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Nutritional Composition, Physical Characteristics and Sanitary Quality of the Tomato Variety Mongol F1 from Burkina Faso

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Abstract

Tomato (*Lycopersicon esculentum* Mill) is quantitatively the highest vegetable consumed in Burkina Faso. The objective of this study was to evaluate the physico-chemical, nutritional characteristics, and sanitary quality of the tomato variety Mongal F1 from different production sites. Twenty-eight (28) samples of Mongal F1 fresh tomatoes were collected from 28 producers at three different localities of Ouahigouya, Loumbila and Ouagadougou. The physico-chemical and nutritional characteristics were determined by standardized methods and the traces metallic elements by atomic absorption spectrophotometry. The results revealed a degree brix varying from 4.07˚ to 5.50˚ and a pH ranging from 3.71 to 4.08 corresponding to a total acidity of 0.39% to 0.55% citric acid equivalents. The moisture content, the ash content, the total carbohydrates content, the reducing carbohydrates content, the lipids content and the protein content were ranged from 95.09% to 96.17%, 9.25% to 10.60%, 47.00% to 53.43%, 30.03% to 41.21%, 3.04% to 7.71% and 17.09% to 25.03% respectively. The results of the trace metals showed a high accumulation of total cadmium from 0.11 to 0.22 ppm, of total lead of 1.15 to 1.27 ppm and arsenic total of 0.19 to 0.20 ppm. The results proved that environmental conditions influence the quality of the tomato Mongal F1. Detection of trace elements in the tomato fruits suggests that a better production practices are needed.

Keywords

Tomato, Mongol F1, Characteristics, Nutrient, Trace Metal

1. Introduction

Fruits and vegetables are an excellent source of nutrients for the human diet but in several developing countries their availability is seasonal. Tomato (*Lycopersicum esculentum* Mill.) is one of the most cultivated fruit vegetable consumed in the world in fresh or processed form [1]. In Burkina Faso, tomato occupies a very important place in the vegetable sector (second after onion) with a 157,067 metric tons in 2008 and 179,217 metric tons in 2011 [2].

Tomato has high content of water, minerals (Ca, Fe, K, Mg, Na) and vitamins including pro-vitamin A, vitamin C and B vitamins [3] [4] [5]. It is also rich in antioxidant such as total phenolics, flavonoids, lycopene, and ascorbic acid [6]. The nutritional composition of tomato may vary depending on several factors such as variety, cultivation techniques, the locality and the sampling period [4]. On the health concern, tomato like other vegetables may accumulate metal micropollutants in the heart of their culture [7] [8] [9]. These accumulations can sometimes exceed the recommended standards [8] [10] and induce health problems for the human body [11] [12].

In Burkina Faso, tomato is produced by small holding farmers during the rainy and dry season. Several tomatoes cultivars are grown but varieties such as “Roma Vf”, “Rossol Vfn”, “Caraibo”, “Xina”, “Mongal F1”, “Petomech”, “Tropimech”, “Red Cloud Vf”, “Nadira”, “Jaguar”, and “F1 Thorgal” are preferred [13]. Despite the importance of the tomato fruit in Burkina Faso, to date very few published studies were done on the nutritional and health characteristics of tomato in Burkina Faso. Most of the researches done are oriented to agronomy practices [14]. Therefore the aim of the present study was to determine the morphological and physicochemical characteristics, the nutritional composition and the levels of trace metals of tomato Mongal F1 for technological and nutritional interest.

2. Material and Methods

2.1. Sampling

Twenty-eight (28) samples of fresh tomatoes (variety Mongal F1) were collected from three production sites including Loumbila, Ouahigouya and Ouagadougou. Twelve (12) samples were collected in Loumbila, thirteen (13) in Ouahigouya and three (3) in Ouagadougou (research experimental site at IRSAT). At each production site randomly selected, about 120 tomato fruits were randomly picked from different batches to constitute a sample. Fresh tomatoes from the same batch were weighed, washed with distilled water, drained and mashed. The mashed samples were homogenized and divided into two parts packed (with plastic opaque bottle) and stored in a freezer at −20˚C for analysis.

