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(RESEARCH ARTICLE)

Impact of organic or conventional cultivation and drying method on phenolic compounds, carotenoids and vitamin C contents in tomato

Christophe Dabiré [1, 2, *], Abdoulaye Sérémé [1], Abdoudramane Sanou [2], Virginie Marie Dakéné [3], W. D. B. Aimée Guissou [4], Edwige Bahanla Oboulbiga [4] and Mamoudou H. Dicko [2]

[1] *Department of Natural Substances (DSN), Institute for Research in Applied Sciences and Technologies (IRSAT), National Center for Sciences and Technological Research (CNRST), Ouagadougou, Burkina Faso.*
[2] *Laboratory of Biochemistry, Biotechnology, Food Technology and Nutrition (LABIOTAN), University Joseph Ki-Zerbo, Ouagadougou, Burkina Faso.*
[3] *Food Control and Applied Nutrition Direction, National Public Health Laboratory; 09 BP 24 Ouagadougou 09; Burkina Faso.*
[4] *Department of Food Technology (DTA), Institute for Research in Applied Sciences and Technologies (IRSAT), National Center for Sciences and Technological Research (CNRST), Ouagadougou, Burkina Faso.*

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Abstract

Nowadays, organic foods are recognized for having a better nutritional quality than those from conventional agriculture, which explains the growing demand for organic vegetables. For the present research, three tomato cultivars, Mongal F1, Roma VF and F1 Cobra 26 were grown using conventional and organic methods, to assess the impact of cultivation practices and drying method on the micronutrient content of these cultivars. Samples were compared for micronutrient content of lycopene, β-carotene, flavonoids, vitamin C and total content of phenolic compounds using the FRAP and DPPH methods. The results show a high antioxidant activity (5901.338 mmol TE/100g and 6020.545 mmol TE/100g) and a high content of total polyphenols (1595.046 mg EAG/100g DM) for organic growing. The average contents of flavonoids (121.572 mg/100g DM and 129.053 mg/100g DM), β-carotene (39.618 mg/100g DM and 39.751 mg/100g DM), lycopene (169.739 mg/100g DM and 168.894 mg/100g DM) and vitamin C (301.995 mg/100g and 268.252 mg/100g DM) in tomatoes from organic and conventional cultivation show no statistically significant difference. After drying, results report an increase of 188.88% of Flavonoids content (from 62.413 ± 47.285 for mashed tomato to 180.304 ± 72.152 for dried Tomato); a decrease of 34.60%, 27.18% and 47.95% respectively for β-carotene content (from 47.388 ± 1.615 mg /100g DM for mashed tomato to 30.988 ± 0.767 mg /100g DM for dried tomato), lycopene content (from 188.085 ± 7.100 mg/100g DM for mashed tomato to 136.955 ± 2.810mg/100g DM for tomato dried) and vitamin C content (from 385.686 ± 37.825 mg/100g for mashed tomato to 200.743 ± 14.181mg/100g DM for dried tomato).

There is variability in the micronutrient content depending on the variety of tomato, the cultivation practice and the processing technique used. Organic cultivation practice improves the micronutrient content. Using gas dryers for drying has the most detrimental effects on the micronutrient content.

Keywords: Tomato; Cultivation practices; Drying technics; Antioxydants

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[*] Corresponding author: Christophe Dabiré
Department of Natural Substances (DSN), Institute for Research in Applied Sciences and Technologies (IRSAT), National Center for Sciences and Technological Research (CNRST), Ouagadougou, Burkina Faso.

1. Introduction

Tomato is an important source of the food supply, for national and sub-regional trade in Burkina Faso. In 2017, tomato was classified as the second most important market garden crop with an estimated production of 300,000 tons [1]. Several varieties of tomato are available and well appreciated on the market. The main ones are the Mongal F1, Roma VF and F1 Cobra 26. Tomato contains bioactive compounds that have strong antioxidant activity in human's body [2]. It is also consumed mainly for its intake of provitamin A in the form of carotenoid terpenes [3]. Unfortunately, tomato production is negatively impacted by pests which cause significant losses for producers during cultivation and storage. To mitigate the impact of weeds and pests, producers use a lot, chemical plant protection products [4]. With regard to the toxicological risks of these pesticides, alternative products of organic origin are heavily recommended. Moreover, scientific research has shown that organic agriculture has a higher content of nutritional compounds and antioxidants compared to conventional agriculture [5]. In addition, as a climateric fruit, tomato is difficult to preserve, especially in developing countries where technologies are not accessible. Indeed, the process of respiration causes oxidation and then rotting of tomatoes. Thus, the lack of processing leads to huge post-harvest losses. Faced with these constraints linked to processing and conservation conditions, tomato is more valuable in dried form. Drying is a technological operation that ensures the continued availability of tomato. With a regard to a good mastery of the technology in order to minimize the degradation of bioactive molecules, exposure to light and temperature are essential factors [6]. The present study had a twofold objective, which is to assess the impact of organic and conventional production on the one hand and, on the other hand, the impact of different drying methods on the bioactive molecules of three tomato varieties produced in Burkina Faso.

