quantify the phenolics in the samples and calculated using the following linear equation:

$$y = mx + b$$

Where:
y = Absorbance of the sample extract
x = Total phenolic content in the sample (mg/L)
m = Slope of the calibration curve
b = Intercept of the calibration curve

To determine the total phenolic content (x) for each treatment, the equation was rearranged as follows:

$$x = \frac{y - b}{m}$$

All tests were performed in triplicate and the total phenolic content values were expressed as milligrams of gallic acid equivalents per litre of sample extract (mg GAE/L) and corrected for the dilution factor by multiplying by 10.

Determination of total flavonoid content (TFC): The total flavonoid content (TFC) of the different concentrations of aqueous ginger extract was determined using the method described by Oboh and Omoregie[24] with slight modification. A 1 mL of ginger extract sample was mixed with 1.0 mL of 10% aluminum chloride solution, followed by the addition of 1.0 mL of 1M potassium acetate and 3 mL of distilled water and then incubated at room temperature for 30 min. The absorbance was subsequently measured at 415 nm using a spectrophotometer. A standard calibration curve was prepared using quercetin at 0, 10, 20, 40, 60, 80 and 100 mg/L.

The linear regression equation obtained from the standard curve was used to quantify the flavonoid in the samples and calculated using the following linear equation:

$$y = mx + b$$

Where:

y = Absorbance of the sample extract
x = Total flavonoid content in the sample (mg/L)
m = Slope of the calibration curve
b = Intercept of the calibration curve

To determine the total flavonoid content (x) for each treatment, the equation was rearranged as follows:

$$x = \frac{y - b}{m}$$

All tests were performed in triplicate and the total flavonoid content values were expressed as milligrams of quercetin equivalents per litre of sample extract (mg QE/L).

Determination of 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging activity: The antioxidant ability of the ginger extract treatments was evaluated using DPPH free radical scavenging assay as describe by Oboh and Omoregie[24] with slight modification. A 1.0 mL of the sample ginger extracts was thoroughly mixed with 1 mL of a methanolic DPPH solution (0.4 mM). The mixture was shaken vigorously and incubated in the dark at room temperature for 30 min. The absorbance of the remaining DPPH radicals was subsequently measured at 517 nm using a UV-Vis spectrophotometer. A control containing only the methanolic DPPH solution was used as the experimental blank. All tests were conducted in triplicate. The percentage radical scavenging activity was calculated for each treatment replication using the following formula:

$$\text{Radical scavenging activity } (\%) = \frac{\text{Blank absorbance} - \text{Sample absorbance}}{\text{Blank absorbance}} \times 100$$

Pre-harvest management of early blight: The tomato fruits used for the postharvest study were harvested from a field experiment conducted from September to November 2025 during the rainy season at the Research and Demonstration Farm of Enugu State Polytechnic, Iwollo, Nigeria, to evaluate the efficacy of different concentrations of aqueous ginger (*Zingiber officinale*) extract for the management of early blight in tomato under field conditions. The treatments consisted of 0% (negative control), 5%, 10%, 15% and 20% v/v aqueous ginger extract, together with Redforce fungicide (Metalaxyl 12%+Copper (I) oxide 60% WP) as the standard positive control. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications.

The treatments were applied using a 2-liter handheld sprayer. The first application was by soil drenching at 400 L/ha two weeks before transplanting, followed by foliar applications at the same spray volume every two weeks from 2 to 8 weeks after transplanting. Redforce fungicide was prepared and applied according to the manufacturer's recommended rate of 2.5 g/L of water.

Isolation, identification and pathogenicity of *Alternaria solani*: Early blight infected tomato leaves were collected from the experimental field and examined in the laboratory to confirm the causal pathogen. Lesions excised from infected leaves were macerated in 10 mL of sterile distilled water. The resulting suspension was filtered through cheesecloth to remove leaf debris, mounted on a glass slide and examined under a KYOWA TOKYO JAPAN monocular microscope at ×100 magnification for morphological identification of the pathogen following the procedure of Adomako *et al*.[25]. Pathogenicity was confirmed using Koch's postulates[26]. Disease-free tomato leaves was placed on the moistened filter paper and inoculated with 2 mL of sporangial suspension containing the pathogen as described by Adomako *et al*.[25].

