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Assessment of the Content of β-Carotene, Lycopene and Total Phenolic of 45 Varieties of Tomatoes (*Solanum lycopersicum* L.)

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Abstract: Tomato is a highly consumed food in the world because of its richness in nutrients especially carotenoids, vitamins and total phenolic. It has been proven very beneficial for the body. This study aimed to evaluate the composition of β-carotene, lycopene and total phenolic of 45 tomatoes varieties from experimental station in Burkina Faso. The content of β-carotene and lycopene was determined by HPLC while the total phenolic contents were analyzed by spectrophotometry. The lycopene content and the β-carotene content of the 45 varieties ranged from 2.41 ± 0.00 (variety 27T4) to 83.51 ± 0.22 (BT1 variety) mg /100 g of dry matter and 0.83 ± 0.00 (variety 27T4) to 26.80 ± 0.08 (Variety BT1) mg / 100 g of dry matter respectively. The total phenolic contents were between 502.84 ± 47.46 (variety 4T1) to 1181.08 ± 182. 97 (variety 25T2) mg GAG /100 g of dry matter. The 45 varieties of tomato analyzed are potential sources of lycopene, β-carotene and total phenolic. Some of the varieties can be promoted for cultivation at national level due to their high content in these three elements.

Keywords: Tomato, β –Carotene, Lycopene, Total Phenolic

1. Introduction

Fruits and vegetables are an excellent source of vitamins and minerals for human body [1]. As part of the daily diet, they prevent major chronic diseases such as heart disease, diabetes, obesity and some cancers [2]. The tomato (*Solanum lycopersicum* L.) is a very popular and versatile vegetable-fruit that is used in the preparation of several dishes. It is a much consumed legume because of its richness in nutrients. Tomato is nutritionally rich in fiber, minerals, vitamins and antioxidants.

The antioxidants are total phenolic compounds, flavonoids, lycopene, vitamin A and vitamin C [3]. By its antioxidant properties, it plays an important role in protecting the body. It is considered to be the primary source of lycopene, which has been shown to reduce the risk of certain chronic diseases [4-8]. Etmina *et al.,* [9] showed that consumption of tomatoes and tomato products prevented prostate cancer. Also, diets that include tomatoes have been associated with the reduction of certain cardiovascular diseases [10]. However, the nutritional composition of tomatoes such as β-carotene, lycopene, and total phenolic may vary depending on variety, climate, maturity and environmental conditions [11-16].

Currently, in Burkina Faso, several varieties of tomato are grown, but the most part are varieties imported from other countries. The breeders of these varieties prefer mainly productivity, adaptation to growing conditions and resistance to diseases to the detriment of any other character of interest. The organoleptic and nutritional quality of these varieties on the market no longer satisfies consumers. As a result, the acquisition of good organoleptic and nutritional value has become a major issue. Indeed, the research in Burkina Faso to overcome this problem entailed putting in place varieties whose nutritional composition especially ß-carotene, lycopene and total polyphenols deserve to be known. The objective of this study was to evaluate the β-carotene, lycopene and total phenolic composition of 45 tomato varieties selected by the research station in Burkina Faso (Institute of Environment and Agricultural Research) to see which varieties are potentially nutritional.

2. Materials and Methods

2.1. Plant Material

Forty-seven (45) tomatoes genotypes were collected from Burkina Faso (27), Mali (12) and Brasilia (6). The details are shown in the table 1. All the genotypes are cultivated at west experimental station of Institute of Environment and Agricultural Research (Bobo Dioulasso) in the raining season from July to October 2015. The experimental design used was RCBD with 4 replications. The cultural practices was followed according Rouamba et al. [17]. To make the samples of biochemical analysis, 1kg of fruit (250g per replication) per genotype was harvested from central plant per plot at the full repining stage and at the thirst harvest. These samples were crushed using a Moulinex type mill in order to obtain a homogeneous paste. These samples were stored in the freezer at - 20°C before analyses.