2. Material and methods

2.1. Study site and farming system

The agronomic experimentation was carried out on two sites. Organic production on the agro-ecological "school farm" of the Beo-Neere (Latitude 12°28'38.45 "N, Longitude 1°29'5.60 "W), and conventional production, on another site (Latitude 12°28'55.00 "N, Longitude 1°28'22.54 "W), located at 1.6 km, from the first one. The two (02) sites are both located in the commune of Nongr Massom, in the province of Kadiogo. Organic production consisted of using manure, ashes and phytopesticides (decoction of neem and papaya leaves). Conventional production, on the other hand, consisted of using chemical fertilizers including NPK (Nitrogen, Phosphorus and Potassium) and synthetic pesticides.

2.2. Plant material

Three varieties of tomatoes (Mongal F1, Roma VF and F1 Cobra 26) were used for the study. The fruits were harvested at maturity on both sites (organic and conventional). Once in the lab, the tomatoes samples were sorted, washed, disinfected with 2% bleach and rinsed with distilled water before being divided into four batches. The first batch was crushed using a blender and each of the three other batches were cut into thin slices and respectively dried under a shade (30°C) for 72 hours, in the sun (45°C) for 48 hours, and in a gas convection dryer (60°C) for 24 hours for the last batch, until obtaining a constant weight. Figure 1 shows the technological process followed for the samples processing. The samples were kept in the freezer for future analysis.

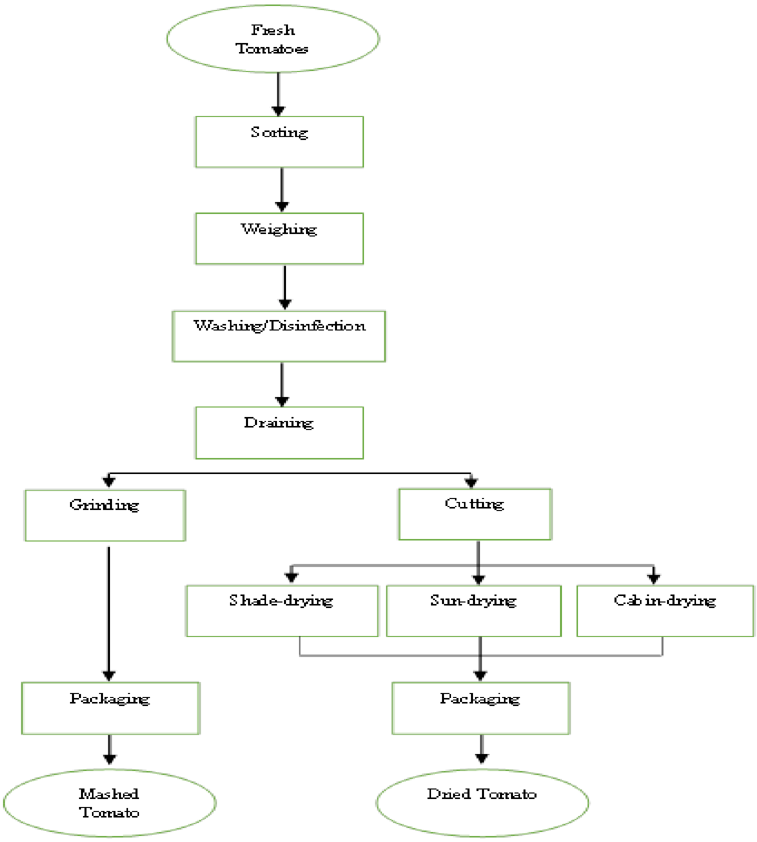

Figure 1 Flow Diagram of dried and mashed tomato production

2.3. Dosage of phenolic compounds and antioxidant activities

A quantity of 10mg of each extract was solubilized in 10 ml of an acidified hydro-methanolic solvent in the proportions of distilled water: 19, Methanol: 80 and 1% hydrochloric acid. These aliquots were used for the various analyses. The tests were carried out in triplicate.

2.4. Determination of total polyphenols

The total polyphenols in tomato extracts were quantified by spectrophotometry using the Folin -Ciocalteu reagent method [7] with modifications. Indeed, 25 µL of each extract were mixed with 105 µL of Folin - Ciocalteu reagent (10% v/v). After homogenization using a vortex for 5 minutes, 105 µL of sodium carbonate (7.5%) was added. The mixture was incubated for 2 hours and the absorbance was measured at 765 nm using a spectrophotometer. The total polyphenol content was determined using a standard curve (10 - 250 µg/mL, r2 = 0.994) for gallic acid, and the results were expressed in mg GAE/100g DM.

2.5. Determination of total flavonoids

The method described by Zhishen et al. [8] with some modifications was used for the determination of total flavonoids in tomato samples. 75 µL of each aliquot was homogenized in 75 µL of $AlCl_3$ (7.5 %). After 15 minutes at room temperature, the absorbance was measured at 415 nm with a spectrophotometer. The total flavonoid content was determined using the calibration curve (10 - 250 µg/mL, r2 = 0.996) and the results were expressed in mg quercetin equivalent (mg EQ/100g DM).

