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Characterisation of the Physico-Chemical Properties, Antioxidants, Anti-Nutrients and Minerals of Two (2) Varieties of Tomato (*Solanum lycopersicum L.*): the African Tomato and the Salad Tomato Sold on Markets in Korhogo in the North of Côte d'Ivoire

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ABSTRACT

Two varieties of tomato (the African tomato and the salad tomato) are sold on the markets of Korhogo, in the north of Côte d'Ivoire. The African tomato is the least popular. The people who eat them are unaware of the nutritional value of the two varieties of tomato. There has been no comparative study of the physico-chemical parameters, antioxidants, anti-nutrients and minerals of the two (2) varieties of tomato. This study is an enhancement of the African tomato. The physico-chemical properties of African tomatoes and salad tomatoes respectively showed high humidity (93.36% and 95.81%), acid pH (3.99 and 4.2), low fibre (0.81% and 0.68%), lipid (0.38% on average), protein (1.71% and 1.58%), total carbohydrate (3.4% and 1.4%) and calorie (23.65 Kcal/100g and 15.63 Kcal/100g) content. The study also revealed that tomatoes are high in polyphenols (123.64mg/100g and 101.98mg/100g), flavonoids (54.37mg/100g on average) and carotenoids (41.17mg/100g and 39.84mg/100g). Tomatoes also contain vitamin C (12.49mg/100g and 10.52mg/100g). Phytates (2.92mg/100g and 2.23mg/100g) and oxalates (9.19mg/100g and 6.79mg/100g) were determined in small quantities. Determination of the minerals by atomic absorption showed the presence of several minerals such as magnesium, potassium, calcium, iron, copper and zinc with potassium predominating. Based on this study, we can say that the African tomato has a higher nutrient content, while the salad tomato has a higher mineral content. Both varieties of tomato contain fibre, macronutrients, antioxidants and minerals that are beneficial to the people of Korhogo.

Keywords: African tomato, salad tomato, Solanum lycopersicum L, Korhogo, antioxidants, minerals

INTRODUCTION

The tomato belongs to the Solanaceae family, which comprises 102 genera with around 2,500 species of annuals, woody and non-woody perennials, small shrubs and trees. Depending on the 7 subfamilies, the genera and their species are either widespread throughout the world (Solanoidae), or native to South America (Schwenckioidae, Petunioidae), Central America (Petunioidae), the West Indies and Australia (Nicotianoidae). The tomato is an herbaceous plant that tends to lignify as it ages. It grows upright when first planted, but becomes naturally bushy if not staked as it matures. The alternate leaves can take on very different shapes, depending on the variety [1].

Tomatoes are one of the most widely grown vegetable crops in the world, both in the field and in the garden [2]. In 2001, 3.7 million hectares of tomato were planted, with production estimated at 100 million tonnes [3,4]. However, this production is unevenly distributed. Asia ranks first with 45% of world production, Europe 2nd with 22%, followed by America 19% and Africa 12% [4]. Tomatoes play an important role in the human diet. They are eaten either raw, in salads, mixed with other ingredients or in juice, or cooked in countless culinary preparations. In 2003, worldwide consumption of tomatoes (fresh and processed) totalled 102.8 million tonnes. China is the biggest consumer (25.27 million tonnes in 2003), followed by the United States and India (10.11 and 6.84 million tonnes respectively). In terms of per capita consumption, Libyans and Greeks consume the largest quantities of tomatoes (117 and 115 kg/year/capita respectively) [5].

In Côte d'Ivoire, tomatoes (Solanum lycopersicum L.) are grown in the north, centre and east on loose soils rich in organic matter. It reacts strongly to temperature variations [6].

According to Ildefonse (1995) [7], tomatoes are the second most important fruiting vegetable in terms of range and relative importance after the "N'drowa" variety (Solanum aethiopicum L.) of traditional vegetables found on Ivorian markets. Fresh tomato production in Côte d'Ivoire rose from 34,734 tonnes in 2013 to 44,078 tonnes in 2018, an increase of around 31%. Over the same period, imports of tomato paste fell by 30%, from 21,033 tonnes in 2013 to 14,818 tonnes in 2017[8].