Table 1. *List of the plant material with their origin and their genetic nature.*

Code	Country	Province	Department	Village	Genetic nature
12T3	Burkina Faso	Houet	Karangasso Vigué	Saaré	Indigenous variety
15T5	Burkina Faso	Kénédougou	Orodara	Tin	Indigenous variety
2T4	Burkina Faso	Bam	Kongoussi	Kongoussi	Indigenous variety
32T1	Burkina Faso	Poni	Boussera	Nonkinena	Indigenous variety
34T1	Burkina Faso	Sanmatenga	Kaya	Zannogo	Indigenous variety
34T2	Burkina Faso	Sanmatenga	Kaya	Zannogo	Indigenous variety
4T2	Burkina Faso	Bazèga	Kombissiri	Saberaogo	Indigenous variety
12T2	Burkina Faso	Houet	Karangasso S	Toronson	Indigenous variety
13T1	Burkina Faso	Ioba	Dano	Bonembar	Indigenous variety
15T1	Burkina Faso	Kénédougou	Kangala	Mahon	Indigenous variety
15T6	Burkina Faso	Kénédougou	Orodara	Tin	Indigenous variety
1T1	Burkina Faso	Balé	Pâ	Boro	Indigenous variety
18T1	Burkina Faso	Kossi	Nouna	Babi golo	Indigenous variety
23T1	Burkina Faso	Loroum	Titao	Bouma Yiri	Indigenous variety
25T2	Burkina Faso	Nahouri	Pô	Tambolo	Indigenous variety
25T3	Burkina Faso	Nahouri	Pô	Tambolo	Indigenous variety
27T2	Burkina Faso	Nayala	Kougny	Kougny	Indigenous variety
27T3	Burkina Faso	Nayala	Kougny	Niaré	Indigenous variety
27T4	Burkina Faso	Nayala	Kougny	Tiouma	Indigenous variety
30T1	Burkina Faso	Oudalan	Gorom-Gorom	Gorom-Gorom	Indigenous variety
31T3	Burkina Faso	Passoré	Goumpounssou	Minsnoogué	Indigenous variety
38T1	Burkina Faso	Sourou	Lanfièra	Lanfièra	Indigenous variety
3T1	Burkina Faso	Banwa	Kouka	Molli	Indigenous variety
3T3	Burkina Faso	Banwa	Kouka	Molli	Indigenous variety
4T1	Burkina Faso	Bazèga	Kombissiri	Kombissiri, sect 5	Indigenous variety
4T3	Burkina Faso	Bazèga	Doulgou	Gana	Indigenous variety
5T1	Burkina Faso	Bougouriba	Diébougou	Bapla-Birifore	Indigenous variety
BT1	Brésil	NA*	NA	NA	Hybrid variety
BT2	Brésil	NA	NA	NA	Hybrid variety
BT3	Brésil	NA	NA	NA	Hybrid variety
BT4	Brésil	NA	NA	NA	Hybrid variety
BT5	Brésil	NA	NA	NA	Hybrid variety
BT6	Brésil	NA	NA	NA	Hybrid variety
MlT1	Mali	Bougouni	N'Tjila	Bougouni	Pure Line
MlT10	Mali	Bamako	Bamako	EIR	Pure Line
MlT11	Mali	Bamako	Bamako	EIR	Pure Line
MlT12	Mali	Bamako	Bamako	EIR	Pure Line
MlT13	Mali	Bamako	Bamako	EIR	Pure Line

Code	Country	Province	Department	Village	Genetic nature
MIT2	Mali	Bougouni	Djambala	Bougouni	Pure Line
MIT4	Mali	Koutiala	Kèlèni	Ziéna	Pure Line
MIT5	Mali	Ségou	Siguidolo-Bamana	Konobougou	Pure Line
MIT6	Mali	Kati	Dougoulakoro	Baguineda	Pure Line
MIT7	Mali	Bamako	Bamako	EIR	Pure Line
MIT8	Mali	Bamako	Bamako	EIR	Pure Line
MIT9	Mali	Bamako	Bamako	EIR	Pure Line

* Not available.

2.2. Determination of β-Carotene and Lycopene

Beta-carotene and lycopene were determined by high-performance liquid chromatography (HPLC), method validated by Somé et al. [18]. The analyzes were carried out under yellow light and the sample containers were protected from light by aluminum foil.

Preparations for standard solutions: For each carotenoid (β carotene, lycopene), a small amount (a few milligrams) was dissolved in 3 ml of hexane. Dilutions to 1/10, 1/100, 1/1000 of this solution were carried out. The respective optical densities were measured at 450 nm. The solution with an optical density of between 0.1 and 0.9 was chosen. Its concentration was then calculated according to the formula:

$$C = (DO/e) \times 10^{-3} (\mu g\ ml^{-1}) \quad (1)$$

DO is the optical density read and e is the molar extinction coefficient.