2.6. Determination of Lycopene

The lycopene content was determined by the direct spectrophotometric method as described by Fish et al. [9] with slight modifications. A calibration curve was first established from different concentrations of lycopene solutions ranging from 0.00782 to 0.125 mg/ml. The analyzed extracts were obtained from fresh tomato paste and dried tomatoes according to the method of Chanforan [10]. For the preparation of the extracts, 1.5 g of each sample was extracted with 20 ml of hexane - acetone - methanol (50: 25: 25) solvent system stabilized with 0.05% Butylhydroxytoluene (BHT) by maceration under magnetic stirring for fifteen minutes (15 minutes). Then 5 ml of distilled water was added. The solution was stirred again for 5 minutes and after settling, the organic phase was collected for the dosage. The operation was thus repeated three times. The absorbance of 0.5 ml of the organic phase, suitably diluted, was measured at 502 nm using a spectrophotometer. The lycopene content, expressed in milligrams per gram (mg/g) of tomatoes is given by the following formula [9, 11]:

$$\mathrm{CLyc(mg/g)} = \frac{\mathrm{Abs\ 502.Fd.MLyc.Vd}}{\mathrm{\mathcal{E}Lyc(502).m(ech)}}$$

C_{lyc}: Lycopene concentration in mg/g,
Abs_{502}: Absorbance at 502 nm, Fd: dilution factor, m_{ech}: sample weight,
Vd: Extract volume, M_{lyc}: Molar mass of lycopene,
ƐLyc : molar extinction factor

2.7. Determination of Vitamin C

The ascorbic acid was quantified using the method described by Mehta *et al*. [12] with minor modifications. This method is based on the discolorisation of 2,6-dichlorophenolindophenol (DCPIP) by ascorbic acid. For this, 50 µL of the extracts (50 mg/mL) were added to 150 µL of DCPIP (0.2 mM). Each test was carried out in triplicate and the absorbance read with a spectrophotometer at 515 nm using a blank consisting of 150 µL of DCPIP and 50 µL of distilled water. A calibration curve was drawn with ascorbic acid in the concentration range 10 µg/mL to 100 µg/mL. Ascorbic acid levels were expressed in µg Ascorbic Acid Equivalent per 100 g of dry weight (µg EAA/100 mg of dry weight).

2.8. Antioxidant activities

The ability of tomato extracts and fractions to trap the DPPH (2,2-diphenyl-1- picrylhydrazyl) radical was determined according the procedure described by Sombié *et al.* [13]. For each sample, a quantity of 100 µL was mixed with 200 µL of 0.2 mg/mL methanolic DPPH solution. The mixture was incubated for 15 minutes at room temperature and the absorbance read at 517 nm compared to a blank made with 100 µL of extract and 200 µL of methanol. The antiradical activity of the extracts and fractions was determined using an ascorbic acid calibration curve (0 - 10 mg/ml). The antiradical activity is expressed in mmol Ascorbic Acid Equivalent per gram of extract or fraction (mmol EAA/g).

The ability of tomato extracts to reduce Fe (III) to Fe (II) was determined using the method described by Sombié *et al.* [13]. A volume of 0.5 mL of each sample dissolved in water was mixed with 1.25 mL of phosphate buffer (0.2 M, pH 6.6) and 1.25 mL of an aqueous solution of potassium hexacyanoferrate [K3Fe (CN) 6.1 %]. After incubation at 50°C in water bath for 30 minutes, 1.25 mL trichloroacetic acid (10%) was added and the mixture was centrifuged at 3000 rpm for 10 minutes. Then 1.25 mL of the supernatant was mixed with 1.25 mL of distilled water and 0.25 mL of freshly prepared $FeCl_3$ (1%). The absorbance was read at 700 nm against a previously drawn ascorbic acid curve (0 - 200 mg/mL). The antioxidant activity of extracts and fractions to reduce iron (III) to iron (II) is expressed in mmol Ascorbic Acid Equivalent per gram of extract (mmol EAA/g).

2.9. Statistical analysis

All analyses were conducted in triplicate. Data were processed to derive descriptive statistic values. In addition, an analysis of variance (ANOVA) followed by Tukey test was carried out to determine statistical differences between samples from organic and conventional cultivation with a confidence interval of 95%, using the XLSTAT-Basic, version 2020.3. Finally, to visualize the spread of values for drying method with regard to micronutrients content, a Principal Component Analyses (PCA) was performed using the FactoMinR package with the RStudio software, version 1.1.463.

3. Results

3.1. Influence of organic and conventional production on the micronutrients of tomato

The contents of total polyphenols, total flavonoids, β-carotenes, lycopene and vitamin C for 100g of dry weight as well as the antioxidant activity of the tomato varieties Mongal F1, F1 Cobra 26 and Roma VF from conventional and organic production are presented in table 1.

