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Effect of Drying on the Preservation of Lycopene and Antioxidant Activity in Tomato Varieties From the Ashanti Region of Ghana

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ABSTRACT

Research background: Tomato (*Solanum lycopersicum*) is a widely consumed vegetable known for its nutritional value and numerous health benefits. In Ghana, substantial postharvest losses occur during peak harvest due to its high moisture content. This study compared fresh and dried tomato powder from greenhouse and open-field systems to assess lycopene and antioxidant preservation.

Experimental approach: Four tomato varieties (505, 520, 101, and Prostar F1) were harvested from greenhouse cultivation, while three varieties (*Rano*, *Asante,* and *Cocoa ABA*) were obtained from open-field farms in the Asante Region of Ghana. All samples were harvested at the red ripe stage, homogenized, and analyzed for physicochemical properties, proximate composition, and lycopene content to characterize their chemical profiles. Varieties exhibiting high lycopene levels were selected for further evaluation of total phenolic content (TPC) and DPPH radical scavenging activity in both fresh and dried states. Drying was conducted at 40°C for 72 h.

Results and conclusions: Lycopene content varied significantly among fresh samples ($p < 0.05$), with *Asante, Prostar F1*, and 101 recording high values of 2.832 mg/g, 2.101 mg/g, and 1.985 mg/g, respectively. TPC increased after drying, notably in *Prostar F1* (from 630.95 ± 8.65 to 1445.13 ± 8.00 mg GAE/100 g), whereas antioxidant activity declined across varieties, with Asante maintaining the highest activity (95.67 ± 0.37 to 83.63 ± 0.30%). These findings underscore the potential of the Asante variety for developing antioxidant-rich dried tomato products. The *Asante* variety may be suitable for industrial applications due to its high lycopene and antioxidant activity, while the other varieties are more appropriate for fresh consumption.

Novelty and scientific contribution: This study reveals the *Asante* variety as optimal for preserving lycopene and antioxidants in dried tomatoes. This study could have promising applications in the food industry and in ensuring food security.

1 | Introduction

Tomato (*Solanum lycopersicum*) is a widely consumed vegetable, globally valued for its nutritional benefits and versatility in various culinary applications [1]. It is used both raw and cooked in a variety of dishes across cultures. Belonging to the family Solanaceae, which includes many other economically important crops, the tomato is widely cultivated in warm temperate and tropical regions [2]. Certain planting practices such as rejuvenation pruning, weeding, irrigation, and frost protection can enable the tomato plant to behave as a perennial or

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semiperennial. However, they are generally cultivated as an annual crop in commercial settings [2], and their climacteric nature makes them highly perishable [3].

Tomato plants can be cultivated in diverse geographic regions, either in open fields or greenhouses. In several countries, greenhouse systems are employed for large-scale tomato production [4]. Tomatoes can be harvested manually or mechanically, depending on the scale of production. Greenhouse cultivation provides a controlled environment that protects the crop from extreme weather conditions and pests, leading to improved yield and better-quality produce compared to open-field cultivation [5, 6]. It also ensures year-round productivity and maximizes the use of land, making it more efficient than traditional farming methods [6].

Tomato fruits contain approximately 95% water, making them highly perishable. The remaining 5% consists of carbohydrates, fiber, niacin, calcium, and other nutrients essential for human metabolism [6]. Tomatoes are also excellent sources of vitamins A, C, and E, as well as minerals that support immune function and disease prevention [7]. Additionally, they contain over 600 carotenoids, including lycopene [8]. Lycopene, a red-colored hydrocarbon carotenoid ($C_{40}H_{56}$) of particular interest due to its potent antioxidant activity, is responsible for many of tomato's health-promoting properties [9, 10].

In Ghana, tomatoes are among the most widely cultivated and consumed vegetables, particularly in regions such as Ashanti, which is a key tomato-producing zone. However, despite high production levels, postharvest losses remain a major challenge, largely due to poor handling practices, limited storage infrastructure, and inadequate processing facilities. According to recent studies, over 30% of harvested tomatoes in the Ashanti Region are lost before reaching consumers, posing significant economic and nutritional implications [11]. Enhancing postharvest processing, such as drying into tomato powder, could reduce waste, extend shelf life, and support food security in the region (Figure 1).