Preparation of the calibration mixture: From the standard solution thus prepared, the concentration of which was determined, the precise volumes of each solution of carotenoids were taken so as to obtain a solution of final concentration after absorption of 15 pmol in 20 µl for each carotenoid in the mixture. Except for β-carotene, the final concentration of which was 30 pmol / 20 µl. The volumes thus taken were combined, evaporated under nitrogen, and the residue was taken up with 500 µl of acetonitrile to obtain the concentrations indicated above.

Extraction of ß carotene and lycopene: A sample of about 1 g of dough was taken from a tube. The carotenoids were extracted by vortexing with 2 × 2 ml of hexane in the presence of echinenone (internal standard) at a concentration of 0.6 µmol µl -1. After vigorous stirring, the mixture at 3000 rpm-1 for 5 min at -5°C was centrifuged. After centrifugation, the hexane phases were combined and evaporated under nitrogen. The residue thus obtained was taken up in 800 µl of acetonitrile to obtain a solution containing 15 pmol / 20 µl of the internal standard; 20 µl were then injected.

Calculation of the concentration of each type of carotenoid: After injection of the calibration mixture of defined concentration and comprising the internal standard, a relative calibration factor was calculated for each peak:

$$f_i = A_i C_{SI} / C_i A_{SI} \quad (2)$$

Where f_i is the calibration factor of the compound i with respect to the internal standard (SI), A_i is the area under the curve or the peak height of the compound i, C_i is Concentration of compound i in the mixture. A_{SI} is the area under the curve of the internal standard (SI) and C_{SI} its concentration in the calibration mixture.

The C_{xi} concentration of each carotenoid was given by:

$$C_{xi} = (1f_i) (A_{iX} C_{SIE} / A_{SIE}) \quad (3)$$

Where C_{xi} is the concentration of compound i in the sample and A_{xi} the area obtained after injection of the sample. C_{SIE} and A_{SIA} are respectively the concentration and area under the curve of the internal standard introduced in the sample.

2.3. Determination of Total Phenolic

Total phenolic content of the tomato extract was determined by spectrophotometry according to the Folin-Ciocalteu reagent method of Singleton et *al.* [19] with the modifications.

Extraction: The methanol-HCl 1% solvent was used for extraction. 2.5 g of tomato pulp was placed in a flask and 50 ml of the extraction solvent was added. The vial was protected from light with aluminum foil. The mixture was placed under magnetic stirring for 10 minutes and then in the refrigerator. After 24 hours of maceration, the mixture was filtered with a filter paper N°2. The filtrate was placed in a spherical flask and stored to refrigerator at 4°C until use.

Dosage: An aliquot of 0.250 ml of extract was mixed with 1.25 ml of the Folin-Ciocalteu reagent (0.2 N). After 5 min of incubation at ambient temperature, 1 ml of sodium carbonate solution (75 g / L) was added. The mixture was then placed in a water bath, cooking double boiler, at a temperature of 65°C for 20 min and read at the spectrophotometer at 760 nm against a blank not containing the extract [19]. The measurements were carried out in triplicate. The total polyphenol content was determined from a calibration curve carried out with different concentrations of gallic acid. The results were expressed in mg gallic acid equivalent (GAE) per 100 g dry matter.

2.4. Statistical Analysis

Statistical analyzes focused on Principal Component Analysis (PCA), Analysis of Variances (ANOVA) and Hierarchical Ascending Classification (HAC). These analyzes were carried out with the XLSTAT software version XLSTAT 2014.5.03. Differences between methods were evaluated by Duncan's test. Statistical significant difference was stated at $P < 0.05$.

3. Results and Discussions

3.1. Lycopene Content (mg / 100g DM)

The table 2 shows the lycopene content in the 45 varieties of tomatoes. The lycopene content of the 45 varieties varied according to the variety with values ranging from 2.41 ± 0.00 mg / 100g DM to 83.81 ± 0.22 mg / 100g DM. The BT1 variety had the highest lycopene content and the lowest content was observed with the variety 14 27T4. The statistical analyzes shown a significant difference between the varieties ($P \leq 0.05$). The values obtained for some varieties are lower than those of Sahlin et *al.* [20] on two varieties (Aranca, Exell) with values of 45, 6 and 47.9 mg / 100g DM. On the other hand, there are others which are superior to this one. George et *al.* [21] obtained a value of 61.1 mg / 100 g DM and Rotino et *al.* [22] values ranging from 65.95 to 92.85 mg / 100g DM on four tomato genotypes from Italy. Furthermore, the values obtained are considerably lower than those of Tudor-Radu et *al.* [23] on four varieties of tomatoes in Romania with values of 164 to 359.88 mg / 100g DM. Lycopene is the main component responsible for the red color of tomato fruit [24]. The variability in lycopene levels between tomato varieties may be due to the varieties themselves but also to the degree of maturity of these varieties of tomato. According to Davies and Hobson [13] Giovanecci *et al.* [14], Abushita et *al.* [15] and Thompson et *al.* [16], the nutritional composition such that the lycopene content may vary depending on the variety and maturity of the tomato.

