Comparative study related to physico-chemical properties of four tomato cultivars grown in Kurdistan region, Iraq

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Abstract

This study was conducted to evaluate the physical, chemical and quality properties of four tomato cultivars Hawraman, Sktan, Kunara, and Krbchna, grown under a plastic house during 2021 in order to study growth, yield components, quality, and some phytochemical characteristics. A completely randomized block design RCBD with three replications was followed in this study. The results showed the cultivar of Hawraman obtained the maximum values of shape index, firmness, total sugar, ascorbic acid, and chlorophyll a with 1.520, 1152.440g, 1.880%, 39.031mg/100g FW, and 0.591 µg/ml FW, respectively. Sktan cultivar gave a higher value of a number of fruits per plant, yield per plant, juice, total carotenoids with (153.0 fruit plant^{-1}, 6864.039g plant^{-1}, 65.652%, and 0.532 µg/ml FW) respectively. Kunara cultivar achieved maximum values of a number of branches per plant, pH, TSS, TTA, chlorophyll b, and total chlorophyll with 13 branches plant^{-1}, 5.470, 7.667%, 0.523%, 2.410 µg/ml FW and 2.693 µg/ml FW, respectively. While the Krbchna cultivar gave the maximum values of average fruit weight and size, polar and equatorial diameter, total phenolic and lycopene with 73.943g, 76.553 cm^3, 64.450 mm, 48.537 mm, 84.684 mg/100g FW and 206.306 mg/100g FW respectively. While no significant differences in DM% and pectin% of tomato fruits were identified across all cultivars in this investigation.

Keywords: Solanum lycopersicum, cultivars, growth and yield, physical and chemical properties.

Introduction

Tomato (*Solanum lycopersicum* L.) belonging to the Solanaceae family and is one of the famous vegetable crops grown throughout the world for a wide range of climates including tropical, subtropical, and temperate regions in the open field and under greenhouse conditions (26). It is originated in the area extending from Ecuador to Chile in the western of South America (14). Tomato is an economically important vegetable crop and considered the first rank in some countries; in others, it will be the second in rank after potatoes. The world tomato production is around 182,301,395 tons anually which are grown on 4.85 million hectares worldwide. The top ten country of tomato production were China, India, United states of America, Turkey, Egypt, Italy, Iran, Spain, Brazil and Mexico. Asia are major tomato producer in the world accounts about 61.1%, and 13.5, 13.4 and 11.8% for europe, america and africa, respectively **.**

Tomato is recognized as important trade and dietary vegetable commodities, because tomato fruit is the most prevailed and common vegetable crop all over the world, used freshly or in salad as well as cooking, food processing such as canning, drying, freezing, tomato paste, ketchup and juice it is getting more interest and studies compared to any other horticultural or vegetable crops (35, 34, 32). The nutrient value of tomato fruits is described by the content of pigments, polyphenols, sugars, organic acids, some minerals such us (Ca, P and Fe), antioxidants and vitamins (8, 15, 24, 16), as well as volatile compounds (37). Tomato carotenoids are the main source of lycopene in the human diet (36). Lycopene is the most useful tomato compound with important health effects, having a higher level of antioxidant activity (4, 39, 40).

There is currently a rising interest in increasing the quality and quantity content of beneficial chemicals in tomato fruits in order to boost the crops nutrient potential. The aim of modern biochemical investigation is to discover and measure the ingredients of plant materials, as well as to determine their biological activity. Such information is required for the production of beneficial nutritional and nutraceutical supplements, among other things. In terms of total soluble solids, non-soluble solids, Lycopene, vitamin C, total acidity, total sugar, fruit size, color, weight, and fruit hardness, the economic worth of tomato fruits varies with cultivar, degree of maturity, climatic conditions, and agricultural techniques. These traits, together with a commercial output, increase the worth of the fruit and boost the pricing for customers (21). Quality of fruit is an important factor for market value, transfer, and storage conditions. Market demand for high-quality products has resulted in a shift in greenhouse industry production strategies (5).

Furthermore, yield is regarded as one of the primary qualities that has a direct impact on total output. Shrestha *et al.*(30) reported that one of the major contributing factors of low productivity of tomato is the lack of high yielding varieties. It also appears that released varieties may also degrade their performance due to a number of biotic and abiotic stresses.

