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Nutritional evaluation of twenty-four disease and pest resistance tomato varieties

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Tomato, a fruit vegetable, is widely used in many dish components such as soup, stew/sauce, salad, and juice with many benefits. Even though annual and perishable, tomatoes are required yearly for use. Tomato production thus serves as a livelihood and food security activity across the country with different varieties. Some of these varieties, however, do not meet production criteria and consumer preferences. As such, introducing the twenty-four disease and pest-resistance varieties will help ease the burden on farmers and the frequent losses associated with the cultivation of non-resistant varieties. The tomato variety experimentations were conducted at Nyangua in the Kassena Nankana East Municipality of the Upper East Region of Ghana. Samples from the 24 disease-resistant varieties were collected for laboratory analysis on fruit skin colour, titratable acidity, moisture content, total soluble solutes, and vitamin C. The analyses were conducted using the official methods of analysis by the association of official and analytical chemists. Laboratory results were analysed for variance (ANOVA) using Minitab statistical software. Results indicated all twenty-four varieties contained adequate nutritional value for consumer acceptance, having passed the production phase successfully. It is, however, recommended that the varieties be commercially produced for farmers' use.

Key words: Vegetable, *Solanum lycopersicum*, pathological resistance, nutrient composition, fruit quality, commercial production.

INTRODUCTION

Vegetable production is an important agricultural component contributing to the health of consumers and the economic growth of many nations. Vegetables can be categorised as indigenous and exotic and described as roots, bulbs, fruits, stems, and leaves. Examples of vegetables include pepper, tomato, amaranth/spinach, carrot, cabbage, jute mallow, okro/okra, and roselle. In most African dishes, vegetables are added to the protein parts to form stews/sauces and soups. One common vegetable often added to most stews and soups is the tomato. Tomatoes are a nutritious and delicious food that offers a variety of health benefits. Incorporating tomatoes into diets can help to improve heart health, reduce the risk of certain types of cancer, improve skin health, aid digestion, and assist in weight management.

In Ghana, different varieties/cultivars of tomatoes are

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grown with some cultivars named after the areas of production, such as “Techiman”, “Akumadan, Wenchi”, “Burkina”, “Dagomba”, and “Wosowoso”. However, the production of tomatoes in Ghana has its benefits and challenges, such as a source of employment for value chain actors, pests and diseases, poor quality of fruits, inadequate market, and high postharvest losses.

The AfricaRising project introduced high beta carotene tomato varieties in 2017 to implement the nutrition-sensitive agriculture option. Although these were high-yielding lines, farmers could not sell the extra production because the market did not accept the orange-coloured skin. Farmers in Northern Ghana have been facing diseases and pest damage to vegetables (tomato wilting, virus on pepper, white flies, and *Tutaabsoluta*). In some areas around the dams of the Upper East Region (UER), farmers abandoned vegetable production due to the high pressure and damage of parasites. Twenty-four (24) pests and diseases tolerant/resistant lines of tomatoes that meet both farmers' and the market requirements were experimented in Nyangua in the Kassena Nankana East Municipality, UER and Duko in the Savalugu Municipality, Northern Region (NR). The purpose of this study to test the twenty-four varieties and evaluate the yield and nutritional attributes.

MATERIALS AND METHODS

Study area

The experimental trials were conducted at Nyangua in the KassenaNankana East Municipality of the Upper East Region of Ghana. The KassenaNankana East municipality lies approximately between latitude 11°10' and 10°3' North and longitude 10°1' West. About 82.7% of households are engaged in agriculture. In rural areas, 93.1% of households are agricultural, while 56.8% are agricultural-based in urban areas. Most households in the municipality (96.1%) are involved in crop farming, with poultry (chicken) as the dominant animal reared in the municipality (GSS, 2014).