3.2. β-Carotene Content (mg / 100 g DM)

The ß-carotene content of the 45 varieties varied from 0.83 ± 0.00 (variety 14 27T4) to 28.88 ± 0.08 (variety BT1) mg / 100 g DM. Statistical analyzes also showed a significant difference between the β-carotene contents. The Beta-carotene determines the activity of vitamin A and is responsible for the orange color of tomato fruits [24]. The values obtained are lower than those of Rotino *et al.* [22] with values ranging from 49.11 to 69.85 mg / 100 g DM on four tomato genotypes. They are similar to those obtained by Georgé *et al.* [21] and Tudor-Radu *et al.* [23] with respective values of 17.4 and 9.26 to 33.40 mg / 100g MS. Like the lycopene content, the β-carotene content may also depend on several factors such as variety, degree of maturity and agronomic conditions [13, 25].

3.3. Total Polyphenol Content (mg GEA / 100 g DM)

The total phenolic content was including between 502.84 ± 47.46 and 1181.08 ± 182.96 mg GEA / 100 g DM (Figure 2). The total phenolic content was including between 502.84 ± 47.46 and 1181.08 ± 182.96 mg GEA / 100 g DM. The results show that all the varieties studied are rich in total phenolic. The 25T2 variety is the richest one in total phenolic (1181.08 ± 182.96 mg GEA / 100 g DM), followed by the variety 31 M1T11 (1150.787 ± 158.58 mg GEA / 100 g DM) and of the 22 3T1 variety (972.998 ± 139.37 mg GEA / 100 g DM). The statistical analyzes show a significant difference between the varieties ($P \leq 0.05$). The values found in the present in the present study are below than those reported by Tudor-Radu *et al.* [23] which ranged from 29911.50 to 42874.01mg of GEA / 100g DM. On the other hand, they are lower than the values of George et *al.* [21] on red tomato and those of Sahlin *et al.* [20] on two varieties (Excell, Aranca) with respective values of 268 mg and 354.83 to 438.6 mg GEA / 100 g DM. Also, they are above those obtained by Seremé *et al.* [26] for Burkina Faso tomato Mongal F1 with values of 157.33 to 193.47 mg GEA / 100 g DM. The variability in total phenolic content observed may be due to the very difference of the varieties and their degree of maturity. It may also be due to the solvent used during extraction of the total phenolic. In previous study on *Hibiscus sabdariffa*, Arthur et al. [27] demonstrate the variability in the content of phenolic compounds using three different solvent ((70: 30% v / v), ethanol / water (70: 30% v / v) and methanol-HCl (1%)) during extraction. The variability in total phenolic content may also depend on UV radiation and the stress on the tomato [28].

Table 2. *Composition in lycopene, β-carotene and total phenolic of tomato varieties.*

Code of varieties	Lycopene (mg/100g DM)	ß-carotene (mg/100g DM)	Total phenolic (mg GAE DM)
12T2	8.87 ± 0.07^{z}	3.07 ± 0.02^{aa}	$682.86 \pm 91.41^{fghijklmno}$
25T2	50.66 ± 0.36^{d}	17.52 ± 0.13^{e}	$1\ 181.08 \pm 182.97^{a}$
25T3	4.65 ± 0.04^{aeaf}	1.61 ± 0.01^{afagah}	$748.18 \pm 84.63^{defghijkl}$
27T2	30.14 ± 0.38^{q}	10.42 ± 0.13^{q}	$600.06 \pm 28.26^{jklmno}$
27T3	12.25 ± 1.06^{y}	4.49 ± 0.00^{y}	$666.06 \pm 30.47^{ghijklmno}$
27T4	2.41 ± 0.00^{ak}	0.83 ± 0.00^{al}	553.70 ± 40.92^{lmno}
2T4	5.13 ± 0.01^{ad}	1.77 ± 0.00^{ae}	$699.12 \pm 48.63^{fghijklmn}$
30T1	4.81 ± 0.00^{adaeaf}	1.66 ± 0.00^{afag}	535.72 ± 92.90^{mno}
31T3	38.85 ± 0.19^{o}	13.44 ± 0.06^{o}	$781.18 \pm 44.\ 61^{cdefghij}$
32T1	7.41 ± 0.04^{aa}	2.56 ± 0.01^{ab}	$569.48 \pm 117.84^{klmno}$
34T1	41.90 ± 0.07^{l}	14.49 ± 0.02^{l}	869.58 ± 74.43^{bcdef}
12T3	6.17 ± 0.00^{abac}	2.13 ± 0.00^{ad}	$654.02 \pm 110.05^{ghijklmno}$
34T2	4.92 ± 0.01^{adae}	1.70 ± 0.00^{aeaf}	$681.08 \pm 18.98^{fghijklmno}$
38T1	32.23 ± 0.06^{p}	11.15 ± 0.02^{p}	$589.72 \pm 23.57^{jklmno}$
3T1	$4.42 \pm 0.07_{afag}$	1.53 ± 0.02^{ahai}	973.00 ± 139.37^{b}