One of the key causes for low tomato production in Kurdistan is a lack of acceptable high-yielding varieties, as well as a breeding program that is confined to

only a few crops, including tomatoes. Because of the gradual deterioration of local varieties, the decrease in quantitative and qualitative characteristics, the continuous introduction of exotic hybrid varieties, and the risk of not obtaining good varieties in time for farmers when selecting tomato varieties suitable for the conditions of the region and with desirable and high specifications desirable characters. Development of hybrid tomato cultivars having desirable characters has proven to be an effective strategy to increase tomato production, according to Islam *et al*.(10) yield of hybrid tomato is 20 to 25 % more. Continuous varietal evaluation is needed for providing sufficient varietal options for the farmers (3).

Therefore, research should be oriented towards tomato cultivar improvement through hybridization, selection, varietal evaluation, and release of new cultivars that possess disease resistance, high yielding, and also meet the demanding consumer in reference to fruit quality. there is no information obtainable concerning the rendition of different hybrids cultivated under protected structures. However, modern technologies have been used to produce high-quality tomatoes. Kurdistan region farmers of getting desirable varieties during planting season and selecting new cultivars what is available in the market cannot ensure the quality of consumer satisfy. The aime of this investigation was carried out to evaluate some new cultivars of tomato in respect of growth, yield and quality index under protected condition and future breeding, according to their nutrition composition.

Materials and Methods

This study was conducted at Krbchna village, Sangaw, 77 km Southwestern of Sulaimaniyah governorate - Kurdistan region - Iraq, GPS reading of (latitude: 35. 282 N, longitude: 45. 277 E, altitude 979 masl) Climate of the study area is arid and semi-arid (19) during 2021 growing season. The experiment was laid out in randomized complete block design with three replications. The distance between the plants was (40x40 cm) and (80 to 90 cm) between the rows. The tomato cultivars used in this study were namely (Hawraman, Sktan, Kunara, and Krbchna) (Fig. 1). The tomato seedlings were raised under plastic tunnels by sowing seeds on Feb. 01, 2021. Seedlings were transplanted to a plastic house on March 18, 2021. Each cultivar was given the same management treatments i.e. fertilization, irrigation, weed control, and spray against insects and diseases. Fruits were harvested at the ripe stage (marketable stage) throughout the harvesting period, and data were collected on various parameters . Number of fruits per plant, number of branches per plant, plant yield (g), average fruit weight (g), average fruit size (cm^3), fruit polar diameter (mm), fruit equatorial diameter (mm), Shape index, fruit firmness, Juice%, pH, Dry matter% (DM), Pectin%, Total soluble solids (TSS%), total treatable acidity (TTA%) , Maturity index (TSS/TTA), Sugars%, Total phenolic (mg/100 ml FW) , Ascorbic acid (mg/100 g FW) , Total chlorophyll (µg/ml FW) ,Carotenoids and lycopene (µg/ml FJ).

Figure 1: the fruit phenotype of the studied cultivars

Statistical Analysis

The analysis of variance ANOVA was employed, using a Statistical Software (XL-STAT), to show the difference between the four cultivars' parameters, using Duncan's new multiple range tests at $P \leq 0.05$.

Results and Discussion

A wide range of variations was observed among the study cultivars as response to most of the studied variables. Kunara cultivar produced significantly higher number of branches plant^{-1} (13.00٠) over other cultivars. Krbchna and Sktan cultivars with 11.000 and 9.000 branches plant^{-1} followed it, respectively. Hawraman cultivar had the lowest number of branches per plant (7.000). The data showed that an increase in the number of branches per plant is correlated to an increase in plant height. These results are in close conformity with the findings of Sharma and Rastogi(29) who reported significant variation among the cultivars of tomato for the number of branches per plant. Significant variations were detected in the number of fruits per plant among the tomato cultivars (Table 1). Sktan was superior on all other cultivars which produced 153.000 fruits plant^{-1} Hawraman (94.000), Kunara (91.000) and Krbchna (66.000). These results resemble those of (11) who reported that Abinash- II tomato cultivar recorded the highest number of fruits per plant (69.07) among four studied hybrid cultivars. Moreover, the results agreed with the results of (1) who reported the number of fruits per plant ranged between 29.47-98.30 fruits per plant for Nemadina to Local round variety respectively.