2.2. Analytical Method of Morphological Characteristics

The height and the diameter of the tomato were measured using a digital caliper. The shape coefficient (Cf) was determined as described by Doussou *et al.* [15]:

Cf = Height/Diameter. The firmness, the color and the green collar were determined according to by the method used by Fagbohoun and Kiki [16]; firmness was appreciated by touch (finger pressure) whilst color and green collar were visually appreciated. The number of lobs was determined by the method of counting the cross-section of tomato [16]. The average weight of the fruit, the average content of pulp, the average content of epicarp and the average content of seeds were determined by measurement carried out using an electronic balance [16]. The weight and average contents of the samples were obtained on the basis of 40 tomatoes.

2.3. Determination of Physicochemical Characteristics

Acidity and pH were determined according to AFNOR [17]. About 5 g of sample are suspended in 25 ml of distilled water. After a strong magnetic stirring, the pH is measured using a pH meter previously calibrated. For the acidity determination, the solution is centrifuged at 5000 g for 5 min; the collected supernatant was then titrated with 0.1 M NaOH in presence of a few drops of phenolphthalein and the content was calculated as percentage of citric acid. The degree brix was measured directly with a refractometer according to the NF V05-109 [18].

2.4. Determination of Nutritional Characteristics

Moisture content, ash content, crude protein content and crude fat content were determined according to the AOAC official methods [19]. samples moisture content was determined by drying in an oven at 105˚C overnight, total ash was determined by the difference of weight before and after incineration at 600˚C overnight, total proteins were determined by the Kjeldahl method and crude fat content was determined using Soxhlet method with hexane as solvent. The total sugars were determined according to the sulfuric orcinol methods as described by Montreuil and Spik [20]. The reducing sugars were determined by the sodium Dinitrosalycilate (DNS) method. The theoretical energy value was calculated using the coefficients of Merrill and Watt [21].

2.5. Analytical Method of Metallic Trace Elements

The metallic trace elements were determined by Atomic Absorption Spectrophotometry (AAS) as described by Walsh (1955) [22]. Cadmium and Lead were analysed by Atomic Absorption Spectrophotometry flame. Arsenic was determined by Atomic Absorption Spectrophotometry flame after generating volatile hydrides. Mercury was determined by AAS after generating cold steam hydrides.

Determination of Cadmium and Lead contents: The samples are first treated by acid digestion 0.2 g (of samples) is introduced into a glass vial and 10 mL of concentrated nitric acid are added thereto. The whole is left at laboratory temperature for 24 hours. The mineral deposit obtained is diluted 1/100 with Milli Q water and used for the determination of the cadmium and lead contents by the spectrophotometric method. Their dosage in the different samples re-

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quired a first calibration step of the apparatus. For calibration purposes, a series of standard cadmium solution on the one hand and the lead on the other hand are prepared from commercial stock solutions dosed at 1000 ppm. Preparation of the calibration range of 0.2; 0.4; 0.6; 0.8 and 1 g/ml was the introduction of 20, 40, 60, 80, and 100 µl of a part in the solution of cadmium and secondly the Lead solution in 100 ml flasks. Then 1% of 0.5 N nitric acid is added thereto, the remaining volume is made up with Milli-Q water. Before the establishment of the calibration curve with the SpectrAA software (Pro version 1.5), the camera sensitivity is first verified. For this, certain parameters such as the quality of the light beam and flame quality are optimized to achieve the best possible signal. Furthermore, a blank made from the same matrix as the sample (Milli-Q water acidified) and a known concentration of control solution are used and treated in the same way as the samples. The results were given by the SpectrAA software (Pro 1.5) and expressed in ppm.

Determination of Mercury: The samples are first treated by acid digestion. 0.2 g of sample is introduced into a glass vial and 10 mL of concentrated nitric acid are added thereto. The whole is left at ambient temperature for 24 hours. The methodology used is based on hydrides generation. For calibration purposes, series of standard solutions of cadmium on hand and lead on the other are prepared from commercial stock solutions dosed at 1000 ppm. All these standard solutions are handled as samples, that is to say dilution performed with acidified Milli-Q water. Working solutions obtained were concentrated to 20, 40, 60 and 80 ppb. The reagents necessary for the hydrides generation are also prepared: in this case, a reducing solution of sodium borohydride ($NaBH_4$ 0.5%), stabilized with sodium hydroxide (NaOH 0.5%) and a solution of hydrochloric acid (5 M HCl). Before the establishment of the calibration curve, the camera sensitivity is first checked. For this, certain parameters are optimized to achieve the best signal possible. Furthermore, control solutions, including a blank made from the same matrix as the sample (Acidified Milli-Q water) and a reference material are used and treated in the same way as the samples. The results were given by the SpectrAA software (Pro 1.5) and expressed in ppm. The concentration is calculated according to the test sample and the dilution of the mineral deposit.