In Korhogo, in the north of Côte d'Ivoire, two (2) varieties of tomato are sold on the markets: the ribbed African tomato and the round salad tomato without ribs. The African tomato is undervalued and sold at a lower price than the salad tomato. The African tomato is used to prepare local sauces, while the salad tomato is used in fruit salads, as an accompaniment to lettuce and for other special dishes. Unfortunately, the people who eat them are unaware of their nutritional value, and there is a lack of scientific data on these Ivorian tomato varieties. This study is about promoting the African tomato. This study will consist of determining for these two (2) varieties of tomatoes:

- Physico-chemical properties
- Antioxidants
- Anti-nutrients
- Minerals

And to compare the results obtained.

MATERIAL AND METHODS

Material

Biological Material:

The biological material used consists of two varieties of the species Solanum lycopersicum L: the African tomato and the salad tomato sold on the three (3) main markets in Korhogo: The Sinistré market, the Grand Marché and the Koko market.

Methods

Sampling:

Samples of the two (2) varieties of Solanum lycopersicum were purchased in three (3) markets in the town of Korhogo, namely the Sinistre market, the Koko market and the large market. For each market, 4kg of samples of each variety of the species Solanum lycopersicum were purchased from three different sellers (traders), making 12kg of each variety of tomato purchased per market. The total was 36 kg of each variety of Solanum lycopersicum for all three markets. The samples were then taken to the laboratory for analysis.

Determination of Physico-Chemical Properties:

Size and Circumference:

The size and the circumference of the full fruit were estimated using a meter tape, and allowed the deduction of the general fruit shape.

Weight:

The fruit weight was measured using a 2 digits scale (Sartorius).

Moisture Content [9]:

The method used for determining the moisture was that suggested by AOAC [9]. The moisture was assessed by drying 5 g of tomato into an oven at 105°C till constant weight resulted after 24 h.

Ash Content [9]:

The ash content was measured by incinerating five (5) g of oven-dried tomato into a muffle furnace at 550°C for 12 h.

pH:

The pH was determined using the **AOAC (1990) method [9].**

Ten (10) grams of ground sample are diluted in 100 mL of distilled water. The solution obtained is filtered through Whatman filter paper. The pH is measured directly by immersing the electrode of a previously calibrated pH meter (HANNA) in the filtrate obtained.

Total Sugar and Reducing Sugar Contents:

Extraction of Ethanosoluble Sugars

Ethanosoluble sugars were extracted from 1 g of ground dried tomato with 20 mL of 80% (v/v) ethanol, 2 mL of 10% (m/v) zinc acetate and 2 mL of 10% (m/v) oxalic acid, according to the method of Agbo et al., 1985 [10]. The extract was centrifuged at speed of 3,000 rpm for 10 min. The ethanol residue was evaporated from the extract upon a hot sand bath.

Determination of Total Sugars

Then, the extracted total sugars were measured out using the method of Dubois et al., 1956 [11]. The operation consisted in adding 0.9 mL of distilled water, 1 mL of 5% (m/v) phenol, and 5 mL of 96% sulfuric acid into 100 µL of extract, then measuring the absorbance at 490 nm with a spectrophotometer (PG instruments). Calibrations were performed with standard solutions of sucrose for recovering the final total carbohydrates contents in the studied samples.

Determination of Reducing Sugars

For the reducing sugars, 1 mL of extract was processed with 0.5 mL of distilled water and 0.5 mL of 3, 5- dinitrosalycilic acid [12] prior to the recording of the absorbance from the final solution at 540 nm with a spectrophotometer (PG instruments). Calibrations were performed with standard solutions of glucose for recovering the final reducing carbohydrates contents in the studied samples.

Lipids Content:

Lipids were quantified from 10 g of ground dried tomato sample by solvent extraction using 300 mL of n-hexane reagent and a Soxhlet device for 7 h [13]. The hexan-oil mixture resulted from the extraction was recovered and separated with a rotavapor apparatus (Heidolph). The difference between the sample weight before and after the experiment allowed the estimation of the lipids content

Proteins Content:

Crude proteins content was determined as the total nitrogen using the Kjeldhal method [9]. Thus, 1 g of tomato mash was mineralised at 400°C for 2 h, with adding of concentrated sulfuric acid (H_2SO_4) and potassium sulfate (K_2SO_4) catalyst. The mineralisate was diluted and distilled for 10 min. Thereafter, the distillate collected into a flask containing boric acid and methylen bromocresol reagents ion, was titrated for the total nitrogen using ammonium sulfate ($(NH_4)_2SO_4$). The crude protein content of the aubergine was deduced from the nitrogen level using 6.25 as conversion coefficient.