Code of varieties	Lycopene (mg/100g DM)	ß-carotene (mg/100g DM)	Total phenolic (mg GAE DM)
3T3	42.66± 0.11^{k}	14.76 ± 0.04^{k}	752.26 ± 102.44^{cdefghijk}
4T1	17.54 ± 0.12 ^{w}	6.07 ± 0.04^{w}	502.84 ± 47.46^{o}
4T2	6.55 ± 0.01^{ab}	2.27 ± 0.00^{ac}	960.58 ± 135.62^{bc}
4T3	28.58 ± 0.26^{s}	9.88 ± 0.09^{s}	619.01 ± 41.70^{ijklmno}
5T1	25.65 ± 0.24^{t}	8.87 ± 0.08^{t}	707.21 ± 54.68^{fghijklmn}
M1T1	44.07± 0.19^{i}	15.24 ± 0.07^{i}	638.55 ± 25.06^{hijklmno}
13T1	43.25 ± 0.40^{j}	14.96 ± 0.14^{j}	743.87 ± 1855.77^{defghijkl}
M1T10	66.06 ± 0.09^{b}	22.85 ± 0.03^{b}	672.07 ± 35.10^{ghijklmno}
M1T11	44.89 ± 0.31^{h}	15.52 ± 0.11 ^{h}	1 150.79 ± 158.57^{a}
M1T12	3.76 ± 0.02^{ahai}	1.30 ± 0.01^{aj}	627.35 ± 180.54^{ijklmno}
M1T13	5.98 ± 0.04^{ac}	2.07 ± 0.01^{ad}	930.71 ± 64.53^{bcd}
M1T2	47.44 ± 0.10^{g}	16.41 ± 0.04 ^{g}	684.59 ± 34.14^{fghijklmno}
M1T4	4.18 ± 0.00^{agah}	1.45 ± 0.00^{ai}	783.61 ± 134.04^{cdefghij}
M1T5	49.78 ± 0.03^{f}	17.21 ± 0.01^{f}	597.95 ± 22.95^{jklmno}
M1T6	16.60 ± 0.03^{x}	5.74 ± 0.01^{x}	665.29 ± 53.28^{ghijklmno}
M1T7	4.58 ± 0.00^{aeafag}	1.58 ± 0.00^{agah}	825.21 ±68.25^{bcdefgh}
M1T8	58.78 ± 0.08^{c}	20.33 ± 0.03^{c}	674.42 ± 72.35^{ghijklmno}
15T1	56.69 ± 0.01^{d}	19.61 ± 0.00^{d}	752.11 ± 32.46^{ijklmno}
M1T9	42.82 ± 0.05^{jk}	14.81 ± 0.02^{k}	629.03 ± 48.62 ^{ijklmno}
15T5	3.29 ± 0.01^{aj}	1.14 ± 0.00^{ak}	722.46 ± 14.21^{efghijklm}
15T6	40.67 ± 0.18^{n}	14.07 ±0.06^{n}	704.53± 10.85^{fghijklm}
21T1	21.75 ± 0.03^{u}	7.52 ± 0.01^{u}	814.97 ± 102.63^{bcdefghi}
1T1	9.22 ± 0.02^{z}	3.19 ± 0.01^{z}	904.26 ± 50.60 ^{bcde}
23T1	3.44 ± 0.00^{aiaj}	1.19 ± 0.00^{ak}	702.09 ± 14.28^{fghijklmn}
BT1	83.51± 0.22^{a}	28.88 ± 0.08^{a}	516.41 ± 71.90^{no}
BT2	42.16 ± 0.05^{l}	14.58 ± 0.02^{l}	600.78 ± 91.56^{jklmno}
BT3	41.11 ± 0.23^{m}	14.22± 0.08^{m}	840.57 ± 19.72^{bcdefg}
BT4	20.74 ± 0.10^{v}	7.17 ± 0.03^{v}	698.42 ± 23.31^{fghijklmno}
BT5	2.50 ± 0.08a^{k}	0.86 ± 0.08^{al}	655.38 ± 61.93^{ghijklmno}
BT6	29.39 ± 0.12^{r}	10.16 ± 0.04^{r}	590.08 ± 6.39^{jklmno}
p-value	0,0001	0,0001	0,0001
Signification	***	***	***