Drying is one of the most widely used food preservation techniques, especially in developing countries. It reduces moisture content, inhibits microbial and enzymatic activity, and extends shelf life [12]. Additionally, drying reduces weight and packaging needs, thereby lowering transportation costs [13, 14]. However, the drying temperature can influence the nutritional and functional qualities of the final product. For example, oven drying at 55°C has been shown to retain lycopene and vitamin C, producing safe and stable tomato powder with a shelf life of up to 2 months [15]. In contrast, higher temperatures (e.g., 70°C–80°C) may degrade heat-sensitive nutrients such as antioxidants [7]. Although freeze-drying retains more nutrients, hot air oven drying remains a more accessible and cost-effective method for regions with limited resources [16].

This study evaluated greenhouse and open-field tomato cultivars for proximate composition, physicochemical properties, lycopene content, and antioxidant activity, assessing the effects of drying (40°C for 72 h) on lycopene levels and antioxidant capacity with the objective of determining which cultivation system confers superior retention of nutritional and antioxidant properties, with implications for postharvest processing strategies and food security initiatives in Ghana.

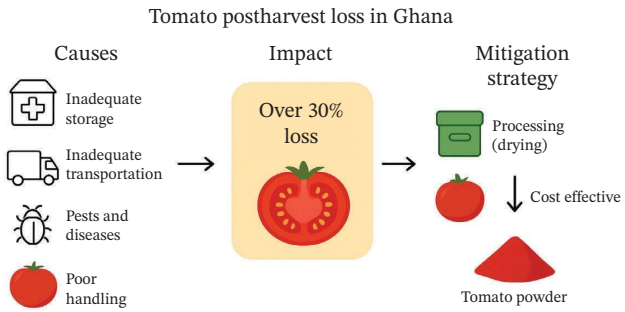

FIGURE 1 | Postharvest losses of tomatoes in Ghana: causes, impacts, and drying to powder as a mitigation strategy.

2 | Materials and Methods

2.1 | Materials and Reagents

Ascorbic acid, 2,2-diphenyl-1-picrylhydrazyl (DPPH), and Folin–Ciocalteau were purchased from Sigma Aldrich (MO, USA). Sodium hydroxide (NaOH), ethanol, acetone, hexane, petroleum ether, and sulfuric acid (H_2SO_4) were of analytical grade.

Seven (7) varieties of tomatoes used for this experiment were obtained from two types of farms, the open field and the greenhouse farms. The open-field varieties (*Rano*, *Asante*, and *Cocoa ABA*) were purchased from a tomato seller at the Kwame Nkrumah University of Science and Technology (KNUST) commercial area market. The greenhouse varieties (520, 505, 101, and *Prostar F1*) were obtained from the Department of Horticulture, KNUST. All tomatoes were purchased or harvested at their fully red-ripe stage and authenticated at the Department of Horticulture, KNUST. The samples were transported in an opaque sealed container to the laboratory at the Department of Food Science and Technology (KNUST), followed by sorting the defective ones and washing them thoroughly with clean, flowing tap water. The samples were portioned in Ziploc bags and stored at −20°C until further analysis.

2.2 | Experimental Design

Both open-field and greenhouse tomato varieties were screened for proximate composition, physicochemical properties, and lycopene content. The highest-lycopene varieties, *Asante, 101*, and *Prostar F1*, were selected. Briefly, 100 g of the selected varieties were homogenized and pretreated with 1 g of ascorbic acid to prevent browning [9]. The mixture was then dried in a hot air oven at 40°C for 72 h to produce a powdered form. Subsequently, lycopene, color, total phenolic content (TPC), and DPPH radical scavenging activity were determined using appropriate standard methods.

2.3 | Proximate Analysis

Moisture content was determined according to the method described by Fssai [17]. Briefly, 5.0 g of both fresh samples were accurately weighed into predried and tared moisture dishes. The dishes were then placed in a hot air oven maintained at 105 ± 2°C for 4 h or until a constant weight was attained. After drying, the dishes were cooled in a desiccator and reweighed. The moisture

content (%) was calculated as follows: Moisture content (%) = (W2-W1)/W1 x100/1.