Total Carbohydrates Content and Energy Value:

Total carbohydrates and energy values were determined using calculation formulas [14] accounting the moisture, fat, protein, ash contents and the energetic coefficients for macromolecules.

$$TCC\ (\%) = 100-[P(\%) + M(\%) + F(\%) + A\ (\%)]$$

$$CEV\ (kcal/100g) = [(4\times P) + (9\times F) + (4\times C)]$$

With: TCC, total carbohydrates content; CEV, caloric energy value; P, protein content; M, moisture content; F, fat content; A, ash content; C, total carbohydrates content

Fibers Content:

The determination of the crude fibres content consisted in the treatment of 2 g of ground tomato sample with 50 mL of 0.25N sulfuric acid and 50 mL of 0.31 N sodium hydroxide and

filtration of the resulting solution upon Whatman paper. The residue was dried for 8 h at 105°C then incinerated at 550°C for 3 h into ovens [15]. The final residue was weighed as crude fibres and expressed in percentage

Antioxidants:

Vitamin C Content:

The vitamin C was evaluated from the tomatoes using 2,6- dichlorophenol-indophenol (DCPIP) reagent [16]. Ten (10) grams of ground dried tomato sample were dissolved into 40 mL of metaphosphoric acid-acetic acid solution (2%, w/v). The resulted mixture was centrifuged at 3,000 rpm for 20 min. Thus, the supernatant was recovered, added with boiled distilled water for 50 mL, and titrated with 2, 6- DCPIP solution (0.5 g/L) previously calibrated with a pure vitamin C solution

Carotenoid Content [17]:

2 g of ground sample was weighed and diluted in 50 mL of acetone. The residue was filtered and decolourised using 2 x 50 mL acetone. The filtrates obtained were combined and transferred to a 500 mL separating funnel. 100 mL petroleum ether was added to the separating funnel, the mixture was gently stirred and allowed to stand for phase separation. The ethereal phase (containing the carotenoids) is recovered in another separating funnel. The absorbance of the ethereal phase is read using a spectrophotometer at 450 nm against the petroleum ether.

$$\boldsymbol{Carotenoid\ (mg/100g)} = \frac{\boldsymbol{DO_{450} \times V\ \times 10^3}}{\boldsymbol{2592 \times\ m_e}}$$

$\boldsymbol{V}$: volume (mL) of the extracted phase containing the carotenoids.
$\boldsymbol{m_e}$: mass (g) of the sample.
2592: mass extinction coefficient of carotenoids in petroleum ether.

Extraction of Phenolic Compounds:

Phenolic compounds were extracted with methanol using the method of Singleton et al (1999) [18].

One (1) gram of tomato sample was homogenised in 10mL of 70% (v/v) methanol. The resulting mixture was centrifuged at 1000 rpm for 10 min. The pellet was recovered in 10 mL of 70% (v/v) methanol and centrifuged again. The supernatants were collected in a 50 mL flask and made up to the mark with distilled water.

Determination of Total Phenols:

The method of Singleton et al (1999) [18] is used for the determination of total phenols. One (1) mL of methanolic extract is introduced into a test tube. To the contents of the tube is added 1mL of Folin-ciocalteu reagent. The tube is left to stand for 3min, then 1mL of 20% (w/v) sodium carbonate solution is added. The contents of the tube were made up to 10 mL with distilled water. The tube was placed in the dark for 30 min and the OD was read at 745 nm

against a blank. The amount of phenol in the sample can be determined using a standard solution of gallic acid (1 mg/mL) prepared under the same conditions as the assay.

Tannins Content:

The tannins were determined using the method described by Bainbridge *et al*. (1996) [19]. One (1) mL of methanolic extract is added to a test tube. To the contents of the tube is added 5 mL of vanillin reagent. The tube is left to stand for 20 min in the dark and the optical density (OD) is read at 500 nm against a blank. The amount of tannins in the samples is determined using a standard range established from a stock solution of tannic acid (2 mg/mL) under the same conditions as the test.

Flavonoids Content:

Flavonoids were determined using the method described by Meda *et al* (2005) [20].