Tests were performed in triplicate; Values are means ± Standard Deviation, DM: Dry Matter, along the columns, values with the same letter (a, b, c, d, e, f, g, h, i, j, k, l, m, n, o) are not significantly different ($p > 0.05$), *** $P < 0.01$.

3.4. Correlation Between Lycopene and β-Carotene Contents

The results in table 3 show a very strong positive correlation between lycopene and β-carotene contents. This correlation is explained by the fact that for the same variety, if the lycopene content is high, the β-Carotene content is also high and if the lycopene content is low, the β-Carotene content is also low. There is a weak negative correlation between lycopene and total polyphenols and between β-Carotene and total polyphenols.

Table 3. *Correlation matrix of lycopene, β-carotene and total phenolic.*

	Lycopenes	ß-Carotenes	Total phenolic
Lycopenes	1	1.000	-0.005
ß-Carotenes	1.000	1	-0.005
Total phenolic	-0.005	-0.005	1

3.5. Principal Component Analysis of the Lycopene, β-Carotene and Total Phenolic Content

The Principal component analysis (PCA) of the lycopene, β-carotene and total phenolic contents is shown in figure 1. This representation follows two axes, F1 (66.67%) and F2 (33.36%), which consist of 100.00% of the reliable results. Axis 1 is represented by total phenolic and axis 2 by lycopene and β-carotene. The PCA shows four groups of tomato varieties. Variety group 1 (13 varieties: 15T6, M1T2, M1T10, M1T10, M1T9, M1T1, 4T3, 27T2, BT6, 38T1, BT2, M1T5 and BT1) is closer to the lycopene and ß-carotene. These thirteen varieties are therefore rich in lycopene and β-carotene. Variety group 2 (10 varieties: 25T2, M1T11, 34T1, BT3, 31T3, 3T3, 13T1, 15T1, 5T1) is mainly characterized by the total phenolic, lycopene and β-carotene variables and are significantly for these three variables (total phenolic, lycopene and β-carotene). They are rich in total phenolic, lycopene and β-carotene.

The group of variety 3 such as the varieties 3T1, 4T2, M1T1, 1T1, M1T7, 7 21T1, M1T4, 25T3, 15T5 is close to the total phenolic variable. These varieties are therefore rich in total phenolic. The group of variety 4 (4T1, 30T1, 27T4, 32T1, M1T12, 12T3, BT5, M1T6, 27T3, BT4, 12T2, 34T2, 2T4, 9T1) are distant from three variables. This means that these varieties are low in total phenolic, lycopene and β-carotene.