Experimental layout

Twenty-four tomato varieties (Table 1) comprising sixteen entries (introduced line) from the World Vegetable Center (WorldVeg) tomato breeding program, seven farmer-preferred varieties (popular inbred line) of good quality and one bacterial wilt-resistant variety constituted the genetic material used for the experiment. A randomized complete block design with three replicates was used for the experiment and evaluated for yield and fruit quality. The WorldVeg tomato entries were previously characterized for the presence of genes conditioning TYLCD resistance (Ty genes) and bacterial wilt resistance genes Bwr-12 and Bwr-6 and several other disease resistances (Hanson et al., 2016). Some commercial hybrids and popular inbred entries were included in this study because of their good fruit appearance and potential good yield. ICRXINA, one of the inbred varieties in this study, is popular in Mali and other neighbouring countries for its yield and heat resistance. Seedlings of these entries and varieties were raised in the nursery under the greenhouse during the dry cool season (November 2019 to March 2020). The fields were cleared, ploughed and ridges were created per plot. Organic manure consisting of cow dung and goat droppings was applied to each plot at a rate of 19 t/ha five days prior to transplanting. Seedlings were transplanted four weeks after nursery establishment and at the 4-5 leaf stages. Seedlings were transplanted at 60 cm between rows and 40 cm within plants. Each plot contained a total of 24 plants with 12 plants per row. Weeding was regularly conducted and NPK (17-17-17) fertilization at a rate of 200 kg/ha was used as a basal application. Plants were irrigated when needed.

Data collection and analysis

Data was collected from each row excluding two plants at the end of each row to determine fruit yield and quality at four harvests. Tomato quality analyses were conducted for fruit skin colour, titratable acidity, moisture content, total soluble solutes, and vitamin C using the following procedure.

Tomato skin colour determination

Fresh tomato samples were wiped with soft tissue paper to remove dirt and moisture on their surfaces. The cleaned tomato fruit samples were subjected to colour analysis using a Konica Minolta chromameter (CR 400, Japan) following procedures outlined by Ashebir et al. (2009), with little modification. Briefly, colour properties such as L* (0 = dark/black and 100 = light/bright), a* (negative value = green and positive value = red), and b* (negative value = blue and positive value = yellow) of two tomato fruits of each sample were measured five times (thrice on one fruit and twice on the other) at different parts by ensuring the chromameter, and the fruits were in direct contact. Before the colour determination, the chromameter was calibrated with a D65 white plate (X= 0.3219, Y= 80.1, y= 0.3394). Average values of the colour mentioned earlier properties of the samples were recorded.

Determination of titratable acidity

Ten milliliters of tomato juice was kept in a 250 ml Erlenmeyer flask. 20 ml of distilled water was added to lighten the colour to make it easy to spot the endpoint. Five drops of phenolphthalein indicator was added to the mixture and swirled. The standard sodium hydroxide solution was titrated with a burette and kept in a sample flask, and swirling continued till a pink colour that was stable for a minimum of 20 s was observed. The endpoint titre values were recorded in triplicate (AOAC, 1990). For 0.0667N NaOH, the quantity of this solution used yields total acidity in the appropriate units without the necessity of any calculations. For example, a total volume of 7.12 ml of 0.0667 N NaOH corresponds directly to a TA of 7.12 g/l as tartaric acid.

Moisture content determination

Three grams of the tomato paste was dried to a constant weight in a hot air oven set at 105°C for 4 h to attain consistent weights. Weight loss was calculated over 100 to determine moisture percentage (AOAC, 2005).

Total soluble solutes determination

The content of the soluble solutes was determined using the 0-32Brix hand refractometer and calibrated using distilled water. Before the reading was taken, a few drops of the tomato mixture were placed on the prism and closed with the lid for 30 s. The

Table 1. Tomato entries evaluated for fruit quality and yield.

Distribution code	Internal code	Type	TYLCD resistance genes			Bacterial wilt genes						RKN	FW	LB
			Ty1/3	Ty-2	Ty-5	Bwr-12	Bwr-6a		Bwr-c		Bwr6-d	Mi	I2	Ph-3
							6–124	6–118	6–17	6–94	6–110			
AVTO1003	CLN3125L	Introduced line	+	+	–	+	–	–	–	–	–	–	–	–
AVTO1007	CLN3078A	Introduced line	+	+	–	+	–	–	–	–	–	–	–	–
AVTO1008	CLN3078C	Introduced line	+	+	–	+	–	–	–	–	–	–	–	–
AVTO1121	CLN3150A-5	Introduced line	–	–	+	+	–	–	–	–	–	–	–	–
AVTO1429	FMTT1733D	Introduced line	+	+	–	+	–	–	–	–	–	–	+	–
AVTO1464	FMTT1733E	Introduced line	+	+	–	+	–	–	–	–	–	–	+	–
AVTO1704	CLN3900D	Introduced line	+	+	–	+	–	–	–	–	–	+	+	–
AVTO1705	CLN3902C	Introduced line	+	+	–	+	–	–	–	–	–	–	+	+
AVTO1706	CLN3961D	Introduced line	+	+	–	+	–	–	–	–	–	–	–	–
AVTO1707	CLN3961C	Introduced line	+	+	–	+	–	–	–	–	–	–	–	–
AVTO1711	CLN3641F	Introduced line	–	–	–	+	+	+	+	+	+	–	–	–
AVTO1715	CLN3938E	Introduced line	+	–	–	+	+	+	+	–	+	–	–	–
AVTO1717	CLN4018B	Introduced line	–	–	–	+	+	+	+	+	+	–	–	–
AVTO1718	CLN4018C	Introduced line	–	–	–	+	+	+	+	+	+	–	–	–
AVTO1719	CLN4018D	Introduced line	+	–	–	+	–	–	+	+	+	+	–	–
AVTO1729	CLN3961E	Introduced line	+	+	–	+	–	–	–	–	–	–	–	–
ICRIXINA		Popular inbred line	-	-	-							+		
Kènèya		Popular inbred line												
Konica		Popular inbred line												
Formona		Popular inbred line												
Nayeli		Popular inbred line												
Malinka		Popular inbred line												
UC82B		Popular inbred line												
V1043614	H7996	Bacterial wilt-resistant rootstock	–	–	–	+	+	+	+	+	+			–