Postharvest evaluation: At maturity, ripe tomato fruits harvested from the respective field treatments were used to evaluate the influence of pre-harvest early blight management on postharvest storage life of the fruits. Completely Randomized Design (CRD) with three replications was used for the study. For each field treatment, 30 fruits were selected for uniformity and divided into 3 replications of 10 fruits each. The fruits were stored under room temperature and inspected daily for visible spoilage, defined as soft spots, water soaked lesions, or mold growth and the spoilt fruits were removed immediately they were confirmed spoilt. The percentage decay and shelf life were consequently calculated to determine the postharvest storage life of the fruits.

Evaluation of shelf life of the fruits: The shelf life of the tomato fruits was evaluated by counting the days it took for at least 40% of the tomato fruits in each treatment per replicate to show symptoms of spoilage and considered to have attained end of shelf life as described by Rai *et al.*[27]. Data on shelf life was collected for each treatment.

Evaluation of percentage decay: The total number of the good fruits at the end of the storage trial was recorded and the number of spoilt fruits was calculated by subtracting the number of good fruits from the number of stored fruits[10]. The percentage fruit decay was calculated using the formula:

$$\text{Percentage fruits decay}(\%) = \frac{\text{Number of decayed fruits}}{\text{Number of stored fruits}} \times 100$$

Data analysis: Data on shelf life and percentage fruit decay were subjected to Analysis of Variance (ANOVA) for Completely Randomized Design using GenStat software. Percentage fruit decay data were arcsine transformed, while shelf life data were square root transformed before analysis to satisfy the assumptions of ANOVA. The statistical model used was:

$$Y_{ij} = \mu + T_i + \varepsilon_{ij}$$

Where:

Y_{ij} = observation for jth replicate receiving ith treatment
μ = overall mean
T_i = effect of the ith treatment
ε_{ij} = experimental error

Treatment means with significant difference were separated using Fisher's Least Significant Difference (F-LSD) at 5% probability level. Total phenolic content, total flavonoid content and DPPH radical scavenging activity were analysed descriptively and expressed as Mean±Standard Deviation of three replicates.

RESULTS AND DISCUSSION

Preliminary qualitative phytochemical screening of aqueous ginger extract: Preliminary qualitative screening showed that the stock aqueous ginger extract contained phenolic compounds and flavonoids (Table 1). The ferric chloride test produced a dark blue colouration, confirming the presence of phenolic compounds, whereas the aluminium chloride test produced a yellow colouration, indicating the presence of flavonoids. These results showed that the aqueous extraction procedure retained important bioactive constituents naturally present in ginger. The occurrence of phenolic compounds and flavonoids in the aqueous ginger extract agrees with reports identifying these metabolites as major bioactive constituents of ginger[20,28]. These phytochemicals are recognized for their antioxidant and antimicrobial properties, which contribute to the biological activity of ginger and support its application in crop protection and postharvest preservation[29,30]. Phenolic compounds inhibit microbial growth through multiple mechanisms, including disruption of cell membranes and interference with essential metabolic processes, while flavonoids also contribute to antioxidant defence by scavenging reactive oxygen species that accelerate tissue deterioration during storage[29,31]. Consequently, the detection of these phytochemicals provides a biochemical basis for evaluating the effectiveness of aqueous ginger extract in the pre-harvest management of early blight and its subsequent influence on the postharvest storage life of tomato fruits in the present study.