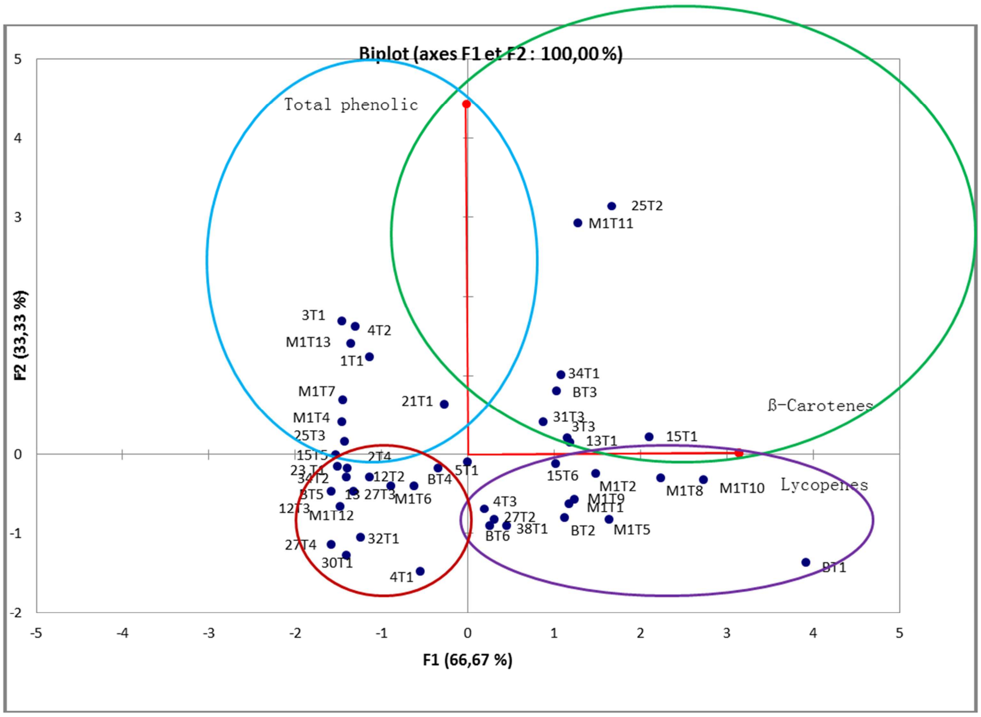

Figure 1. *Principal component analysis of lycopene, β-carotene and total phenolic content of 45 tomato varieties.*

3.6. Hierarchical Ascending Classification of the Total Polyphenol Content

The Hierarchical Ascending Classification (HAC) or dendrogram of the total phenolic content of the 45 tomato varieties shown in figure 2 gives three classes of tomato variety. Class 1 consists of varieties 12T2, 27T2, 27T3, 27T4, 2T4, 30T1, 32T1, 12T3, 34T2, 38T1, 4T1, 4T3, 5T1, M1T1, M1T10, M1T12, M1T2, M1T5, M1T6, M1T8, M1T9, 15T5, 15T6, 23T1, BT1, BT2, BT4, BT5, BT6. These varieties contain the lowest total phenolic contents. Varieties 25T2 and M1T11 form Class 2. These varieties are the richest in total phenolic. As for Class 3, it combines the varieties 25T3, 31T3, 34T1, 3T1, 3T3, 4T2, 13T1, M1T13, M1T4, M1T7, 15T1, 21T1, 1T1 and BT3. These are varieties which have the average contents of total phenolic.

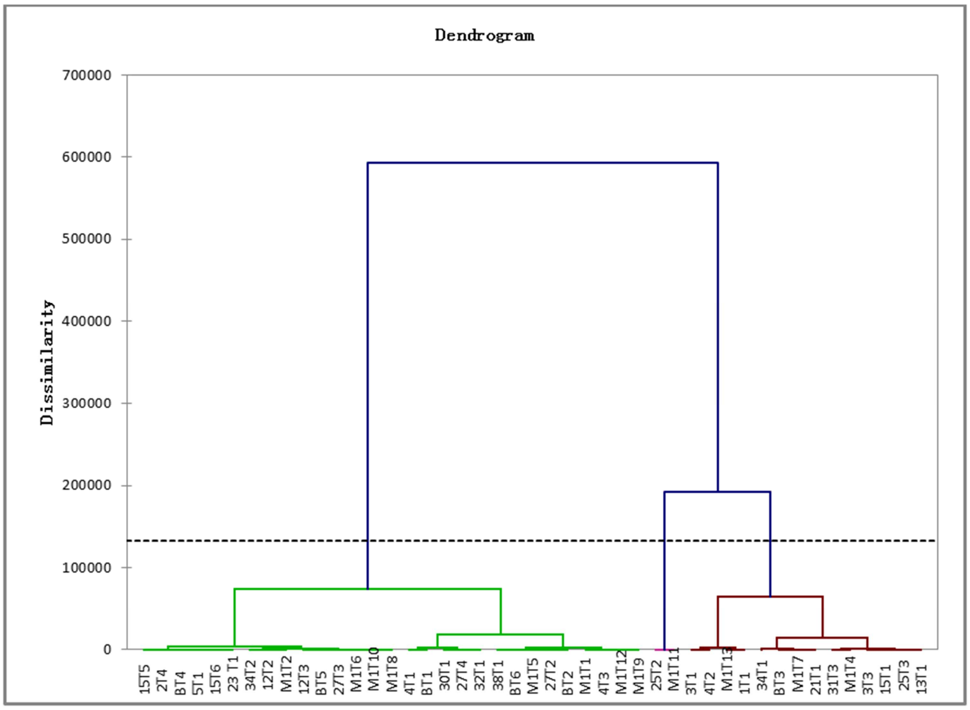

Figure 2. *Hierarchical Ascending Classification of total phenolic content of 45 tomato varieties.*