Determination of Arsenic: The samples are first treated by acid digestion. Thus, 0.2 g of sample is introduced into a glass vial and 10 mL of concentrated nitric acid are added thereto. The whole is left at ambient temperature for 24 hours. They are then placed in an oven at 50˚C for 30 min to reduce pentavalent species by a reducer (KI + Vitamin C). The methodology use dis based on hydrides generation. The determination of arsenic in different matrices needs first a calibration step of the apparatus. For calibration purposes sseries of arsenic standard solution are prepared from the commercial stock solution dosed at 1000 ppm. These standard solutions are all treated as the samples that is to say dilution performed with water (Milli-Q) and acidified reduction with potassium iodide solution and vitamin C. Working solutions obtained are concentrated to

5, 10 and 15 ppb. The reagents necessary for the hydrides generation are also prepared: in this case, a reducing solution of sodium borohydride ($NaBH_4$ 0.5%), stabilized with sodium hydroxide (NaOH 0.5%) and a solution of hydrochloric acid (5 M HCl). Before the establishment of the calibration curve, the camera sensitivity is first checked. For this, certain parameters are optimized to achieve the best signal possible. Furthermore, control solutions, including a blank made from the same matrix as the sample (acidified Milli-Q water) and a reference material are used and treated in the same way as the samples. The results were given by the SpectrAA software (Pro 1.5) and expressed in ppb (ug/L). The concentration is calculated according to the test sample and the dilution of the mineral deposit.

2.6. Statistical Analysis

The data were subjected to Principal Component Analysis (PCA) and to analysis of variance (ANOVA) using the XLSTAT software (Ver.2014.5.03). Differences between means were evaluated by Duncan's test. Statistical significant difference was stated at $P < 0.05$.

3. Results and Discussion

The morphological characteristics of the tomato Mongal F1 are shown in **Table 1**. The fruits from Loumbila had a shape coefficient of 0.75 ± 0.15 corresponding to a flattened and ribbed shape and those from Ouahigouya and Ouagadougou had a shape coefficient of respectively 0.88 ± 0.15 and 0.82 ± 0.6 with a round shape. The shape difference between samples may be due to mixing this variety with others for hybridization of this variety with other varieties since on a same field several varieties may be cultivated [16]. All samples had a very soft firmness, red color and the number of lobs ranging from 3 to 14. With a very soft firmness this variety maybe less prone to room temperature storage and transportation. The observed color is close to the red color described by Namestnikov [23]. This variety may be interesting for the consumers as Namestnikov [23] reported that the dark red and red are the preferred colors of consumers. The average weight was between 58.70 ± 9.65 and 72.49 ± 0.46 g.

Table 1. Morphological characteristics of tomato Mongal F1.

			Parameters				
Localities	Shape coefficient	Form	Firmness	Color	Green collar	Number of lobs	Average weight (g)
Loumbila	0.75 ± 0.15	Flattened and ribbed	Solf	Red	Rare	3 - 9	58.70 ± 9.65^{b}
Ouahigouya	0.88 ± 0.12	Round	Solf	Red	Rare	3 - 14	76.55 ± 20.4^{a}
Ouagadougou	0.82 ± 0.6	Round	Solf	Red	Rare	3 - 10	72.49 ± 30.46^{ab}
p value							0.012
Signification							*

Mean values in the same column with the same superscript letters are not significantly different at $P < 0.05$; $^*P < 0.01$.

Table 2. Physicochemical characteristics of tomato F1 Mongal.

Localities	Parameters		
	pH	Acidity (% citric acid équivalent)	Degree brix (˚Brix)
Loumbila	3.71 ± 0.05^{b}	0.55 ± 0.03^{a}	5.51 ± 0.43^{a}
Ouahigouya	3.71 ± 0.05^{b}	0.50 ± 0.05^{a}	5.02 ± 0.59^{b}
Ouagadougou	4.08 ± 0.05^{a}	0.39 ± 0.05^{b}	4.07 ± 0.61^{c}
p value	0.0001	0.000	0.000
Signification	***	***	***
Average	3.93 ± 0.19	0.48 ± 0.08	4.86 ± 0.73

Tests were performed in triplicate; Values are means ± Standard Deviation. Mean values in the same column with the different superscript letters are significantly different at $P < 0.05$; ***$P < 0.001$.