The results showed significant differences in fruit yield per plant among the cultivars. Sktan cultivar recorded the highest fruit yield (6864.039 g plant^{-1}) followed by Krbchna cultivar (4880.238 g plant^{-1}) and Hawraman cultivar (4532.398 g plant^{-1}). Minimum fruit yield (3150.420 g plant^{-1}) was produced by Kunara cultivar.

Table 1. Evaluation of some growth and yield parameters on four tomato cultivars

Cultivars	Number of branches plant^{-1}	Number of fruits plant^{-1}	Plant Yield (g plant^{-1})
Hawraman	7.000 d	94.000 b	4532.398 c
Sktan	9.000 c	153.000 a	6864.039 a
Kunara	13.000 a	91.000 c	3150.420 d
Krbchna	11.000 b	66.000 d	4880.238 b

Different letters in the same column indicate significant differences between means according to Duncan's new multiple range test at P≤ 0.05.

Table 2 revealed that cultivar Krbchna with 73.943 g average fruit weight was significantly higher value than other cultivars. Other cultivars Hawraman and Sktan also achieved remarkably good fruit weight of (48.217 g) and (44.863 g), respectively. While the Kunara cultivar showed minimum fruit weight was (34.620 g).

Fruit size showed same trend as previous parameter. Krbchna cultivar gave significantly highest average fruit size of (76.553 cm^3) than other cultivars. Lowest average fruit size (34.497cm^3) was recorded by Kunara cultivar. The differences among Hawraman and Sktan cultivars were not significant (Table 2).

The longest polar diameter fruit was recorded in Krbchna and Hawraman cultivars (64.450 mm) and (62.140 mm), respectively, followed by Kunara cultivar (45.403 mm) and Sktan cultivar (41.433 mm). It could be due to the differences of tomato varieties and genotypes are mainly due to their genetic character and the response of these genotypes to acclimatize to the plastic house conditions. The results were in ranged 2.85-5.13 cm that finding byOmar and Maruf(21).

The mean fruit equatorial diameter values ranged between (48.537 and 35.790 mm). The Krbchna cultivar (48.537 mm) followed by Sktan (42.957 mm) and Hawraman (40.877 mm) produced significantly highest fruit width, whereas lowest fruit equatorial diameter was recorded in Kunara cultivar (35.790 mm). These results are in line with the findings of Prema *et al.* (23) in cherry tomato. Furthermore, Omar and Maruf (21) found that the results were in ranged 4.08-6.13 cm.

Fruit shape index values range from 0.964 to 1.520. Fruit shape index was found maximum in Hawraman cultivar (1.520) followed by Krbchna (1.328) and Kunara (1.269) which is mainly due to the oval shape of fruits in these grow types,

whereas the Sktan cultivar (0.964) recorded the minimum. Similar findings were reported by (33) in tomato. The results were in ranged 0.46-1.11 that finding by Omar and Maruf (21). The high fresh fruit yield of the studied cultivars may be related to the high fruit weight per plant (Table 1). Similar to Jaha and Krishi (11) who reported that the yield of fresh fruit per plant was 4.03 kg in cultivar Naveen while (18) reported that the variety Pusa Ruby had the supreme yield of fresh fruit per plant (2.7 kg) among the studied 39 cultivars, Moreover, Jha and Saha (28) recorded the fresh fruit yield of (60.70) ton ha^{-1} during 1994-1995 and (47.00) ton ha^{-1} in 1995-1996 from BT18 cultivar.

Table 2. Evaluation of some physical parameters on four tomato cultivars

Cultivars	Average Fruit Weight (g)	Average Fruit Size (cm^3)	Polar Diameter (mm)	Equatorial Diameter (mm)	Shape Index
Hawraman	48.217 b	50.220 b	62.140 a	40.877 c	1.520 a
Sktan	44.863 b	43.993 b	41.433 c	42.957 b	0.964 c
Kunara	34.620 c	34.497 c	45.403 b	35.790 d	1.269 b
Krbchna	73.943 a	76.553 a	64.450 a	48.537 a	1.328 b

Different letters in the same column indicate significant differences between means according to Duncan's new multiple range test at $P \leq 0.05$.