'+' homozygous for resistance allele, '-' homozygous susceptible allele, '/' = heterozygous, H = heterogeneous. Bwr-12 and Bwr-6 genes condition bacterial wilt resistance. Ty1/Ty3, Ty2and ty5 genes condition resistance to tomato yellow leaf curl disease. Ph-3 conditions late blight (LB) resistance. Mi gene conditions resistance to the RKN = root-knot nematode (Meloidogyne incognita). I2 conditions resistance to race 2 of the FW = Fusarium wilt pathogen. WorldVeg lines prefixed with AVTO code were evaluated for disease-resistance genes. ICRIXINA is a pure line resistant to nematode and *Xanthomonas campestris* but susceptible to TYLCD. H9881 is a hybrid resistant to Verticillium wilt race 1, Fusarium wilt race 1 and 2, and nematode. Absence of + or – in the table means, no information is available if those commercial hybrids or popular inbred lines have resistance genes for one or more pathogens.
Source: Bihon et al., 2022

instrument was then turned towards the light for the reading to be taken. The position at which the demarcation line between the light and the dark regions crossed the vertical scale gave the percentage of the readings (AOAC, 1990).

Vitamin C determination

A clean 50 ml graduated cylinder was used to measure 20 ml of vitamin C standard solution and transferred into a 50 ml Erlenmeyer flask (the shape of this flask allows you to swirl the solution to mix it without spilling). Ten drops of starch indicator solution were added to the mixture. A 50 ml burette was set up on the ring stand. A funnel was used to carefully fill the buret with the iodine titration solution. The Erlenmeyer flask (containing the vitamin C with starch indicator solution) was placed under the buret. The spring clamp of the buret was carefully released to add iodine solution drop by drop. The flask was swirled to mix in the iodine solution after each addition. The titration was completed when the iodine created a blue-black colour in the solution that lasted longer than 20 s. The final volume of the iodine solution in the burette was recorded. The difference between the initial and final volumes was the amount of iodine titration solution needed to oxidise the vitamin C (AOAC, 1990).

Statistical analysis

Data was analysed for variance (ANOVA) using Minitab statistical software. The treatment means were separated using Turkey post Hoc option with significance at P≤0.05, Kruskal-Wallis test in XLSTAT version 2016.

RESULTS AND DISCUSSION

Tomato fruit yield

There was a significant difference (<0.001) in yield recorded for the various varieties. The average tomato fruit yield recorded was 14.6 t/ha with the lowest of 8.67 t/ha (Formona) and the highest yield of 31.11 t/ha (VI043614). Bihon et al. (2022) reported similar findings as tomato yield ranged from 6.5 - 40.9 t/ha. Higher yields generally translate to more profit which makes tomato farmers in Ghana interested in the yield capabilities of tomato varieties (Lamptey and Koomson, 2021). Varieties V104364, ICRIXINIA and UC82B had higher yield potentials and would therefore be a variety of interest to farmers.

Nutrient quality evaluation

Nutrient qualities (Table 2) varied and could be attributed to genetic differences between varieties. The results were compared to the USDA-recommended daily allowances (RDAs) for nutrients (vitamins and minerals) in tomatoes (USDA, 2020).