Phytochemical content and antioxidant activity of aqueous ginger extract at different concentrations: The regression equations from the standard calibration curve of gallic acid and quercetin used for the determination of total phenolic and flavonoid contents in different concentrations of aqueous ginger extract are presented in Fig. 1-2, respectively. The results of the quantitative phytochemical analyses and antioxidant assay showed increase in total phenolic content (TPC), total flavonoid content (TFC) and DPPH radical scavenging activity of the aqueous ginger extract with increased extract concentration (Table 2). Total phenolic content increased from 24.17±1.44 mg GAE/L in 5% extract concentration to 95.83±1.44 mg GAE/L in 20% concentration. Similarly, total flavonoid content increased from 3.56±0.20 mg QE/L at 5% to 12.78±0.19 mg QE/L in 20% v/v aqueous ginger extract. The DPPH radical scavenging activity also followed the same concentration-dependent pattern, increasing from 7.53±0.66% in 5% to 74.08±1.00% in 20% v/v aqueous ginger extract. The increase in TPC and TFC with increased extract concentration indicates that higher proportions of the stock aqueous ginger extract supplied higher amounts of phenolic and flavonoid compounds. Since

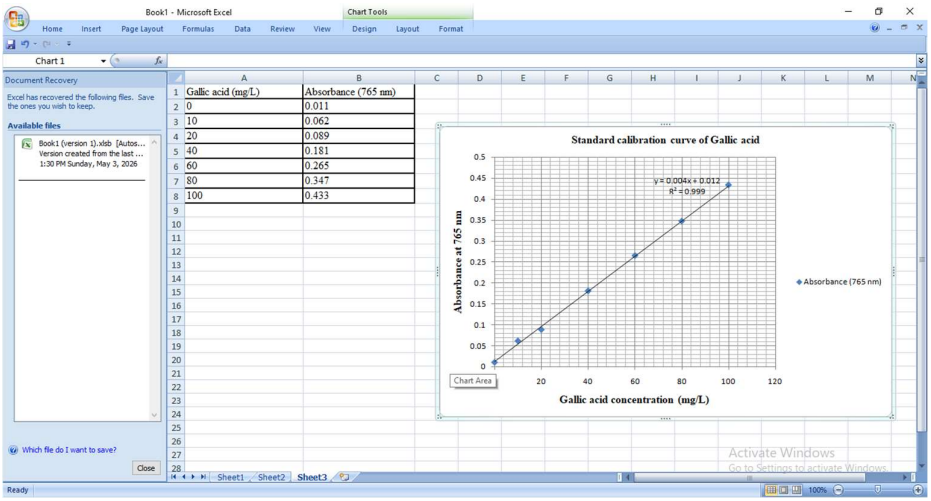


Fig. 1: Standard calibration curve of gallic acid

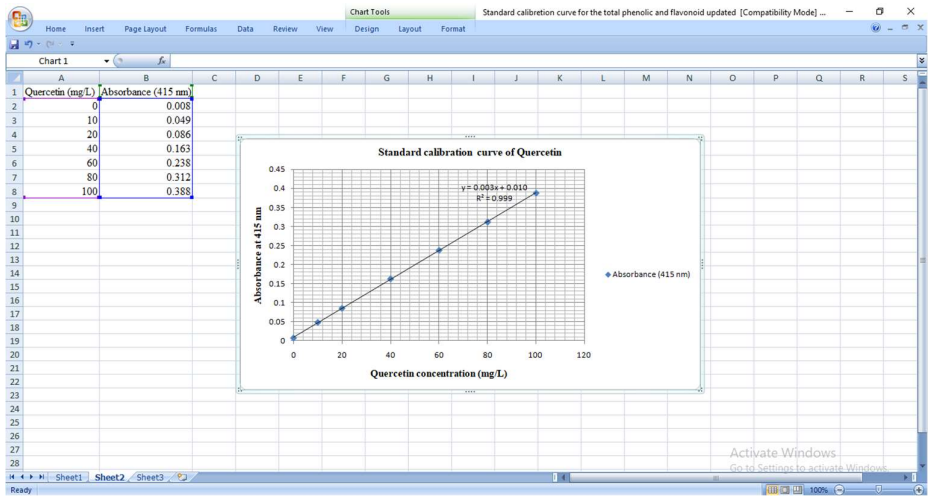


Fig. 2: Standard calibration curve of quercetin

Table 1: Preliminary phytochemical screening of aqueous ginger extract

Phytochemicals	Result
Phenols	+
Flavonoids	+
Others	Not tested

these phytochemicals constitute the principal antioxidant constituents of ginger, their increased concentration corresponded with enhanced free radical scavenging activity observed in the DPPH assay. This relationship is consistent with reports that phenolic compounds, particularly gingerols, shogaols, paradols and related polyphenols in ginger, are primarily responsible for the antioxidant capacity of ginger extracts by donating hydrogen atoms or electrons to neutralize free radicals and interrupt oxidative chain reactions[32,33]. The concentration dependent increase in antioxidant activity observed in the study agrees with findings of Morvaridzadeh *et al.