The results for the firmness showed that Hawraman cultivar had the highest value of (1152.440g), whereas the Kunara cultivar (800.563g) recorded the lowest firmness (Table 3). However, there are no significant differences observed between Sktan and Krbchna cultivar. Firmness is one of the major factors of tomato fruit quality **(27)** and one of the most important qualitative characteristics in tomato fruits which is usually referred as the second rank following morphological characteristics particularly for the purpose of long distant export.

Maximum juice content (65.652%) was found in Sktan cultivar, while the Krbchna cultivar gave the lowest juice content (54.562%), whereas no significant differences were found between Sktan, Hawraman and Kunara cultivars (Table 3), and regarding the pH value, it was significantly different among the cultivars (in the same table). The highest pH value 5.470 was noted in Kunara cultivar. While minimum pH value 5.047 was recorded in Hawraman cultivar. No significant differences were found among all cultivars under this study on DM% and pectin% of tomato fruits.

Table 3. Evaluation of some quality parameters on four tomato cultivars

Cultivars	Fruit Firmness (g)	Juice (%)	pH	DM (%)	Pectin (%)
Hawraman	1152.440 a	60.532 ab	5.047 b	8.831 a	2.946 a
Sktan	993.905 b	65.652 a	5.283 ab	8.393 a	2.442 a
Kunara	800.563 c	59.755 ab	5.470 a	9.282 a	2.427 a
Krbchna	1037.453 b	54.562 b	5.310 ab	7.395 a	2.853 a

Different letters in the same column indicate significant differences between means according to Duncan's new multiple range test at P≤ 0.05.

Significant differences were recorded for the TSS% between the studied tomato cultivars (Table4). The highest TSS% (7.667) was recorded in Kunara cultivar followed by Sktan (7.367%), while lowest TSS% (5.900) was found in Hawraman cultivar followed by Krbchna cultivar (6.467%) (Table4). The results agree with (12). Likewise, Yagmur *et al* (38) recorded variation in TSS% among different tomato cultivars.

Analysis of the data regarding total titratable acidity (TTA %) shows significant differences between the cultivars (Table 4). The result shows that maximum TTA% (0.523) was recorded in Kunara cultivar, and the minimum TTA% (0.388) was in Krbchna cultivar followed by Hawraman cultivar (0.400%). These results agreed with Javaria *et al.* (12) findings. Additionally, no significant differences were found between all cultivars on maturity index (TSS/TTA).

Table 4 also provides information about the total sugar%, which significant variation was observed as well. The results indicate that maximum total sugar (1.880%) was observed in Hawraman cultivar, whereas minimum total sugar (1.492%) was reported in Krbchna cultivar. No significant differences were found between Sktan and Kunara cultivar. Moreover, the total phenolic contents (mg/100 ml FW) were also exhibit in table 4. The maximum total phenolic (84.684 mg/100 ml FW) was noted in Krbchna cultivar followed Kunara having 77.882 (mg/100 ml FW). Whereas lowest value 68.649 (mg/100 ml FW) was noted in Sktan cultivar. The findings agree with Iqbal *et al.* (9).

The results showed significant difference between the cultivars for their fruits ascorbic acid content (Table 4). The highest ascorbic acid content (39.031 mg $100g^{-1}$) was recorded in Hawraman cultivar followed by Krbchna cultivar (32.911 mg $100g^{-1}$) and lowest value was in Sktan cultivar (15.777 mg $100g^{-1}$), followed by Kunara cultivar (20.382 mg $100g^{-1}$). (31) Reported alike results.

Table 4. Evaluation of some chemical parameters on four tomato cultivars

Cultivars	TSS (%)	TTA (%)	Maturity index (TSS/TTA)	Total sugar (%)	Total phenolics (mg/100 ml FW)	Ascorbic acid (mg/100 g FW)
Hawraman	5.900 c	0.400 b	14.882 a	1.880 a	71.745 bc	39.031 a
Sktan	7.367 a	0.480 ab	15.571 a	1.647 ab	68.649 c	15.777 d
Kunara	7.667 a	0.523 a	14.786 a	1.657 ab	77.882 ab	20.382 c
Krbchna	6.467 b	0.388 b	16.708 a	1.492 b	84.684 a	32.911 b

Different letters in the same column indicate significant differences between means according to Duncan's new multiple range test at P≤ 0.05.