A volume of 0.5 mL of methanolic extract was introduced into a test tube. To the contents of the tube were successively added 0.5 mL distilled water, 0.5 mL 10% aluminium chloride, 0.5 mL 1M potassium acetate and 2 mL distilled water. The tube was left to stand for 20 min in the dark and the optical density (OD) was read at 415 nm against a blank. The amount of flavonoids in the sample is determined using a standard solution of quercetin (0.1 mg/mL) under the same conditions as the assay.

Dosage of Anti-Nutrients:

Oxalates Content:

The oxalate content was determined with the standard AOAC method, 1990 [9]. Two (2) grams of ground dried tomato sample were homogenised into 200 mL of distilled water and added with 20 mL of 6N hydrochloric acid (HCl). The mixture was heated in boiling water bath for 1 h, cooled, and filtered. Fifty (50) mL of the filtrate were then homogenised into 20 mL of 6 N HCl, and filtered again. The 2nd filtrate was treated with methyl red (0.1%, w/v), concentrated ammonia, heated, and filtered. The 3rd filtrate was boiled, treated with calcium chloride (5%, w/v) for the formation of calcium oxalate crystals, and then filtered once more. The residues deriving from the filtration steps were successively washed with distilled boiling water, dried into an oven; dissolved into 10 mL of diluted sulfuric acid, and titrated with 0.05N potassium permanganate solution.

Phytates Content:

The phytates were measured according to the method processed by Mohammed *et al.* [21]. A slight ground tomato sample (0.5 g) was treated with 25 mL of TCA solution at 3% (w/v) and centrifuged at 3,500 rpm for 15 min. Five (5) mL of the supernatant was removed, treated with 3 mL of ferric chloride 1% (w/v) reagent, heated in a boiling water bath, cooled and also centrifuged at 3,500 rpm for 10 min. The 2nd supernatant was treated with 5 mL of 0.5N hydrochloric acid, 5 mL of 1.5N sodium hydroxide, heated in a boiling water bath and centrifuged once more at 3500 rpm for 10 min. Thus, 1 mL of the final supernatant was added with 4.5 mL of distilled water and 4.5 mL of orthophenantroline reagent and then measured for the absorbance at 470 nm with a spectrophotometer against standard Mohr salt solution treated likewise and taken as phytates ferric control.

Determination of Minerals:

The determination of minerals is carried out by atomic absorption with an air-acetylene flame AAS 20 type VARIAN. The tomatoes are dried and crushed down to 0.1mm. 0.3 g of dried tomato is calcined at 600°C for 5 h in a furnace until a white ash is obtained. After cooling, 5mL of 1N nitric acid was added and evaporated to dryness on a sand bath. To the residue is added 5mL of 1N hydrochloric acid and the whole is fired again at 400°C for 30 min. Once the calcined product (residue) is recovered from the oven, 10mL of 0.1N hydrochloric acid is added to the crucible to recover the product. The resulting mixture is poured directly into a 50 ml volumetric flask. The operation (washing the crucible with 10 ml of 0.1 N HCl) is repeated three times and the flask is filled to the mark. Allow to decant and take the supernatant for filtration through a 0.36 µm syringe filter. The elements contained in the solution are then determined by AAS. To avoid interference from the elements Ca, K, 5 ml of lantane chloride are added.

Statistical Analysis:

All analyses were performed in triplicate and the data processed using Statistical Program for Social Sciences (SPSS version 20.0, SPSS for Windows, USA). For each characteristic, the results were expressed in the form of means followed by their standard deviations as data dispersion parameters. A one-factor analysis of variance (ANOVA 1) was also performed to test the effect of variety on the characteristics evaluated, at the 5% statistical significance level. For statistically different means, classification was carried out using the student-Newman-Keuls test.