Table 1 Micronutrients contents of F1 Cobra 26, Mongal F1 and Cobra VF varieties from organic and conventional farming.

Varieties	Growing	FRAP-AAO (mmol TE)	DPPH-AAO (mmol TE)	PolyPhenol (mg GAE)	Flavonoid (mg rutin)	β-carotenes (mg)	Lycopene (mg)	Vitamin C (mg)
F1Cobra 26	Organic	9708.90^{a}	8381.563^{a}	2737.744^{a}	155.89^{a}	44.945^{b}	185,920^{a}	416.448^{a}
	Conventional	3114.49^{b}	3072.012^{b}	1241.525^{b}	23.634^{b}	48.918^{a}	191.221^{a}	358.310^{b}
Mongal F1	Organic	5637.57^{a}	5439.636^{b}	1027.313^{a}	58.606^{a}	46.551^{b}	185.573^{a}	415.572^{a}
	Conventional	5521.98^{a}	5781.462^{a}	1084.908^{a}	34.050^{b}	48.962^{a}	185.856^{a}	346.420^{b}
Roma VF	Organic	4383.98^{a}	6204.986^{a}	1281.112^{b}	71.898^{a}	47.160^{a}	189.253^{a}	424.104^{a}
	Conventional	3697.27^{b}	3858.562^{b}	2115.442^{a}	30.396^{b}	47.789^{a}	190.688^{a}	353.260^{b}
Significant	F1Cobra 26	0.000	<0.0001	0.001	0.000	0.002	NS	0.016
	Mongal F1	NS	0.033	NS	0.033	0.014	NS	0.029
	Roma VF	0.020	<0.0001	0.006	0.007	NS	NS	0.002

Values with different superscript letters in the same column are significantly different (P- ≤0.05).
NS, not significant different statistically

Total polyphenol contents varied from 1027.313 mg GAE/100g DM (Mongal F1 in organic production) to 2737.744 mg GAE/100g DM (F1 cobra 26 in organic production). Total Flavonoid varied from 23.634 mg rutin/100g DM to 155.896 mg rutin/100g DM. The lowest as well as the highest contents were observed with F1 cobra 26 for conventional and organic production respectively. The lowest content of β-carotenes (44.945 mg/100g DM) was recorded for the F1 Cobra 26 variety in organic production and the highest value (48.962 mg/100g DM) for the Mongal F1 variety in conventional production. Lycopene contents from 191.221 mg/100g DM (F1 Cobra 26 in conventional production) to 185.573 mg/100g DM (Mongal F1 in organic production) were recorded without observing a statistically significant difference between conventional and organic cultivation for F1 Cobra 26 (P=0.485), Mongal F1 (P=0.973) and Roma VF (P=0.752). Vitamin C levels varied from 346.420 mg/100g DM (Mongal F1 in conventional production) to 424.104 mg/100g DM (Roma VF in organic production).

Statistical analysis shows a significant difference in micronutrients contents according to growing type (organic and conventional) for all three tomato varieties (Mongal F1, F1 Cobra 26 and Roma VF), except for vitamin C contents.

Table 2 Average of micronutrients of three tomato varieties from organic and conventional farming.

Growing	FRAP-AAO (mmol TE)	DPPH-AAO (mmol TE)	PolyPhenol (mg GAE)	Flavonoid (mg rutin)	β-carotenes (mg)	Lycopene (mg)	Vitamin C (mg)
Organic	5901.338 ^{a}	6020.545 ^{a}	1595.046 ^{a}	121.572 ^{a}	39.618 ^{a}	169.739 ^{a}	301.995 ^{a}
Conventional	4884.864 ^{b}	5178.295 ^{b}	1441.511 ^{a}	129.053 ^{a}	39.751 ^{a}	168.894 ^{a}	268.252 ^{a}
Significant	0.018	0.009	NS	NS	NS	NS	NS

Values with different superscript letters in the same column are significantly different (P ≤0.05).
NS, not significant different statistically

3.2. Influence of the drying method on the micronutrients contents of tomato

Table 6 shows the micronutrient in 100 g of dry matter for the three tomato varieties contents according to the drying method. The results are the average value per treatment (drying method) regardless of the production method and variety.

Total polyphenol contents varied from 1459.691mg GAE/100g DM (sun-dried samples) to 1581.341mg GAE/100g DM (Mashed samples) without a statistically significant difference observed between the different drying methods and mashed samples. The contents of total flavonoids varied from 62.413 mg rutin/100g DM (Mashed tomato) to 180.304 mg rutin/100g DM (Cabin drying). The highest content of β-carotenes was 47.388 mg/100g DM for the mashed samples compared to 38.353 mg/100g DM for the lowest content observed in the sun-dried samples. For lycopene and vitamin

C, the highest values were found in the mashed samples and were 188.085 mg/100g DM and 385.686 mg/100g DM respectively. The lowest levels for these two parameters were 169.830 mg/100g DM and 220.111 mg/100g DM respectively and derived from sun-dried samples.