Vitamin C

Vitamin C also known as ascorbic acid is an essential nutrient that plays a vital role in human health through the provision of antioxidants for consumers. All samples contained adequate vitamin C in the range of 2.43 to 8.00 although lower than with 21.83 to 38.45 in comparison with Stoyanova et al. (2018) for consumers' nutritional support and protection. On average, a medium-sized tomato contains around 17 to 22 mg of vitamin C, which is approximately 20 to 25% of the recommended daily intake for adults. However, some tomato varieties have been found to contain much higher levels of vitamin C, with certain cultivars containing up to 50 to 60 mg per tomato.

A study by Stommel and Klee (2009) found that there was a positive correlation between fruit colour and vitamin C content in several tomato varieties. The study found that as the fruit ripened and developed a deeper red colour, the vitamin C content increased. Hounsome et al. (2008) also found a positive correlation between fruit colour and vitamin C content in a sample of commercially available tomato varieties. The study found that fruits with a deeper red colour had higher vitamin C content than those with a lighter red or green colour.

These studies suggest that fruit colour can be a useful indicator of vitamin C content in tomatoes, with fruits that have a deeper red colour generally having higher vitamin C content. Vitamin C is a powerful antioxidant that helps to protect cells from damage caused by harmful molecules called free radicals. It also plays a critical role in supporting the immune system, aiding in the absorption of iron from plant-based foods, and has been associated with a range of health benefits, including a reduced risk of chronic diseases such as heart disease, cancer, and age-related degenerative disorders. The high vitamin C content in tomatoes can help to improve skin health by increasing collagen production and reducing the appearance of wrinkles and fine lines (Freedman et al., 2015).

Titratable acidity

Titratable acidity indicates the amount of acid typically measured as the amount of citric acid required to neutralize the acid present in tomato fruits and can impact both flavour and nutritional value. The amount could indicate the quantity of certain acids, such as ascorbic and malic, which are beneficial for human health, energy release, and reduced risk of certain ailments. However, the higher acidity of tomato fruits could affect consumer acceptance, as most consumers do not prefer acidic or sour taste tomato fruits. All samples ranged between 1.80 and 12.30 and were significantly different. The range for samples were however higher than 0.29 to 0.41 as observed by Stoyanova et al. (2018).

Studies have shown that titrable acidity levels can vary widely among tomato varieties, and can be influenced by factors such as growing conditions, ripeness, and post-harvest handling (Anupama et al., 2020). Higher titrable acidity levels in tomatoes have been associated with a more acidic and tart taste, which can be desirable in certain culinary applications. In addition, titrable acidity has been shown to have a positive correlation with certain nutritional components of tomatoes, such as lycopene and phenolic compounds. For example, lower titrable acidity levels may be more desirable for making tomato juice or sauces, while higher levels may be preferred for use in salsas or other dishes where a tart or acidic taste is desired.

Table 2. Yield and nutrient quality evaluation of tomato varieties.