Where W2 is the initial weight of the sample (g), and W1 is the weight after drying (g)

The method described by Nielsen [18] was used in determining the ash content. Briefly, 5.0 g of fresh samples were weighed into tared crucibles and incinerated in a muffle furnace at 600°C for 6 h until a light gray ash was obtained. After cooling to 250°C, crucibles were carefully removed, cooled in a desiccator, and weighed. The recorded weights were used to calculate the ash content as follows:

$$\text{Ash}(\%) = \frac{(W3 - W1)/(W2 - W1)}{2} \times 100, \quad (1)$$

where $W1$ is the weight of the empty crucible, $W2$ is the weight of the crucible plus the sample before ashing and $W3$ is the weight of the crucible plus ash after ashing.

Protein content was determined by the Kjeldahl method [2, 18]. Briefly, 0.2 g of both fresh samples were weighed into Kjeldahl digestion tubes. H_2SO_4 (10 mL) and a catalyst were added to digest the samples until clear. The digested samples were cooled, diluted with distilled water, and 10 mL of the diluted solution was neutralized with excess NaOH. Subsequently, 10 mL of 4% boric acid was placed in a 250 mL conical flask, into which 100 mL of the neutralized sample was distilled. The distillate was titrated with 0.0239 M hydrochloric acid using two drops of mixed indicator. Protein content was calculated using the formula as follows:

$$\text{protein}(\%) = \frac{(\text{sample} - \text{blank}) \times 0.014 \times 0.1\text{N.HCl} \times 100 \times 6.25)/(\text{weight of sample})}{3} \times 100, \quad (2)$$

where sample and blank are the titrant volumes (mL).

Fat content was determined by the standard continuous solvent extraction method using petroleum ether (Goldfish method) as described by Nielsen [18]. Samples were accurately weighed into preweighed extraction thimbles and placed in the extraction apparatus. Petroleum ether was used as the extraction solvent and allowed to reflux continuously over the samples for 4 h. Following extraction, the solvent was evaporated by drying the extraction flask at 100°C for 30 min. The flask was then cooled in a desiccator and weighed. Fat content (%) was calculated as follows:

$$\text{fat}(\%) = \frac{W2 - (W2 - W1)}{\text{sample weight}(g)} \times 100, \quad (3)$$

where $W2$ and $W1$ represent the weights of the extraction flask before and after fat extraction, respectively.

Crude fiber was determined according to the standard Soxhlet extraction method [19]. Briefly, 5.0 g the samples were boiled with 100 mL of 1.25% H_2SO_4 under reflux for 30 min. The mixture was filtered and washed with distilled water until acid-free. The residue was then boiled with 100 mL of NaOH solution under reflux for another 30 min, filtered using a preweighed crucible, and washed until neutral. The crucible was oven-dried at 110°C for 2 h, cooled in a desiccator, and weighed. It was then ignited in a muffle furnace at 600°C for 30 min, cooled, and reweighed. The crude fiber content (%) was calculated based on the difference in weight before and after ashing.

$$\text{crude fiber}(\%) = \frac{(\text{W2} - \text{W1})}{(\text{W1} \times 100)}, \quad (4)$$

where $W1$ is the weight of the sample, $W2$ is the weight of the crucible and dried residue and $W3$ is the weight of the crucible and ash.

2.4 | Physicochemical Analysis

The pH was measured using a calibrated Mettler Toledo pH meter (model: Seven Compact pH/S220). Dried samples were reconstituted and analyzed using the same procedure. The pH readings were taken in triplicates.

Total soluble solids (TSSs) were determined using a Reichert AR200 digital refractometer. Briefly, homogenized filtered fresh samples and reconstituted dried samples were applied to the illumination plate, and the Brix values were recorded in triplicate.

Color parameters of fresh and dried tomato samples were measured using a Chroma Meter CR-410 (Konica Minolta Inc., Japan) based on the Hunter Lab scale. The L^* value denotes lightness (0 = black, 100 = white), a^* indicates red-green intensity, and b^* represents yellow-blue intensity [19]. The total color difference ΔE was calculated as

$$\Delta E = \sqrt{\left(\left\{(L^*)^2 + (a^*)^2 + (b^*)^2\right\}\right)}, \quad (5)$$

where L^*, a^* and b^* represent the lightness, red-green, and yellow-blue values, respectively.