3.7. Hierarchical Ascending Classification of the Lycopene and β-Carotene Content of the 45 Tomato Varieties

Figure 3 shows the dendrogram of the lycopene and β-carotene content of the 45 tomato varieties. The dendrogram consists of three classes of tomato varieties. Class 1 consists of 29 varieties 12T2, 25T3, 27T3, 27T4, 2T4, 30T1, 32T1, 12T3, 34T2, 3T1, 4T2, M1T12, M1T13, M1T4, M1T7, 15T5, 1T1, 23T1, BT5. These are lower varieties of lycopene and β-carotene. Class 2 consists of 17 varieties: 25T2, 31T3, 34T1, 3T3, M1T1, 13T1, M1T10, M1T11, M1T2, M1T5, M1T8, 15T1, M1T9, 6 15T6, BT1, BT2, BT3. These varieties are the richest in lycopene and β-carotene. Class 3 consists of 09 varieties 27T2, 38T1, 4T1, 4T3, 5T1, M1T6, 21T1, BT4, BT6. This is the group of varieties containing average levels of lycopene and β-carotene.

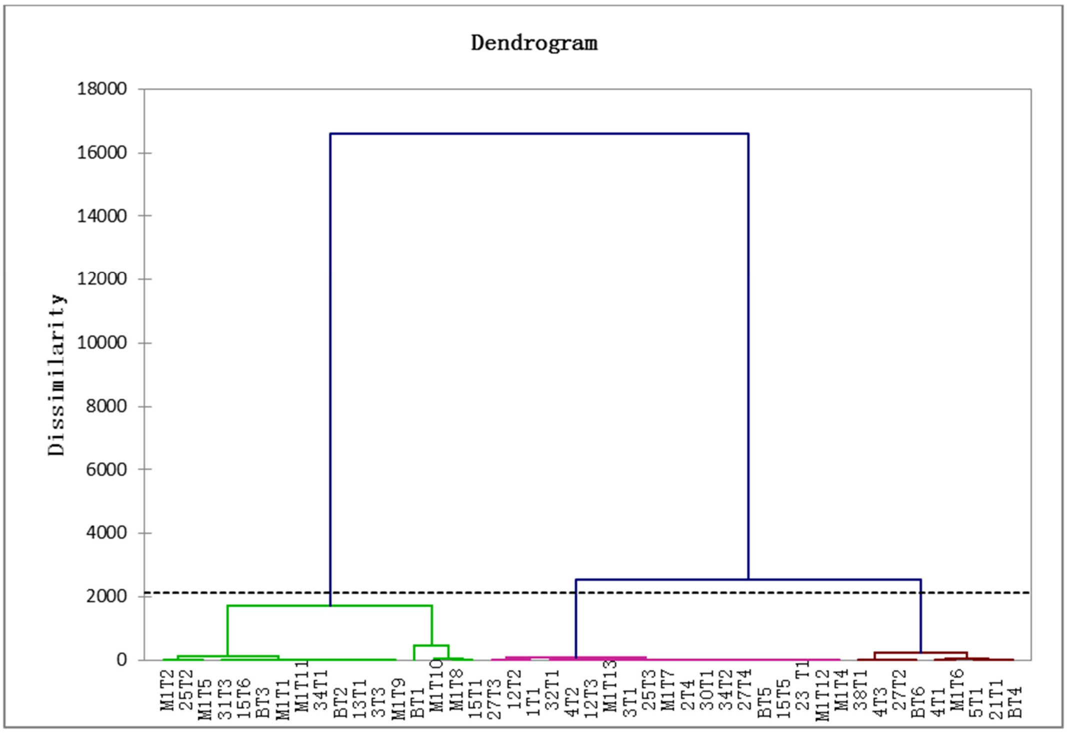

Figure 3. *Hierarchical Ascending classification of the content of lycopene and β-carotene.*

4. Conclusion

At the end of this study, it appears that the 45 tomato varieties present a good content of lycopene, β-carotene and total phenolic. These results shown that these varieties are potential sources of antioxidant. The highest levels of lycopene and β-carotene were observed in the BT1 of Brazil and M1T10 varieties of Mali compared to the other varieties. The determination of the total phenolic revealed that the 25T2 of Burkina Faso and M1T11 of Mali varieties had a large amount of total phenolic than the other varieties of tomatoes. Varieties with high levels of lycopene, ß-carotene and total phenolic could be advised by the producer for cultivation at the national level.

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Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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