RESULTS

Physico-Chemical Properties (Table 1)

The African tomato and the salad tomato are both red in colour. The African tomato is ribbed with flattened ends, while the salad tomato is round. The African tomato has several ribs (10.84) whereas the salad tomato has none. The salad tomato has the largest size (5.56 cm), while the African tomato has the smallest size (3.12 cm). For circumference, there was no significant difference between the African tomato (16.10 cm) and the salad tomato (16.63 cm) at the 5% threshold. In terms of weight, the salad tomato had the highest value (82.71 g) and the African tomato the lowest (42.45 g). The salad tomato has the highest moisture content (95.81%). The lowest moisture content was found in the African tomato (93.36%). The highest ash content was found in the African tomato (1.17%) and the lowest in the salad tomato (0.8%). The African tomato has the lowest pH (3.99), while the salad tomato has the highest pH (4.2). Both (2) tomato varieties have an acid pH. The African tomato had the highest fibre content (0.81%) and the salad tomato the lowest fibre content (0.68%). There was no significant difference between the lipid content of the African tomato (0.35%) and that of the salad tomato (0.41%) at the 5% threshold. The salad tomato had the lowest protein content (1.58%), while the African tomato had the highest (1.71%). The total carbohydrate content of the African tomato is highest (3.4%), while that of the salad tomato is lowest (1.4%). The salad tomato has the lowest total sugar content (1.63%), while the African tomato has the highest (1.74%). There was no significant difference in reducing sugar content between the African tomato (0.79%) and the salad tomato (0.81%) at the 5% threshold. The salad tomato expressed the lowest energy value (15.63 Kcal/100g), while the African tomato dominated with an energy value of 23.65 Kcal/100g.

Table 1: Physico-chemical properties of African and salad tomatoes

Parameters	African tomato	Salad tomato	General average	P-value
Colour	Red	Red	-	-
Shape	Ribbed with flattened ends	Round	-	-
Number of ribs	10.84 ± 0.44b	0a		0.000
Size (cm)	3.12±0.13a	5.56±0.14b		0.000
Circumference (cm)	16.10±0.63a	16.63±0.17a	16.36	0.230
Weight (g)	42.45 ± 5.21a	82.71 ± 1.60b		0.000
Moisture (%)	93.36 ±0.17a	95.81 ± 0.13b		0.000
Ashes (%)	1.17 ± 0.05b	0.8 ± 0.04a		0.001
pH	3.99 ± 0.03	4.2 ± 0.02b		0.000
Fibres (%)	0.81 ± 0.02b	0.68 ± 0.04a		0.009
Lipids (%)	0.35 ± 0.04a	0.41 ± 0.03a	0.38	0.067
Proteins (%)	1.71 ± 0.01b	1.58 ± 0.006a		0.000
Total carbohydrate (%)	3.4 ±0.13b	1.4 ± 0.14a		0.000
Total sugar (%)	1.74 ± 0.02b	1.63 ± 0.04a		0.016
Reducing sugar (%)	0.79 ± 0.03a	0.81 ± 0.02a	0.80	0.444
Energy value (Kcal/100g)	23.65 ± 0.63b	15.63 ± 0.34a		0.000

By line, values followed by different letters are statistically different at 5%. P-value: value of the statistical probability test. With a < b; P value < 0.05 (5%) therefore the difference is significant.

Antioxidants

Statistical tests did not reveal any significant difference in flavonoid content between African tomatoes (55.59 mg/100g) and salad tomatoes (53.16 mg/100g) (Table 2). African tomatoes had the highest polyphenol content (123.64 mg/100g), while salad tomatoes had the lowest (101.98 mg/100g). The salad tomato has the lowest vitamin C content (10.52 mg/100g), while the African tomato dominates with a value of 12.49 mg/100g. The lowest carotenoid content was found in salad tomatoes (39.84 mg/100g) and the highest in African tomatoes (41.17 mg/100g). As for tannins, the African tomato had the highest content (43.73 mg/100g) while the salad tomato had the lowest (38.88 mg/100g).

Anti-Nutrients

Statistical analysis showed a significant difference between all the anti-nutrients of the two (2) tomato varieties (Table 3). For phytates, the salad tomato had a lower value (2.23 mg/100g), while the African tomato had the highest phytate content (2.92 mg/100g). The highest oxalate content was found in the African tomato (9.19 mg/100g), while the lowest was found in the salad tomato (6.79 mg/100g).

Table 2: Antioxidants in African and salad tomatoes

Parameters	African tomato	Salad tomato	General average	P-value
Polyphenols (mg/100g)	123.64±0.46b	101.98±0.17a		0.000
Flavonoids (mg/100g)	55.59±2.84a	53.16±0.07a	54.37	0.212
Vitamin C (mg/100g)	12.49±0.40b	10.52±0.03a		0.001
Carotenoids (mg/100g)	41.17±0.14b	39.84±0.09a		0.000
Tannins (mg/100g)	43.73±0.13b	38.88±0.12a		0.000

By line, values followed by different letters are statistically different at 5%. P-value: value of the statistical probability test. With a < b; P value < 0.05 (5%) therefore the difference is significant.