2.5 | Extraction and Quantification of Lycopene

The quantification of lycopene in both fresh and dried tomato samples was carried out using a spectrophotometric method as described by Fish et al. [20], with slight modifications. Briefly, 0.6 g of the homogenized tomato sample was accurately weighed into a test tube, followed by the addition of 5 mL of acetone, 5 mL of 95% ethanol, and 10 mL of hexane. The mixture was vortexed for 15 min while kept in an ice bath to enhance extraction efficiency. Subsequently, 3 mL of distilled water was added and vortexed for 5 min. The sample was allowed to stand at room temperature for 5 min to facilitate phase separation. The upper hexane layer, containing the lycopene extract, was carefully collected. The absorbance was measured at 503 nm using hexane as the blank.

2.6 | Antioxidant Activity

Fresh and dried homogenized tomato samples were extracted using 50% acetone. One gram (1 g) of each sample was placed in a test tube, mixed with 10 mL of 50% acetone, vortexed for 2 min, and kept in the dark for 10 min. This extraction was repeated twice, yielding a total volume of 30 mL. The mixture was then

centrifuged at 4000 rpm for 4 min, and the supernatant was obtained for subsequent experiments [21].

TPC was measured using the Folin–Ciocalteu method [22]. Sample extracts (100 μL) were mixed with 0.2 mL of Folin–Ciocalteu reagent and 2.0 mL of distilled water, then incubated at room temperature for 3 min. Subsequently, 1.0 mL of 20% sodium carbonate was added, and the mixture was incubated for 1 h at room temperature. Absorbance was measured at 765 nm using a spectrophotometer (Mettler Toledo UV5). The TPC was calculated from a standard curve of gallic acid ($R^2 = 0.9946$), and the results are expressed as gallic acid equivalents (GAE), in milligrams per 100 g of dry matter.

The antioxidant activity of the extracts was evaluated using the DPPH radical scavenging assay [23]. Briefly, 3 mL of tomato extract was mixed with 1 mL of 0.1 mM DPPH solution in methanol. The mixture was incubated at 37°C for 30 min in the dark, after which the absorbance was measured at 517 nm against a methanol control using a spectrophotometer. The percentage of inhibition was calculated by comparing the absorbance of the sample to that of the control using the following equation:

$$\text{DPPH scavenging activity}(\%) = \frac{(Ao - A1)}{(Ao)} \times 100, \qquad (6)$$

where Ao 1s the absorbance of the control and $A1$ is the absorbance of the sample.

3 | Results and Discussion

The proximate composition analysis of the seven tomato varieties revealed notable variability in moisture, ash, protein, fat, and crude fiber content, reflecting inherent genetic and environmental influences on their nutritional profiles (Table 1).

Moisture content, ranging from 94.35% to 96.86%, was within the typical range reported for fresh tomatoes [24]. The higher moisture levels observed in varieties such as *Rano* and *Cocoa ABA* could influence their postharvest shelf life and susceptibility to microbial spoilage, emphasizing the need for effective drying or preservation methods to reduce postharvest losses, which are significant in Ghanaian tomato production systems [11].

Ash content, indicative of total mineral content, was relatively uniform across varieties, suggesting comparable mineral accumulation despite differences in cultivation systems. This aligns with findings from other studies reporting minor variation in mineral content among tomato cultivars [25]. The slightly higher ash content in variety 505 may suggest marginally better mineral nutrition, potentially advantageous for dietary mineral intake.

Protein levels varied considerably, with varieties 520 and 101 exhibiting higher protein content (2.13% and 2.29%, respectively). Though tomatoes are not primary protein sources, this variability may contribute modestly to nutritional value, especially in diets relying on plant-based foods [26].

Fat content was low across all varieties, consistent with the known low lipid profile of tomatoes [27]. However, variations were noted, with 505 and *Prostar F1* showing relatively higher fat content, which may influence sensory properties like flavor and mouthfeel.

Dietary fiber is crucial for digestive health, and higher fiber content enhances the functional value of tomatoes [28]. Crude fiber content showed significant differences, particularly with Asante and *Rano* varieties containing notably higher fiber levels (1.9% and 1.27%, respectively). The differences might also affect texture and drying characteristics, as fiber contributes to water binding and structural integrity.

These compositional differences underline the importance of variety selection based on the desired nutritional profile and intended use. For example, varieties with higher fiber and moderate moisture, such as *Asante* and *Rano*, might be better suited for drying into powders or functional food ingredients due to potentially improved drying efficiency and retention of health-promoting components. Conversely, varieties with higher protein content, like 101 and 520, may appeal more for fresh consumption, where nutritional diversity is prioritized. Moreover, understanding these compositional parameters aids in optimizing processing conditions to maximize nutrient retention, particularly for bioactive compounds such as lycopene and phenolics, which are sensitive to moisture and thermal degradation during drying [29]. Such insights are valuable for reducing postharvest losses and enhancing the value addition of tomatoes in Ghana.