The physicochemical characteristics of tomato Mongal F1 from the different sites are presented in **Table 2**. The pH was ranged between 3.71 ± 0.05 and 4.08 ± 0.05 corresponding to a total acidity of 0.39% ± 0.05% to 0.55% ± 0.03%. For the total acidity, a significant difference was observed among the three tomatoes sampling sites ($P < 0.05$). The pH found are in line with those obtained by Fagbohoun and Kiki [16] and Dossou *et al.* [15] who found values from 3.7 to 4.1 and 4.01 to 4.17 respectively. In contrary, these values are lower than those obtained by Aoun *et al.* [24] who reported values between 4.19 and 4.45 for 16 tomato varieties collected from Tunisia. Previous studies reported that pH of 3 to 6 is very favorable to the growth of yeasts and molds while bacteria prefer neutral media, typically pH between 7 and 9 [25]. The Mongal F1 tomato can be ranked among the acidic food category ($3 < pH < 6$) meaning that the products from this variety are not favorite media for the growth of some pathogens. The total acidity is similar to those obtained by Fagbohoun and Kiki [16] and Dossou *et al.* [15] with respective values from 0.48% to 0.6% and from 0.26% to 0.45%. According to Saliba [26], acidity may be influenced by temperature. The degree brix ranged from 4.07 to 5.50 with a significant difference among the three sampling sites. The degree brix obtained for this variety is superior to that found by Aoun *et al.* [24] who reported values ranging from 2.02 to 4.57 for 16 varieties of traditional tomatoes from Tunisia. The values found were similar to those found by Fagbohoun and Kiki [16] who reported values ranging from 4.2 to 5.1.

The proximate composition of the tomato fruits is shown in **Table 3**. The water content ranged from 95.09% to 96.17% with a significant difference between tomatoes from Loumbila and the other two sites. The values obtained are higher than those of FAO [5] and Sulbarán *et al.* [27] who reported value of 93.5% and 94.60% respectively. This difference may be due to the variety and cultivation conditions such as water supply. These values found shows that tomato is one of the vegetables with high water content, which explains its perishable nature, limiting the suitability for room temperature storage for a long period of time [28]. Crude ash content was ranged from 9.25% to 10.60%. There was no significant difference between the different sampling sites. Dossou *et al.* [15] and Hernández *et al.* (2008) [4] found in other varieties values ranging respectively

Table 3. Nutritional composition of the tomato Mongal F1.

	Parameters						
Localities	Moisture (%)	Ash (% DM)	Total sugar (% DM)	Reducing sugars (% DM)	Lipid (% DM)	Protein (% DM)	Energy (Kcal/100g DM)
Loumbila	95.09 ± 0.47^b	9.79 ± 1.32^a	47.00 ± 6.29^a	30.03 ± 7.82^b	4.77 ± 1.21^b	25.03 ± 3.17^a	331.05
Ouahigouya	9568 ± 0.63^a	10.60 ± 0.32^a	48.29 ± 6.52^a	36.27 ± 7.99^{ab}	5.39 ± 1.25^{ab}	24.36 ± 3.78^a	339.11
Ouagadougou	96.17 ± 0.61^a	9.25 ± 1.59^a	53.43 ± 6.95^a	41.21 ± 8.08^a	7.00 ± 1.26^a	17.09 ± 0.02^a	345.08
P value	0.006	0.236	0.385	0.055	0.034	0.137	0.52
Signification	**	NS	NS	*	*	NS	
Average	95.64 ± 0.54	9.88 ± 0.67	49.57 ± 3.40	35.83 ± 5.60	5.72 ± 1.15	22.16 ± 4.40	338.41 ± 7.04

Tests were performed in triplicate; Values are means ± Standard Deviation, DM: Dry Matter, Mean values in the same column with different superscript letters are significantly different at $P < 0.05$; NS non-significant; *$P < 0.05$; **$P < 0.01$.

from 4.94% to 10.74%, and 9.84% to 10.48%. Similarly, Agassounon *et al.* [28] found a value of 11.2%. According to Ahishakiye and Ait [29], the variability of the ash content can be influenced by the culture methods such as the use intake of organic and mineral fertilizers during the production and the type of soil: organic and mineral compositions