Table 3: Anti-nutrients in African and salad tomatoes

Parameters	African tomato	Salad tomato	Genral average	P-value
Phytates (mg/100g)	2.92±0.09b	2.23±0.04a		0.000
Oxalates (mg/100g)	9.19±0.03b	6.79±0.04a		0.000

By line, values followed by different letters are statistically different at 5%. P-value: value of the statistical probability test. With a < b; P value < 0.05 (5%) therefore the difference is significant.

Minerals in African and Salad Tomatoes

The two (2) varieties of tomato have a very high potassium content. This is the mineral with the highest content of all the sought-after minerals. The salad tomato has the highest potassium content (309.11 mg/kg) while the African tomato has the lowest (260.25 mg/kg). African tomatoes had the highest sodium content (2.88 mg/kg), while salad tomatoes had the lowest (1.77 mg/kg). African tomatoes have the lowest magnesium content (6.41 mg/kg), while salad tomatoes dominate with a value of 14.85 mg/kg. The lowest phosphorus content was found in African tomatoes (16.82 mg/kg) and the highest in salad tomatoes (27.33 mg/kg). As for calcium, the salad tomato had the highest level (16.28 mg/kg) while the African tomato had the lowest (12.06 mg/kg). Boron content was lowest in African tomatoes (49.86 µg/kg) and highest in salad tomatoes (67.51 µg/kg). There was no significant difference between the manganese content of the African tomato (0.22 mg/kg) and that of the salad tomato (0.16 mg/kg) at the 5% threshold. There was also no significant difference between the iron content of the African tomato (1.66 mg/kg) and that of the salad tomato (1.91 mg/kg) at the 5% threshold. The African tomato had the lowest copper content (50 µg/kg); the salad tomato had the highest copper content (84.10 µg/kg). There was no significant difference between the zinc content of the African tomato (0.18 mg/kg) and that of the salad tomato (0.24 mg/kg) at the 5% threshold. The salad tomato contained the most molybdenum (2.13 µg/kg), while the lowest molybdenum content was found in the African tomato (0.87 µg/kg) **(Table 4).**

Table 4: Minerals in African and salad tomatoes

Parameters	African tomato	Salad tomato	General average	P-value
Potassium (mg/kg)	260.25±0.11a	309.11±0.07b		0.000
Sodium (mg/kg)	2.88±0.11b	1.77±0.04a		0.000
Magnesium (mg/kg)	6.41±0.07a	14.85±0.13b		0.000
Phosphorus (mg/kg)	16.82±0.19a	27.33±0.08b		0.000
Calcium (mg/kg)	12.06±0.09a	16.28±0,07b		
Boron (µg/kg)	49.86±0.08a	67.51±0.05b		0.000
Manganese (mg/kg)	0.22±0.1a	0.16±0.08a	0.19	0.476
Iron (mg/kg)	1.66±0.1a	1.91±0.13a	1.78	0.057
Copper (µg/kg)	50±9.16a	84.10±0.2b		0,003
Zinc (mg/kg)	0.18±0.06a	0.24±0.05a	0.21	0,285
Molybdenum (µg/kg)	0.87±0.11a	2.13±0.11b		0.000

By line, values followed by different letters are statistically different at 5%. P-value: value of the statistical probability test. With a < b; P value < 0.05 (5%) therefore the difference is significant.

DISCUSSION

The African tomato studied has an average of 10.84 ribs, a height of 3.12 cm, a circumference of 16.10 cm and a weight of 42.45g. It has more ribs than the Gbogan tomato variety (6 to 8 ribs) identified by Dossou et al (2007) [22] in Benin. Its average weight is higher than that of another ribbed Tounvi tomato variety (24.25g) [22]. The salad tomato studied has no ribs, with an average height of 5.56 cm, a circumference of 16.63 cm and a weight of 82.71g. Its average weight is higher than that of the xina tomato variety in Benin [22]. There was no significant difference in circumference between the two Korhogo tomato varieties studied, but there was a significant difference in the number of ribs, size and weight.