Figures 2.a and 2.b show a variation in antioxidant activity and total polyphenol content depending on the type of treatment. As for the levels of flavonoids, β-carotenes, lycopene and vitamin C, a reduction in content is observed after drying, the cabin-drying giving the lowest levels.

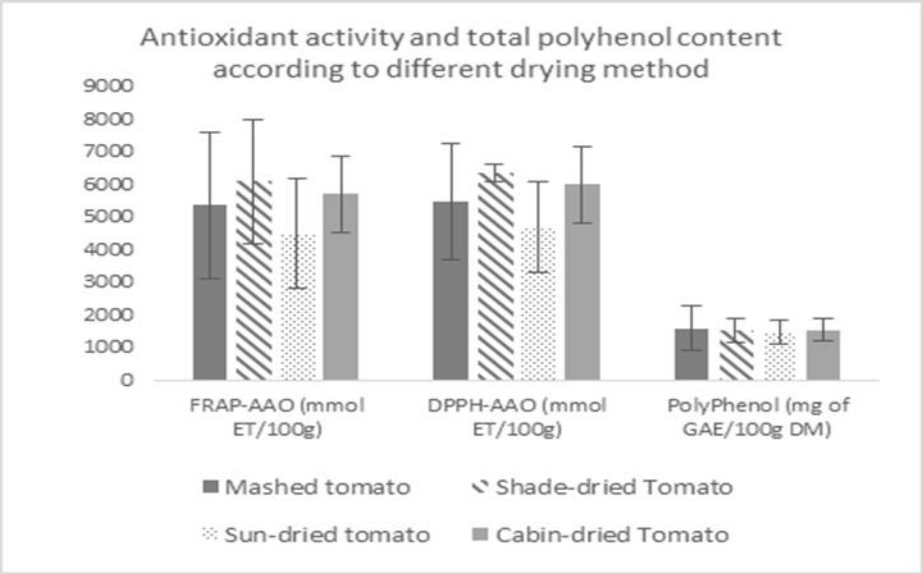

Figure 2a Variation in antioxidant activity and total polyphenol content according to the treatment

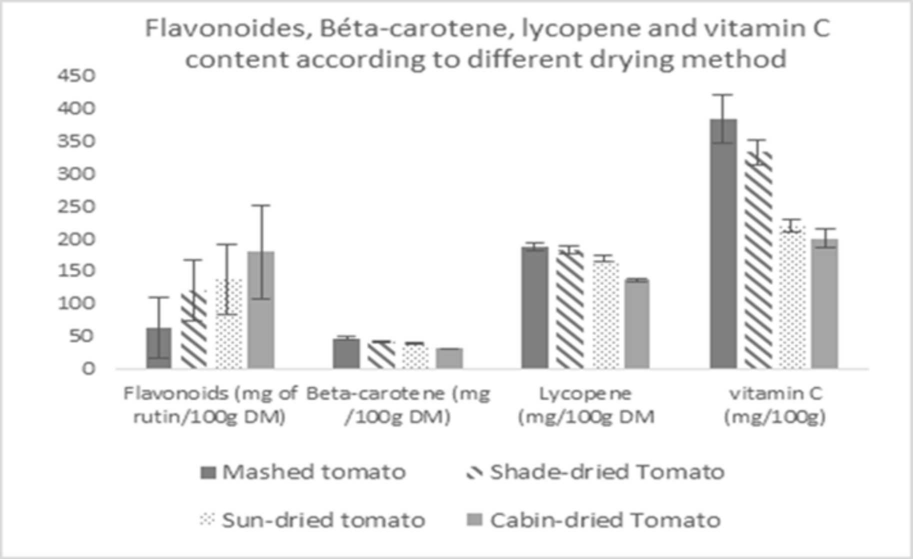

Figure 2b Variation in flavonoids, β-carotenes, lycopene and vitamin C content according to the treatment

Table 3 Micronutrients content according to drying methods.

Treatment	FRAP-AAO (mmol TE)	DPPH-AAO (mmol TE)	PolyPhenol (mg GAE)	Flavonoid (mg rutin)	β-carotenes (mg)	Lycopene (mg)	Vitamin C (mg)
Mashed tomato	5344.038 ± 2246.772^{ab}	5456.370 ±1757.427^{bc}	1581.341 ± 664.597^{a}	62.413 ±47.285^{c}	47.388 ±1.615^{a}	188.085 ±7.100^{a}	385.686 ±37.825^{a}
Shade-dried Tomato	6066.238 ± 1903.213^{a}	6311.580 ±269.754^{a}	1501.529 ±361.398^{a}	120.690 ±47.890^{b}	42.009 ±1.804^{b}	182.395 ±6.022^{b}	333.954 ± 19.942^{b}
Cabin-dried Tomato	5674.981 ±1176.315^{ab}	5968.640 ±1165.954^{ab}	1530.555 ±353.354^{a}	180.304 ±72.152^{a}	30.988 ±0.767^{d}	136.955 ±2.810^{d}	200.743 ±14.181^{d}
Sun-dried Tomato	4487.148 ±1663.151^{b}	4661.090 ± 1396.211^{c}	1459.691 ±363.353^{a}	137.843 ±53.148^{b}	38.353 ±0.927^{c}	169.830 ±5.688^{c}	220.111 ±9.437^{c}
Significant	NS	0.001	NS	<0.0001	<0.0001	<0.0001	<0.0001