The total sugar and reducing sugars contents ranged respectively from 47.00% to 53.43% and from 30.03% to 41.21%. Tomatoes from Loumbila showed the lowest values and those from Ouagadougou the highest. There was no significant difference between the tomatoes content in total carbohydrate whilst a significant difference were noted for reducing sugars between tomatoes from Loumbila and Ouagadougou. The total sugar content of the tomatoes were lower than those found by Dossou *et al.* [15] on other tomato varieties with values ranging from 53.48% to 88.17%. In terms of reducing sugars, the values are lower than those obtained by Dandjouma *et al.* [3], Dossou *et al.* [15], Agassounon *et al.* [28] on other tomato varieties with respective values of 53.63% to 56.33%, 69.8% and 40.35% to 78.86%. This difference in sugar content could be due to the varieties and cultivation techniques used. Indeed, according to Davies and Winsor [30], cited by Saliba [26], the plants cultivation techniques, particularly the electrical conductivity of the nutrient solutions, influence the sugar content in fruits. Also Davies and Hobson [30] showed that light has a major effect on the sugar concentration. The protein and fat contents respectively ranged from 17.09% to 25.03% and from 4.77% and 7.00%. There was no significant difference between sampling sites except for the fat where there is a significant difference between tomatoes from Loumbila and Ouagadougou. Values in proteins are higher to those obtained by Hernandez *et al.* [4], ranging from 12.58% to 14.03% on a study of 06 varieties. However, the proteins values found in the present study were similar to those obtained by Korkalo *et al.* [31] in Mozambique and FAO [5] with respective averages of 15.79% and 15.38%. As to the fat content the values were superior to those obtained by Korkalo *et al.* [31] and FAO [5] in Mozambique who reported average values of 3.08% and 3.51% respectively. The energy values of the samples ranged from 288.20 to 344.24 Kcal/100g DM. Almost samples were lower in energy than the values (338.46 Kcal/100g DM) reported by FAO [5]. The lower energy value can be explained by the lower content in lipid compared to the content in carbohydrates and protein.

The ACP analysis (Figure 1) shown a total inertia percentage of 100.00% (86.88% for F1 and 13.12% for F2) of the viable results. A good representation of ash, energy and reducing sugars was observed with respect to the main axis F1. With respect to the main axis F2, the total sugars, fat, proteins and water content parameters were more represented. This allowed differentiation between the two axes three groups of individuals. The Ouagadougou samples were slightly close to the lipid axis and even closer to that of total sugars. This is due to their higher sugar content compared to the lipid content. The Ouahigouya samples were mainly characterized by the water, ash and protein content variables and were significantly similar for these variables. They can therefore be considered as having high content in these variables. The samples from Loumbila were distant from all the axes of the variables. They were therefore poor in all nutrients compared to the other samples. The samples of the three localities are far from the energy and total sugars variables. This means that they are poor in these variables.

The contents of total Cd and total Pb respectively ranged from 0.11 to 0.22 ppm and 1.15 to 1.27 ppm (Table 4). Total As content was ranged between 0.19 and 0.20 ppm. Regarding to total Hg, no value were recorded at the detection