Tomatoes possess valuable physicochemical properties, including pH, titratable acidity, TSSs, and color attributes, all of which influence processing quality, shelf life, and consumer acceptance.

Low pH and moderate acidity contribute to natural preservation and flavor enhancement in tomatoes [30]. This study revealed a significant difference in the pH values among the fresh tomato varieties, likely due to variations in their citric acid content [31]. The pH values ranged from 3.815 (*Rano*) to 4.485 (505),

TABLE 1 | Proximate analysis of different fresh tomato cultivars.

Variety	%Moisture	%Ash	%Protein	%Fat	%Crude fiber
505	94.345 ± 0.22^{a}	0.611 ± 0.02^{a}	1.020 ± 0.00^{a}	1.117 ± 0.09^{c}	0.310 ± 0.07^{b}
520	96.025 ± 0.01^{bc}	0.379 ± 0.02^{a}	2.13 ± 0.00^{b}	0.792 ± 0.01^{b}	0.268 ± 0.01^{ab}
101	96.095 ± 0.06^{bc}	0.374 ± 0.12^{a}	2.292 ± 0.00^{b}	0.689 ± 0.07^{b}	0.033 ± 0.00^{a}
Prostar F1	95.546 ± 0.02^{b}	0.355 ± 0.12^{a}	1.216 ± 0.12^{a}	0.904 ± 0.07^{bc}	0.068 ± 0.00^{ab}
Rano	96.860 ± 0.18^{d}	0.375 ± 0.00^{a}	1.465 ± 0.06^{a}	0.057 ± 0.00^{a}	1.273 ± 0.06^{c}
Asante	96.454 ± 0.03^{cd}	0.443 ± 0.02^{a}	1.308 ± 0.19^{a}	0.094 ± 0.01^{a}	1.886 ± 0.00^{d}
Cocoa ABA	96.818 ± 0.01^{d}	0.385 ± 0.00^{a}	1.158 ± 0.04^{a}	0.083 ± 0.01^{a}	1.226 ± 0.07^{c}

Note: Data are represented as mean ± SEM ($n = 2$). Values in the same column with different alphabetical superscripts are significantly different at $p < 0.05$.

indicating typical acidity levels for ripe tomatoes [32]. Varieties *Rano* and Asante had notably lower pH values (3.815 and 3.940, respectively), suggesting higher acidity, which can influence taste, microbial stability, and shelf life. Higher acidity is often preferred in tomato products to enhance flavor and act as a natural preservative. Conversely, varieties 505, 520, and *Prostar F1* had higher pH values above 4.3, which might result in milder taste profiles. According to Akbudak et al. [33], pH levels below 4.5 are beneficial for product quality, as they inhibit the proliferation of microorganisms during industrial processing. The low pH observed in the dried tomato powder suggests microbial safety and shelf stability, making them suitable for cost-effective preservation and industrial processing.

TSSs are closely associated with the sweetness and nutritional quality of tomato fruit, reflecting the concentration of sugars and organic acids in the pulp [30, 34]. The highest TSS values were recorded in *Rano* (4.7°Brix) and *Asante* (4.6°Brix), indicating these varieties are likely sweeter and more flavorful. The lowest TSS was found in 520 (3.0°Brix), with other varieties ranging between 3.2 and 3.6°Brix. Higher TSS indicates sweetness and is generally preferred for fresh consumption and industrial processing into sauces or concentrates [35].

Color is a critical quality parameter influencing consumer preference for tomatoes and tomato-derived products [35]. All varieties had similar brightness levels (ΔL) (34.8–39.4), with *Rano*, *Asante*, and *Cocoa ABA* exhibiting slightly higher values (39.2), suggesting these varieties may appear visually brighter or lighter. However, *Prostar F1* showed the highest redness value (16.26), significantly higher than other varieties, indicating a more intense red color, which is desirable in tomatoes. Other varieties had Δa values ranging from 10.18 to 14.45. The redness is a key visual quality parameter, as it is associated with lycopene content and ripeness [36]. The highest yellowness was observed in *Rano* (6.7) and *Asante* (6.38), whereas varieties like 520 (3.98) and 101 (4.5) had lower yellowness. Yellowness can influence perceived ripeness and consumer preference [37].