Values with different superscript letters in the same column are significantly different (P ≤0.05).
NS, not significant different statistically

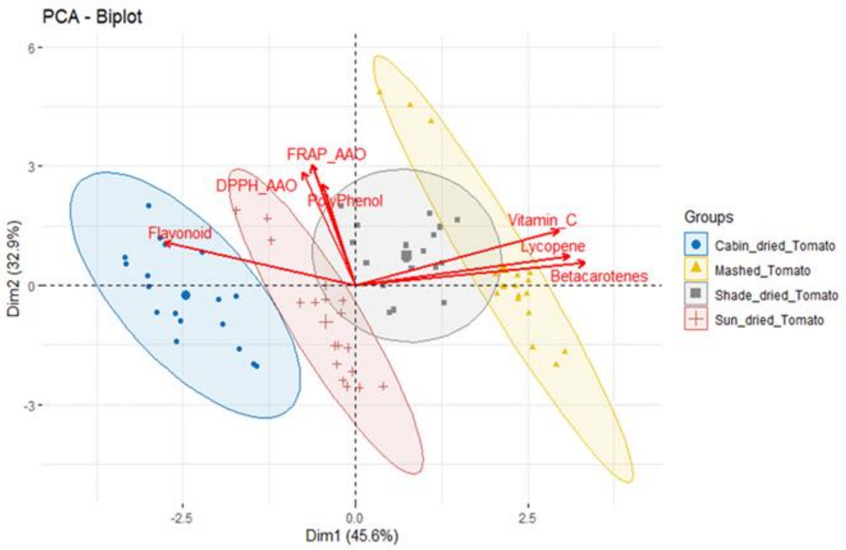

Figure 3 PCA boxplot of the Influence of the drying technique on the micronutrients contents of tomato

The principal components analysis (PCA) of the micronutrient's contents of mashed tomato samples and samples from the different drying methods revealed two main axes explaining 78.5% of the total variation, of which 45.6% was associated with axis 1 and 32.6% with axis 2. The PCA boxplot (Figure 3) shows the variation between the four populations. The mashed samples had the highest average levels of β-carotenes, lycopene and vitamin C, while the cabin-dried samples had the highest average levels of Flavonoids. Statistical analysis reveals a significant difference in the micronutrients contents of the samples subjected to the different drying methods except for the total polyphenol content.

4. Discussion

The results of this study provide interesting information on the influence of the production system and drying methods on the micronutrient content of the three varieties of tomato (Mongal F1, F1 Cobra 26 and Roma VF).

4.1. Influence of organic and conventional production on the micronutrients of tomato Total polyphenols

The presence of polyphenols may contribute to the protective properties of tomatoes [14]. Statistical analysis of the total polyphenol average of the three tomato varieties from organic production (1595.046 mg GAE/100g DM) and those from conventional production (1441.511 mg GAE/100g DM) revealed no statistical significant differences. The organic and conventional production practices would not influence the concentration of total polyphenols. [15] in a study on two varieties of tomato Llado and Antillas reported that the total phenol content was not significantly affected by the production method.

These results are similar to those of [5, 16, 17, and 18].

The total polyphenol means in the present study are similar to those found by [19] in the standard and cherry tomato varieties produced in organic and conventional cultivation for its first year of production (2008) but higher than those of its second year of production (2009). This author found in 2008 and 2009 levels of 1518.82 ± 453.45 mg GAE/100g DM and 994.28 ± 202.23 mg GAE/100g DM for organic production and 1596.20 ± 287.79 mg GAE/100g DM and 954.08 ± 281.84 mg GAE/100g DM for conventional production respectively. Our results are also superior to those found by several authors such as Oliveira et al. in 2013 (508.361 mg GAE.Kg-1 and 299.862 mg GAE.Kg-1 for organic and conventional production respectively), Vallverdú-Queralt et al. [50] in 2011 (320.8 mg GAE/100g DM) and Dewanto et al. [49] in 2002 (142.4 ± 6.5 µg/g). This difference in total polyphenol content could be attributed to several factors. According to [20], the polyphenol content varies according to the variety. Other parameters such as environmental factors and maturity period could have an impact on the polyphenol content [21, 22, 23].

4.2. Flavonoids

Flavonoids are the main components of the total phenolic content of tomatoes [24].