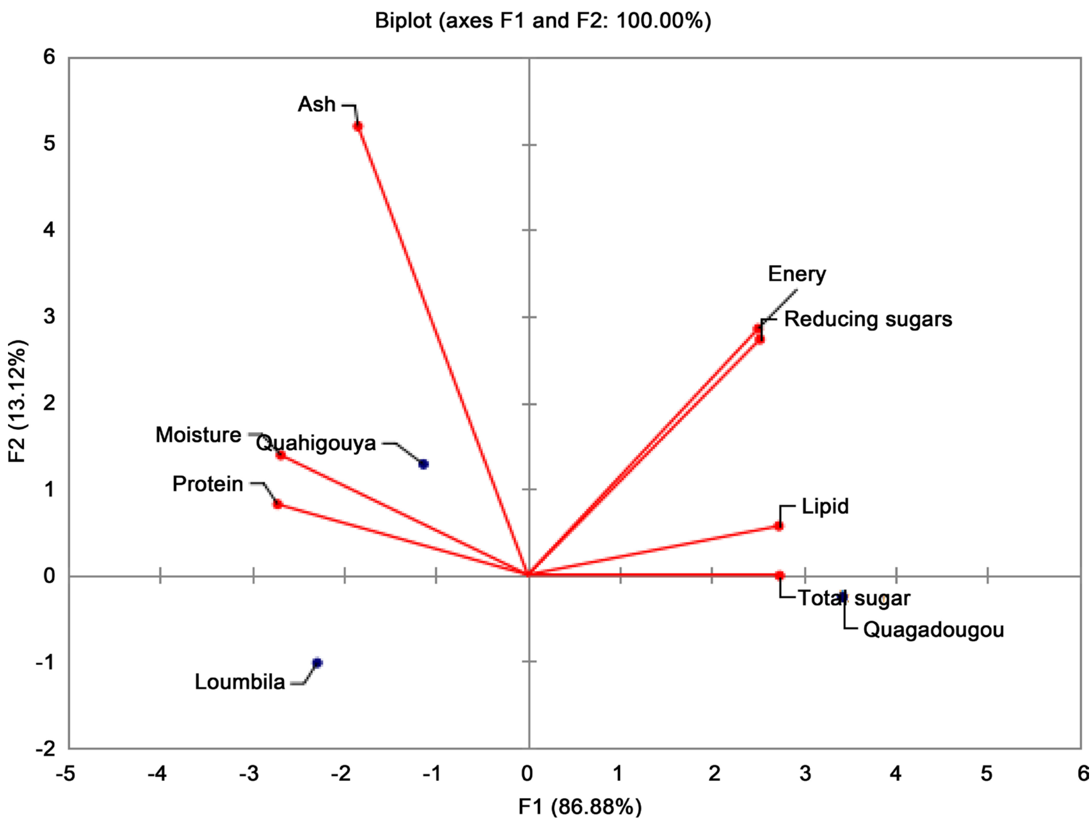

Figure 1. Principal component analysis of nutritional characteristic.

Table 4. Levels of trace metals Mongal F1 tomato samples.

Metalic trace elements	Localities		
	Loumbila	Ouahigouya	Codex regulation limit (ppm)
Cd total (ppm)	0.11 ± 0.00	0.22 ± 0.28	0.05
Pb total (ppm)	1.27 ± 0.06	1.15 ± 0.27	0.1
As total (ppm)	0.19 ± 0.14	0.20 ± 0.02	0.01
Hg total (ppm)	<LD	<LD	

LD = 0.001.

limit of the method used (0.001 ppm). The results shown that there was a large accumulation of total Cd, total Pb and total As on the studied tomato samples. In general, the levels of the three trace metals was much higher than the values set by Codex Standard [32], which are 0.05 ppm, 0.1 ppm and 0.01 ppm for the total Cd, total Pb and total As respectively. The values reported in the present study are higher than normal concentrations typically found in previous studies on vegetables (2, 5×10^{-3} ppm) cultivated in an unpolluted environment. Similarly, these levels are higher than the results found on tomatoes in other countries on tomatoes: Karavoltsos *et al.* [33] in Greece reported a total Cd content of 0.0188 ppm, Mohamed *et al.* [34] in Egypt reported 0.01 ppm for total Cd and 0.26 ppm for total Pb. Likewise Guerra *et al.* [35] in São Paulo in Brazil found a total Cd content of 0.02 to 0.04 ppm. Another study reported by Radwan and Salama [36] in Egypt shown a value of 0.01 ppm for total Pb. By contrast, the results found are lower than those found by Parveen *et al.* [37] in Pakistan with values of 1.33 ppm for total Cd and 1.56 ppm for total Pb; Kananke *et al.* [38] with values from 0.18 to 1.59 for total Pb and Al-Chaarani *et al.* [39] in Tripoli (Lebanon) with values of 0.17 to 0.82 ppm for total Cd. Trace metals found in tomato samples may originated from environment as soil, water dams, dwells and air [40] and also due to the agricultural activity such as the use of chemical fertilizers, pesticides and household waste [41]. According to Picot [12] some heavy metals such as Cd accumulated in plants were from agricultural activities such as the supply in phosphate fertilizers rich in Cd and spreading of sewage sludge in market gardens. According to Miquel [11] and Picot [12], these trace metals when they are highly concentrated are toxic to the human body and can lead to serious disorders, including the brain disorders. By comparing the values with the Codex standards [32], the consumption of this vegetable-fruit could affect the health of consumers, but speciation of these metallic elements is needed since the toxicity of the metal may depend on its chemical form [42].

4. Conclusion

Tomato Mongal F1 fruits were found to be good sources of nutritional content. These fruits should be included in the diet to overcome various nutritional problems like minerals deficiencies. The results revealed that environmental conditions influence the quality of the tomato Mongal F1. Even if efforts were made to boost the tomato production, yet no action was undertaken to limit the presence of trace metals in tomato fruits. Detection of trace elements in the tomato fruits suggests that better production practices are needed.

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