This study reveals that *Rano* and *Asante* have lower pH and higher TSS, suggesting that they could offer a sweeter and more acidic flavor profile favorable for fresh consumption and processing [32]. *Prostar F1*, on the other hand, has higher redness (Δa), indicating strong color appeal, potentially linked to higher lycopene levels, making it suitable for markets valuing visual quality (Table 2). The variation in color parameters among varieties could also influence their processing behavior and product appeal.

TABLE 3 | Lycopene content of different fresh and dried tomato cultivars.

Variety	Lycopene (mg/g)	
	Fresh	Dried
505	1.339 ± 0.21^{a}	ND
520	1.060 ± 0.12^{a}	ND
101	1.985 ± 0.22^{b}	0.44 ± 0.06^{a}
Prostar F1	2.101 ± 0.00^{b}	0.510 ± 0.01^{a}
Rano	1.481 ± 0.24^{a}	ND
Asante	2.832 ± 0.03^{c}	0.896 ± 0.06^{b}
Cocoa ABA	1.424 ± 0.01^{a}	ND

Note: Data are represented as mean ± SEM ($n = 2$). Different superscript letters indicate significant differences ($p < 0.05$). Values in the same column with different alphabetical superscripts are significantly different at $p < 0.05$.
Abbreviation: ND = not determined.

Antioxidants are vital compounds that protect the body from damage caused by oxidative stress and free radicals. Antioxidant-rich foods, including tomatoes, contribute to overall health and reduce the risk of many chronic diseases. Phenolic compounds and lycopene are examples of antioxidants that contribute significantly to the nutritional quality of foods [38]. These compounds, particularly phenolic acids, are metabolic intermediates that typically accumulate in plant vacuoles. Due to the presence of hydroxyl groups, they exhibit strong antioxidant activity by neutralizing reactive oxygen species (ROS) [39].

Lycopene is a potent antioxidant carotenoid predominantly found in tomatoes, capable of efficiently neutralizing ROS due to its extended system of conjugated double bonds. In this study, the lycopene content of fresh tomatoes from open-field and greenhouse systems ranged from 1.060 ± 0.12 to 2.832 ± 0.03 mg/g. The highest concentrations were recorded in *Asante* (2.832 ± 0.03 mg/g), *Prostar F1* (2.101 ± 0.01 mg/g), and 101 (1.985 ± 0.22 mg/g) varieties (Table 3). The open-field variety *Asante* exhibited the highest lycopene level, suggesting that its genetic makeup, cultivation techniques, and environmental conditions may have contributed to increased lycopene biosynthesis [4, 6]. The high-lycopene varieties were dried in a hot-air oven at 40°C for 72 h. Lycopene content decreased across all varieties after drying, likely due to thermal degradation. This aligns with

TABLE 2 | Physicochemical analysis of different fresh tomato cultivars.

Variety	pH	TSS (Brix)	Color		
			ΔL	Δa	Δb
505	4.485 ± 0.01^{d}	3.600 ± 0.00^{b}	35.540 ± 0.72^{a}	13.785 ± 0.26^{a}	5.040 ± 0.12^{abc}
520	4.405 ± 0.01^{d}	3.000 ± 0.00^{a}	37.040 ± 0.17^{a}	10.185 ± 0.16^{a}	3.980 ± 0.05^{a}
101	4.340 ± 0.01^{c}	3.550 ± 0.01^{b}	35.985 ± 1.09^{a}	12.750 ± 0.67^{a}	4.505 ± 0.27^{ab}
Prostar F1	4.450 ± 0.01^{d}	3.200 ± 0.00^{ab}	34.850 ± 2.37^{a}	16.260 ± 2.18^{b}	5.625 ± 0.85^{abc}
Rano	3.815 ± 0.01^{a}	4.700 ± 0.00^{c}	39.415 ± 0.10^{a}	13.985 ± 0.35^{ab}	6.705 ± 0.01^{c}
Asante	3.940 ± 0.02^{b}	4.600 ± 0.20^{c}	39.160 ± 0.05^{a}	14.445 ± 0.02^{ab}	6.380 ± 0.03^{bc}
Cocoa ABA	3.985 ± 0.04^{b}	3.300 ± 0.10^{ab}	39.250 ± 0.14^{a}	12.270 ± 0.10^{ab}	4.675 ± 0.01^{ab}

Note: Data are represented as mean ± SEM ($n = 2$). Values in the same column with different alphabetical superscripts are significantly different at $p < 0.05$.