Variety	Vit C (mg/20 ml)	TTA (g/l)	L*	a*	b*	TSS (%Brix)	Dry matter (%)	Yield (t/ha)
1. AVTO1705	6.86^{a}	4.80^{i}	46.58^{a}	26.42^{a}	32.16^{a}	5.40	7.80	11.81^{ab}
2. AVTO1003	8.00^{b}	10.69^{e}	52.79^{b}	21.80^{b}	40.46^{b}	5.20	7.67	12.74^{ab}
3. AVTO1007	5.43^{c}	10.39^{g}	56.72^{c}	14.96^{c}	40.34^{b}	5.20	7.80	13.65^{ab}
4. AVTO1121	3.43^{d}	14.01^{a}	53.83^{d}	23.24^{d}	41.80^{c}	6.80	8.21	12.01^{ab}
5. AVTO1464	4.57^{e}	11.61^{d}	48.28^{e}	26.29^{e}	38.12^{d}	5.80	7.95	12.6^{ab}
6. AVTO1704	4.29^{f}	7.71^{j}	63.15^{f}	2.68^{f}	47.31^{e}	3.80	4.98	10.73^{a}
7. AVTO1707	4.00^{g}	2.80^{r}	46.69^{a}	27.75^{g}	34.25^{f}	4.00	5.91	12.19^{ab}
8. AVTO1711	5.14^{h}	3.60^{o}	65.67^{g}	$8.30l^{h}$	41.00^{b}	4.20	6.61	10.69^{a}
9. AVTO1715	5.71^{i}	4.00^{n}	42.46^{h}	25.12^{i}	27.28^{g}	5.20	8.37	13.3^{ab}
10. AVTO1718	3.71^{j}	2.60^{s}	45.91^{i}	23.24^{j}	31.77^{a}	5.00	7.17	12.88^{ab}
11. AVTO1719	2.57^{k}	1.80^{t}	54.97^{j}	18.64^{k}	41.11^{b}	5.00	6.40	14.78^{ab}
12. AVTO1729	4.00^{g}	11.70^{c}	53.97^{d}	19.18^{l}	43.55^{h}	5.20	7.11	13.47^{ab}
13. AVTOI008	4.57^{e}	9.20^{i}	46.89^{a}	18.53^{k}	30.30^{i}	5.00	6.76	11.63^{ab}
14. AVTOI429	6.57^{c}	4.60^{m}	64.27^{k}	9.97^{m}	40.78^{b}	6.00	8.23	12.85^{ab}
15. AVTOI706	2.43^{l}	5.60^{k}	44.87^{l}	28.69^{n}	34.87^{f}	3.60	5.33	18.13^{abc}
16. Formona	4.00^{g}	2.80^{r}	45.14^{l}	26.21^{e}	30.92^{j}	5.80	7.66	8.67^{a}
17. ICRIXINIA	6.29^{m}	10.60^{f}	50.00^{m}	20.76^{o}	39.03^{b}	5.40	7.87	27.83^{cd}
18. Keneye	2.86^{n}	11.60^{d}	46.62^{a}	29.75^{p}	35.41^{k}	5.80	7.13	14.06^{ab}
19. Konica	4.57^{e}	9.89h	43.37^{h}	16.52^{q}	24.48^{l}	6.40	8.44	14.51^{ab}
20. Malinka	4.29^{f}	3.00^{q}	40.50^{i}	14.71^{r}	22.90^{m}	4.40	6.78	9.76^{a}
21. Nayeli	4.57^{e}	3.20^{p}	56.81^{c}	15.68^{s}	45.26^{n}	5.00	7.33	12.57^{ab}
22. UC82B	4.29i	12.25^{b}	46.66^{a}	27.44^{g}	35.52^{o}	6.40	7.68	22.56^{bcd}
23. AVTO1717	3.71^{j}	12.30^{b}	47.74^{a}	32.42^{t}	38.06^{d}	6.20	7.35	16.15^{ab}
24. VI043614	4.57^{e}	3.20^{p}	49.05^{e}	28.18^{n}	38.68^{d}	5.60	8.66	31.11^{d}
P-value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001			<0.001

*Mean values with different superscripts in the same column are significantly different.
Source: Study results

Fruit skin colour

Fruit skin colour is used to determine the ripeness, flavour, and overall marketability of tomatoes. Tomato fruit skin colour can range from green to red, with shades of yellow, orange, and pink also being common in certain varieties. The colour of tomato fruit skin is an indicator of the stage of ripeness, with fully ripe tomatoes typically having a deep red colour. Consumers often associate a deep red colour with ripeness and freshness, and therefore, tomato fruits with an attractive red colour are typically more marketable and preferred by consumers. In addition to its impact on marketability, fruit skin colour can also influence the taste and nutritional value of tomatoes.

As tomatoes ripen, they tend to accumulate more nutrients such as lycopene and beta-carotene, which contribute to their characteristic red colour. Therefore, fruits with a deep red colour tend to have higher nutritional value and flavour than unripe or green tomatoes. Red (a*) pigmentation in tomatoes is not only an important visual parameter for consumer acceptability, but it also indicates how much lycopene is available in the fruits. Lycopene is the most abundant carotenoid in ripened tomatoes and is noteworthy in the fruit's plant compounds. In addition, lycopene has lipid-lowering properties, reducing total and LDL cholesterol. The antioxidants in tomatoes, particularly lycopene, have been shown to reduce the risk of heart disease by decreasing inflammation and improving cholesterol levels (de Souza et al., 2017). Similarly, Giovannucci (2002), linked a reduced risk of certain types of cancer, such as prostate cancer to the antioxidant properties of tomatoes, particularly lycopene. It is found in the highest concentrations in the skin; redness (a*), lightness (L*), and yellowness (b*) indicate the presence of pigmented compounds such as carotenoids (Swain et al., 2014).

There were significant differences for all varieties except for AVTO1007, AVTO1121, AVTO1429, and Keneye and AVTO1707, which were not significantly different for b* and L*, respectively. The fruit skin colour of tomatoes is an important quality parameter that can influence consumer acceptance, nutritional value, and overall fruit quality. Research has shown that the colour of the tomato fruit skin is related to its nutritional composition, with some studies suggesting that certain

Table 3. Correlation matrix (Pearson).