No statistically significant difference was observed between the means of flavonoid content for organic production (121.572 mg rutin/100g DM) and conventional production (129.053 mg rutin/100g DM). However, a statistically significant difference was observed between organic and conventional production for the three varieties (Mongal F1, Roma VF and Cobra 26) taken individually. Organic production would allow a better accumulation of flavonoids. According to [17] the flavonoid content of tomatoes seems to be related to the available nitrogen (N). Plants with limited N, accumulate more flavonoids than those with a good supply. If the differences in flavonoid content reflect fundamental differences in soil N behavior between conventional and organic systems, then the N available for tomatoes at the end of the season may have decreased in organic plots in recent years in response to the cumulative effects of lower compost application rates [25].

Flavonoid contents in the present study are higher than those of [26] who found contents of 26,160.33 mg.kg-1 and 33,360.43 mg.kg-1 of yellow flavonoid for organic and conventional production respectively. The yellow flavonoid content was higher in organic fruit (70%) compared to fruit from conventional growing systems, but only at harvest stage for this author. This reduction is similarly observed for the Roma VF and Cobra 26 varieties in the present study, with a decrease of 57.77% and 84.83% respectively in conventional fruit compared to fruit from organic production. This difference could be explained by the difference in the varieties used, but also by the soil composition, which can influence the level of these antioxidants.

4.3. β-carotenes and Lycopene

Lycopene, the most abundant carotenoid in ripe tomatoes that can make up to 90% of the total carotenoids present, is responsible for the red colour of the tomato [27]. The second main colouring agent is β-carotene, which is present in very low content [19].

Tomato samples from conventional and organic production presented means contents in β-carotene of 39.751 and 39.618 mg/100g DM and Lycopene of 168.894 and 169.739 mg/100g DM respectively. Statistical analysis revealed no statistically significant differences for these two carotenoids analyzed. Organic and conventional production systems would therefore not influence the levels of β-carotenes and Lycopene in the studied tomato varieties. A similar result was obtained by [15] on two tomato varieties (Llado and Antillas) produced organically and conventionally in Galicia (Spain). This author found carotene contents for conventional production of 4.44 ± 0.77 mg/100g FW and 1.30 ± 0.08 mg/100g FW for Llado and Antillas respectively and 3.90 ± 0.35 mg/100g FW and 2.02 ± 0.65 mg/100g FW for organic production for these two varieties respectively. The lycopene contents were 6.38 ± 0.14 (Llado) and 1.41 ± 0.18 mg/100g FW (Antillas) for conventional production and 5.51 ± 1.71 mg/100g FW (Llado) and 1.46 ± 0.58 mg/100g FW (Antillas) for organic production.

This observation is similar to that made by [19] in his study on two tomato varieties (standard and cherry). For the lycopene content, he obtained values of 167.54 ± 68.53 mg/100g DM and 164.68 ± 62.57 mg/100g DM for organic and conventional production respectively. These values are higher than those of the present study. However, he observed a difference in carotene contents: 4.42 ± 1.42 mg/100g DM for organic tomato and 4.66 ± 2.07 mg/100g DM for conventional tomato.

The absence of difference could therefore be associated with the difference in the variety used but also with the production conditions for these two methods. Indeed, the carotene content, particularly lycopene, of tomato fruits depends on many factors, including nitrogen. Nitrogen is the main element that forms Acetyl-CoA; this enzyme plays a major role in the synthesis of carotenoid pigments and causes the conversion of β-carotene to lycopene [28]. The levels of β-carotene in this study are higher than those found by [29,30] who obtained levels of β-carotene for organic tomatoes of 10.88 mg/100 g DM and 4.53 mg /100 g DM respectively and for conventional tomatoes of 14.57 mg/100 g DM and 3.93 mg /100 g DM respectively. As for the lycopene contents, they are higher than those reported by [31] (125.10 mg/100 g DM for organic tomatoes and 130.50 mg/100 g DM for conventional tomatoes) and those reported by Barrett et al. in 2007 (131.60 mg/100 g DM for organic tomatoes versus 135.45 mg/100 g DM for conventional tomatoes). These lycopene levels are also higher than those reported by Sawadogo et al (2015) for the Tropimech (0.065 mg/g), Royale (0.051 mg/g), Rio Grande (0.045 mg/g) and Mongal F1 (0.28mg/g) tomato varieties.

Tomato cultivars have different levels of lycopene, which also change significantly during ripening, and accumulates mainly in the bright red stage [32]. Studies on carotene and lycopene levels in organic tomatoes have shown different results, including higher [29] or lower [30] levels compared to conventional methods. According to [33], the lycopene content relative to tomato dry matter is lower in organic farming.

4.4. Vitamin C

Organic and conventional tomatoes showed vitamin C contents of 301, 995 mg /100 g DM and 268, 252 mg /100 g DM respectively as an average of the three studied varieties (Table 5). No statistically significant differences were revealed by statistical analysis. Organic and conventional production would not therefore influence the vitamin C content in tomatoes. The vitamin C values are close to those found by [29] who obtained as mean of two-year contents of 354.7 mg/100 g DM, 346.5 mg/100 g DM for organic and conventional tomatoes respectively. But higher than those found by [34] which were 220.56 ± 0.12 mg/kg for organic tomatoes and 175.36 ± 0.20 mg/kg for conventional tomatoes. These authors report that the vitamin C content is higher in organic production. Indeed, analysis of our vitamin C contents, taking the varieties individually, shows a statistically significant difference between conventional and organic production with high contents for organic production for all three varieties. [33, 17] showed that tomatoes from organic growing procedures had higher vitamin C content than conventionally grown fruit.