*[30] who reported that higher concentrations of ginger extract contain higher quantities of antioxidant phytochemicals and exhibit stronger radical scavenging activity. Increased antioxidant activity is important in maintaining cellular function through the reduction of oxidative damage associated with tissue senescence and deterioration. According to studies on natural plant antimicrobials, antioxidant-rich plant extracts are associated with enhanced antimicrobial activity that reduces the establishment and progression of pathogens responsible for postharvest deterioration[34,35]. The observed increase in TPC,

Table 2: Total phenolic content (TPC), total flavonoid content (TFC) and DPPH radical scavenging activities (%RSA) of aqueous ginger extract at different concentrations

Aqueous ginger extract	TPC (mg GAE/L)	TFC (mg QE/L)	%RSA
5% v/v	24.17±1.44	3.56±0.20	7.53±0.66
10% v/v	51.67±1.44	6.89±0.38	26.94±0.77
15% v/v	73.33±1.43	9.56±0.20	48.36±0.77
20% v/v	95.83±1.44	12.78±0.19	74.08±1.00

Values are expressed as Means±Standard Deviation (SD)

Table 3: Percentage decay and shelf life of tomato fruits harvested from tomato plants treated with different concentrations of aqueous ginger extract against early blight

Treatments	Percentage decay (%)	Shelf-life (days)
0% (negative control)	86.70[a]	3.33[b]
5% ginger extract	80.00[a]	4.00[b]
10% ginger extract	56.70[b]	6.33[a]
15% ginger extract	43.30[b]	7.00[a]
20% ginger extract	43.30[b]	7.00[a]
Redforce (positive control)	53.30[b]	6.67[a]
Grand mean	60.60	5.72
F pr.	<0.001	<0.001
F-$LSD_{0.05}$	8.00	0.2307
SE	4.50	0.1297
CV (%)	8.70	5.20

F pr.: Fisher's probability (p-value), F-$LSD_{0.05}$: Fisher's Least significant difference at 5% level of probability, SE: Standard error of mean, CV (%) = Coefficient of variation. Means followed by the same letter within a column are not statistically different. Statistical analysis was performed on transformed data, original treatment means are presented. SE, CV and LSD values are derived from the transformed data

TFC and DPPH radical scavenging activity at higher aqueous ginger extract concentrations indicates that concentrated extracts contained higher levels of bioactive compounds with enhanced antioxidant potential.