Variable	L*	a*	b*	h^o	Vit. C (mg/20 ml)
L*					
a*	-0.008				
b*	**0.871**	0.187			
h^o	**0.734**	**-0.554**	**0.708**		
Vit. C (mg/20 ml)	**-0.252**	**0.235**	-0.139	**-0.283**	

*Values in bold are significantly different from 0 at significance level alpha=0.05.
Source: Study results

coloured varieties may contain higher levels of antioxidants and other beneficial compounds (Barrett et al., 2010). Additionally, the colour of the tomato fruit skin can also impact consumer preference, with studies indicating that consumers tend to prefer tomatoes with a bright, uniform colour that is indicative of ripeness and freshness (Chen et al., 2014).

Total soluble solutes

The total soluble solids (TSS) of tomatoes represent the sugar content of the fruit and are an important quality parameter that can impact both the taste and nutritional value of the fruit. The TSS levels can be used to determine the ripeness and maturity of the fruit, as well as its potential uses for processing and preservation. Total soluble solutes determined as percent Brix ranged from 3.60 to 6.80. %Brix, which is a measure of the sugar content of a solution, determines the quality and ripeness of tomatoes. Higher %Brix values in tomatoes generally indicated greater sweetness and flavour and can be a sign of optimal ripeness and maturity. Additionally, they impact flavour and texture, and %Brix levels can also be used to assess the suitability of tomatoes for processing and preservation, as higher sugar levels can improve the shelf life and stability of processed tomato products. The TSS content is closely related to the taste and nutritional value of vegetables, and it can vary depending on factors such as the cultivar, growing conditions, and ripeness (Bunea et al., 2008).

All values were within acceptable limits. There were physical value variations among treatments, even though statistical differences could not be determined due to the results supplied.

Dry matter

The mean dry matter percentage for all treatments ranged from 4.98 to 8.66 for AVTO1704 and VI043614, respectively and were in line with Stoyanova et al. (2018) who indicated 3.91 to 5.60 dry matter in their study. Dry matter is the solid content without moisture or water and forms the basis for other compositions such as carbohydrates, fibre, protein, and fats. Dry matter content is an important quality parameter in tomatoes as it represents the percentage of the fruit's weight that remains after the removal of water. Dry matter content can provide valuable information about the fruit's nutritional and physical characteristics, such as its sugar content, texture, and overall quality. High dry matter content is generally associated with good taste, flavour, and nutritional quality in tomatoes (Bertin and Génard, 2018). Additionally, tomatoes with higher dry matter content are often preferred for processing and preservation, as products with improved texture and shelf-life are derived. There were physical value variations among treatments, even though statistical differences could not be determined.

Relationship among nutrient parameters

From Table 3, colour (L*, and, b*, h^o)a*,b* and vitamin C correlated positively. The colour attribute a* correlated with h^o, and vitamin C. A negative a* meant less redness but correspondence with green in tomato fruits. In contrast, a positive b* meant a correspondence with yellow in the tomato. There is often a correlation between fruit colour and vitamin C content in tomatoes, as ripening sets in and the fruit skin colour changes from green to red, the vitamin C content generally increases. This is because vitamin C is a water-soluble antioxidant that accumulates in the fruit as it ripens. Research has shown that fully ripe red tomatoes contain higher levels of vitamin C compared to unripe green tomatoes. Generally, the vitamin C content of red tomatoes was approximately 40% higher than that of green tomatoes. Therefore, fruit skin colour can serve as a useful indicator of vitamin C content in tomatoes. Consumers seeking higher vitamin C content may prefer fully ripe red tomatoes over unripe green ones. However, it is important to note that other factors, such as growing conditions, variety, and processing, can also impact the vitamin C content of tomatoes.

Conclusion

All varieties successfully passed the agronomic phase and contained adequate nutrients for consumer acceptance. Some varieties had a higher yield ability and can therefore be recommended for sustainable intensification in Ghana. The nutritional evaluation of disease and pest resistance tomato varieties is an important step in improving the nutritional value of tomatoes for consumers. Varieties had all the physical and nutritional characteristics for consumers' selection and acceptance. It is also no doubt that farmers will select seeds from these varieties for production based on their disease and pest resistance attributes if seeds are commercially available. The results of this study will provide valuable information for breeders and growers, as well as for consumers interested in increasing nutrient intake especially vitamins and minerals in food.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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