The cultivars also showed significant variation in terms of chlorophylls content (table 5). The results illustrated that the cultivars under taken in this study were differed from each pigment contents. The Hawraman cultivar was superiorly significant in comparison with the other cultivars in Chl. a (µg/ml FW) which was (0.591), on the other hand, the lowest value (0.283) recorded in Kunara cultivar. Contrariwise, Kunara cultivar gave the highest Chl. b and total chlorophyll (2.410 and 2.693 µg/ml FW), respectively. Whereas lowest Chl. b and total chlorophyll were observed in Krbchna cultivar (0.705 and 1.173 µg/ml FW), respectively.

The value of carotene content means (mg/kg FW) among the studied cultivars was significantly different (table 5). The highest value for carotene content was observed in Sktan of all cultivars (0.532 mg/kg FW), whereas, the lowest in Krbchna (0.236 mg/kg FW), while no significant difference was found between Sktan and Hawraman cultivar. The lycopene is a major carotenoids pigment and responsible for red color in tomato. The results on lycopene content show a significant variation among the different cultivars of tomato in the same table, the Krbchna recorded maximum lycopene content (206.306 mg/kg FW) followed Cv. Kunara having 204.072 (mg/kg FW), Whereas the lowest lycopene content 36.067 (mg/kg FW) was noted in Cv. Sktan followed Cv. Hawraman having 39.709 (mg/kg FW).

The lycopene and β-carotene are the most common carotenoids of the varieties of red tomato, while in orange and yellow fruits tomato varieties also have lutein, ζ-carotene, neurosporin, and some other pigments (13). Additionally, there are some other tomato carotenoids identified but in small amounts such as – γ-carotene, phytoene, and phytofluen (6). Skin and flesh color are the most important quality factors (2).

Essentially, the lycopene typical content values are between 40-90 mg kg^{-1} fresh weights in tomatoes. This lycopene content value can widely vary from 10 to 200 mg kg^{-1}. The major factors causing this variation are mostly related to genetics, environmental factors, agricultural practices and techniques, and post-harvest storage conditions (17, 7, 20). The most important antioxidant present in

tomato fruits is carotenoids such as lycopene which differs in the fruits according to ripening stage, environmental conditions, and variety. Carotenoids amounts and their activities as anticancer are affected significantly by varieties (25).

Table 5. Evaluation of some pigments content in four tomato cultivars

Cultivars	Chl. a (µg/ml FW)	Chl. b (µg/ml FW)	Total Chlorophyll (µg/ml FW)	Total carotenoids (µg/ml FW)	Lycopene (mg/kg FW)
Hawraman	0.591 a	0.755 b	1.346 b	0.531 a	39.709 b
Sktan	0.468 b	0.729 b	1.197 b	0.532 a	36.067 b
Kunara	0.283 c	2.410 a	2.693 a	0.285 b	204.072 a
Krbchna	0.468 b	0.705 b	1.173 b	0.236 c	206.306 a

Different letters in the same column indicate significant differences between means according to Duncan's new multiple range test at P≤ 0.05.

Conclusions

Allowing to the outcomes of the modern study, the studied cultivars exhibited amazing multiplicity for both growth and yield components and fruit physical and chemical characteristics. The Hawraman cultivar obtained the maximum values of shape index, fruit firmness, total sugar, ascorbic acid, and chlorophyll- a. Sktan cultivar gave a higher value of the number of fruits per plant, yield per plant, juice, and total carotenoids. Kunara cultivar achieved maximum values of the number of branches per plant, pH, TSS, TTA, chlorophyll b, and total chlorophyll. While the Krbchna cultivar gave the maximum values of average fruit weight and size, polar and equatorial diameter, total phenolic, and lycopene. While no significant differences were found among all cultivars under this study on DM% and pectin% of tomato fruits. These genotypes could be used in future breeding programs to boost fruit yield and quality.

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