It should be noted that the data reported in the literature on vitamin C are controversial. For tomatoes, [5, 17 and 29] found higher concentrations of ascorbic acid in organically grown tomatoes, while [16] found no significant differences. Differences in ascorbic acid content between cultivars have already been reported by [35, 36, 37, 38 and 39], but were not observed by [40] or among hydroponically grown tomatoes by [41].

The vitamin C content of fruits may depend on the type of nitrogen fertilizer used. For pepper, which belongs to the same botanical family as tomatoes, it was found that when ammoniacal nitrogen (NH4) was used, the fruits of the pepper plant contained less vitamin C than when the nitrate (NO3-) form was used [42].

The use of high doses of nitrogen fertilizer in the nitrate form helped to increase the vitamin C content of standard tomatoes and cherries. Vitamin C levels are reported to be significantly dependent on the level and type of fertilization.

4.5. Influence of the drying method on the antioxidant composition of tomatoes

Processing and preparation processes most often involve heat treatments likely to affect the micronutrients contents and therefore the nutritional quality of the finished products. Heat treatments aim to stabilize food for long storage periods [43].

The contents of total polyphenols, flavonoids, β-carotenes, lycopene and Vitamin C according to the treatments applied are shown in Table 6. Total polyphenol contents varied from 1459.691 mg GGE/100g DM (sun-dried samples) to 1581.341 mg GGE/100g DM (mashed). No statistically significant difference was observed between the samples dried using different methods and the mashed samples.

Flavonoid contents varied from 62.413 mg rutin/100g DM to 180.304 mg rutin/100g DM, an increase over mashed sample from 93.37% for the shade-dried samples to 188.88% for the cabin-dried samples.

β-carotenes, lycopene and vitamin contents show a similar evolution during the different drying methods applied. The highest values were observed in fresh samples (mashed). Shade-drying has the lowest losses with a reduction of 11.35%, 3.02% and 13.41% for β-carotenes, lycopene and vitamin C respectively. As for samples dried using the gas dryer, they recorded the greatest reductions in these micronutrients with 34.6%, 27.18% and 47.95% for β-carotenes, lycopene and vitamin C respectively.

The decrease in the levels of β-carotenes, lycopene and Vitamin C during shade, sun and gas drying (Table 6) indicates that the drying method has a negative effect on the levels of these compounds in all three varieties. This negative effect would probably be due to the photo and heat sensitivity of these micronutrients. Indeed, according to [44], the chemical structure of lycopene, in particular the long conjugated chain of C=C double bonds, predisposes lycopene to isomerisation and degradation upon exposure to light and heat. [43], recorded reductions in lycopene of 15 - 31.1% in three tomato varieties studied in Burkina Faso. [32] showed that environmental factors, such as high fruit surface temperature caused by high air temperature or direct sunlight, significantly reduce the lycopene content of the whole fruit. The same authors also showed in 2006 that the lycopene content increases with the ripening of the fruit. Cultivation conditions (harvest date in the year, sunshine, temperature, soil quality, etc.) can greatly affect the carotenoid content [10].

Solar drying negatively affects the carotene and lycopene contents of all tomato varieties. This decrease would be justified by the dual action of heat and sunlight [43].

Fresh tomatoes contain significant amounts of vitamin C. Total vitamin C levels vary according to cultivar and environmental conditions.

The evolution of vitamin C during processing has been widely studied. It is the only micro-component of tomatoes for which there is a consensus in the literature. Tomatoes are naturally very sensitive to oxidation due to their structure, and degrade strongly during processing. Depending on the temperature and duration of the heat treatments, luminosity, pH and oxygen content, the oxidation of this compound will be more or less rapid. Degradation continues during storage, probably in connection with the reactions initiated during heat treatments [45, 46, 47 and 48].

5. Conclusion

Many factors determine the nutritional quality of tomato. The experiment conducted in this study showed that there is a significant difference in the micronutrients contents of the three varieties of tomato due to genetic factor. Apart genetic parameter, tomato fruits from organic production showed significantly higher levels of β-carotene, lycopene and vitamin C compared to those from conventional production. The study also shows that drying methods in the shade, sun and gas influence the micronutrients levels. This sensitivity is generally reflected in lower levels. Lycopene, ascorbic acid, carotenoids and the total polyphenol content of tomatoes can be considered as indicators of good quality. This study shows that it is important to choose the appropriate cultivation practices and drying methods to obtain better concentrations during production or to minimize losses of these compounds during tomato dehydration.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors hereby declare that there is no conflict of interest that could arise.

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