TABLE 4 | Antioxidant activity of different fresh tomato cultivars.

Variety	TPC mg GAE/100 g		% DPPH scavenging activity	
	Fresh	Dried	Fresh	Dried
101	833.90 ± 0.65^{a}	879.63 ± 0.60^{a}	95.07 ± 1.60^{a}	82.61 ± 1.60^{a}
Prostar F1	630.95 ± 8.65^{b}	1445.13 ± 8.0^{b}	93.17 ± 0.25^{b}	80.52 ± 0.20^{b}
Asante	756.36 ± 9.42^{c}	1188.64 ± 9.0^{c}	95.67 ± 0.37^{a}	83.63 ± 0.30^{a}

Note: Data are represented mean ± SEM ($n = 2$). Values in the same column with different alphabetical superscripts are significantly different at $p < 0.05$.

findings by Srivalli et al. [9], who observed substantial lycopene degradation and isomerization during conventional air drying, possibly due to prolonged exposure to heat and oxygen. Similarly, Srivalli et al. [9] reported a significant reduction ($p < 0.05$) in lycopene content in dried tomato powder using the same drying method. In contrast, Yusufe et al. [31] observed an increase in lycopene content when tomatoes were dried at higher temperatures (70°C–90°C) for 8 h, which may reflect varietal differences and processing conditions. Our study suggests that conventional hot air drying at low temperatures still led to significant lycopene degradation due to prolonged heat exposure and oxidation.

All varieties showed an increase in TPC after drying. *Prostar F1* exhibited the most significant increase, with TPC rising from 630.95 to 1445.13 mg GAE/100g, more than doubling its phenolic concentration. *Asante* and 101 also showed increased TPC after drying, reaching 1188.64 and 879.63 mg GAE/100g, respectively. This increase may be primarily due to moisture loss during drying, which concentrates phenolic compounds per unit weight [32]. Additionally, drying can enhance the extractability of bound phenolics by breaking down cell walls [40] or through ascorbic acid pretreatment.

All 3 varieties of tomatoes showed high free radical scavenging activity, which ranged from 93% to 95%, with *Asante* recording the highest scavenging activity (95.67 ± 0.37). According to Chang et al. [41], tomato has tremendous scavenging activity, ranging from 87.7% to 99.7%. Despite the increase in TPC, antioxidant activity measured by DPPH scavenging decreased after drying in all varieties (Table 4). Fresh samples of *Asante* and 101 showed high antioxidant activity (95%), while *Prostar F1* was slightly lower (93%). After drying, activity dropped to approximately 80%–83%, with *Asante* retaining the highest activity (83.63%), followed by 101 (82.61%) and *Prostar F1* (80.52%). This reduction suggests that some phenolic compounds or other antioxidants may degrade or lose efficacy during the drying process [42]. A study by Diaz-Moreno [43] reported much lower antioxidant activity (0.15%–0.17%) in tomato samples dried at higher temperatures (50°C–70°C), highlighting the need to consider drying temperature as a critical factor in preserving antioxidant properties. This study demonstrated that the *Asante* variety retained relatively high TPC and antioxidant activity following drying, highlighting its potential as a promising candidate for products aimed at preserving antioxidant properties.

4 | Conclusions

This study revealed significant variations among tomato varieties in their nutritional and physicochemical characteristics. Open-field tomatoes exhibited higher fresh-state lycopene levels, which may be attributed to increased solar radiation and environmental stress stimulating carotenoid biosynthesis. In contrast, greenhouse cultivation produced more stable lycopene concentrations and enhanced protein and crude fat content under controlled conditions, whereas open-field conditions promoted higher crude fiber and moisture content. Drying notably reduced lycopene content and antioxidant activity but concentrated total phenolic compounds. Among the varieties tested, the open-field *Asante* variety demonstrated superior retention of lycopene and antioxidant capacity postdrying, highlighting its potential for industrial processing and functional food development. Conversely, the other varieties were better suited for fresh consumption. These findings underscore the importance of varietal selection in optimizing both the nutritional quality and processing performance of tomato products, while also contributing to food security in Ghana by reducing postharvest losses and extending tomato shelf life.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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