Effect of preharvest treatments on postharvest decay and shelf life of tomato fruits: The results of the postharvest evaluation showed that preharvest treatments significantly ($p<0.05$) influenced the percentage decay and shelf life of harvested tomato fruits during storage (Table 3). Fruits obtained from untreated plants recorded the highest percentage decay (86.70%) and the shortest shelf life (3.33 days). In contrast, fruits from plants treated with 10%, 15% and 20% aqueous ginger extract recorded significantly lower decay values of 56.70%, 43.30% and 43.30%, respectively. The Redforce treatment also reduced fruit decay (53.30%) compared with the untreated control. A similar pattern was observed for shelf life, where fruits from untreated plants remained acceptable for only 3.33 days, whereas fruits from plants treated with 10%, 15% and 20% v/v ginger extract maintained storage periods of 6.33, 7.00 and 7.00 days, respectively (Table 3). These values were statistically at par with the Redforce treatment (6.67 days). The reduction in postharvest decay following preharvest treatment suggests that management of early blight during production influenced decay development and shelf life of tomato fruits after harvest. Pathogens responsible for postharvest losses often establish infection before harvest, with symptoms becoming visible only when fruits undergo physiological changes during ripening and storage[13]. In tomato, infections by *Alternaria* species can remain latent or develop progressively after harvest as fruit tissues become more susceptible due to ripening associated changes, resulting in increased decay during storage[13,14]. Reducing pathogen establishment in the field can reduce the amount of infection carried into the storage period, thereby limiting decay development after harvest. Improved storage performance observed in fruits from treated tomato plants may be related to physiological condition of the fruits at harvest. Plants exposed to severe disease pressure may produce fruits with increased physiological stress, which can accelerate senescence and reduce storage potential. Effective disease management reduces stress associated with pathogen infection, allowing fruits to maintain better resistance against deterioration after harvest. Plant extracts containing phenolic compounds and flavonoids contribute to enhanced defence responses through activation of plant resistance mechanisms[36]. These compounds stimulate defence related enzymes and increase the accumulation of antimicrobial metabolites, thus improving resistance against pathogen invasion beyond the period of application[37,38]. Although bioactive compounds present in the aqueous ginger extract may have remained on the fruit surface after field application, the improved postharvest storage life observed in this study is more likely attributable to

reduced pathogen establishment before harvest than to residual activity after harvest. Ginger contains bioactive compounds, including phenolics, flavonoids and pungent compounds, which possess antimicrobial and antioxidant properties and may contribute to the protective effects observed following application[21]. This is consistent with the higher phenolic content, flavonoid content and antioxidant activity recorded in the more concentrated ginger extracts. The comparable performance of 10%, 15% and 20% ginger extract treatments with Redforce indicates that aqueous ginger extract provided effective protection that translated into improved postharvest storage performance. However, the absence of significant differences among these treatments suggests that increasing ginger extract concentration beyond 10% did not result in proportional improvement in reducing decay or extending shelf life under the storage conditions of this study.

The findings of the study highlight the importance of integrating preharvest early blight management with reduction in postharvest losses in tomato production. While pre-harvest early blight control is primarily aimed at minimizing field infection and improving crop productivity, the present study shows that its benefits can extend beyond disease suppression in the field by limiting decay development during storage. The use of aqueous ginger extract therefore provide a botanical option for inclusion in sustainable early blight management aimed at reducing reliance on synthetic fungicides while improving postharvest storage life of tomato fruits.

CONCLUSION

The study showed that pre-harvest application of aqueous ginger (*Zingiber officinale*) extract to tomato plants against early blight influenced the postharvest storage life of the fruits. The aqueous ginger extract contained phenolic compounds and flavonoids, with increased concentrations resulting in higher total phenolic content, total flavonoid content and antioxidant activity. Preharvest treatments with 10%, 15% and 20% v/v aqueous ginger extract significantly reduced fruit decay and extended shelf life compared with the untreated control with performance statistically at par with Redforce fungicide treatment. It can be concluded from the findings that preharvest application of aqueous ginger extract at 10, 15 and 20% v/v for early blight management in tomato improves postharvest storage life of the fruits and can be considered as a botanical option for reduction of postharvest losses in tomato value chain.

SIGNIFICANCE STATEMENT

Preharvest application of aqueous ginger extract reduced postharvest fruit decay and extended the storage life of tomato fruits. The 10%, 15% and 20% concentrations showed performance comparable to the standard fungicide treatment, demonstrating the potential of ginger extract as a botanical alternative for early blight management and reducing postharvest losses in tomato production.

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