The humidity of the salad tomato (95.81%) is higher than that of the African tomato (93.36%). The akikon tomato variety in Benin has a moisture content (94.62%) [22] that is intermediate between the two (2) varieties studied. The two (2) varieties studied have a moisture content that is higher than that of the aubergine S. aethiopicum gilo (92.45%) highlighted by Niamke *et al*, (2019) [23]. The water content of tomatoes is disadvantageous for their preservation since tomatoes could be subject to rapid post-harvest change such as rotting. This phenomenon has already been observed by Ali *et al*, (2010) [24] on the fruits of the roast palm. The difference observed in the moisture content of the two varieties could be linked to the variety and the water absorption capacity of each plant [25]. The ash content of the African tomato (1.17%) is higher than that of the salad tomato (0.8%). These ash contents are lower than those of the onion variety FB01 (3.28%) studied by M. Konaté et al., 2017[26].

The pH of salad tomatoes (4.2) is higher than that of African tomatoes (3.99). These two (2) tomatoes have an acid pH. These pH values are lower than that of hot peppers (5.44) [27]. Coliforms of the Escherchia coli type cannot develop on the two tomato varieties since the minimum pH required for the development of such microorganisms is 4.3 according to Rozier et al. (1985) [28]. The relatively low pH of the African tomato is an advantage from the point of view of stability. In fact, this pH level considerably reduces the rate and range of micro-organisms that can develop on the product. Only acidophilic micro-organisms, in particular yeasts, moulds, acetobacter and lactobacillus, can develop [28].

The fibre content of African tomato (0.81%) is higher than that of salad tomato (0.68%). These fibre contents are lower than those of the aubergine S. melogena (1.96%) [23] and the sweet pepper (2.43%) [27]. These two varieties of tomato could be a significant source of dietary fibre, which is eliminated more slowly from the stomach, thus improving intestinal transit. Dietary fibre is absolutely essential to the balance of the digestive tract and the body as a whole. They are a factor in good health. Studies have shown an inverse correlation between dietary fibre consumption and colon cancer. This is because fibre has the ability to complex with carcinogenic molecules, preventing them from coming into contact with the colon and facilitating their excretion [29,30]. Consumption of the two (2) varieties of tomato could therefore increase gastric volume and constitute a post-ingestive state enabling a state of

satiety to be reached more quickly [30,31]. Fibre generally reduces blood glucose, HDL cholesterol and LDL cholesterol levels, thereby helping to reduce coronary heart disease [32].

There was no significant difference between the lipid content of African tomatoes (0.35%) and salad tomatoes (0.41%). These levels are low. These levels are higher than those of cucumber (0.11%) [33], aubergine S. anguivi (0.12% to 0.16%) highlighted by Niamke et al., 2018{34] but are lower than those of the leaves of Phytolaccado dodecandra or wild spinach (1.6%) [35]. According to Anses, (2021) [36], lipids play two (2) major roles: an energy storage role and a structural role (they enter into the composition of cell membranes).

The protein content of African tomatoes (1.71%) is higher than that of salad tomatoes (1.58%). These levels are low. Both levels are higher than that of the golden papaya variety (0.74%) studied by Assanvo et al., 2022[37]. Proteins are essential to the body; they play a structural role (in muscles and skin) but are also involved in numerous processes such as the immune response (antibodies), oxygen transport in the body (haemoglobin) and digestion (digestive enzymes) [36]. The protein contents expressed by the two varieties studied could be explained by the effects of light and $N0_3$ adsorption by the roots [38]. As the plant grows, it draws nitrogen in the form of $N0_3$ from the soil through its roots. The amount of nitrogen absorbed depends on the needs of the plant in relation to the variety. And this quantity tends to increase or decrease with the degree of absorption of light and $C0_2$ during respiration, which also takes into account the variety and climate [25].

The percentage of total carbohydrates in African tomatoes (3.4%) is higher than in salad tomatoes (1.4%). These levels are lower than those of hot pepper (9.13%) and sweet pepper (6.73%) studied by Niamke et al., 2022[27]. Total carbohydrates are essentially part of the body's energy metabolism, and are used in particular to synthesise adenosine triphosphate (ATP). These molecules are ultimately converted into glucose, redistributed to the cells and then used by them [39]. Obviously, tomatoes are vegetables and are not really used as a source of carbohydrates, lipids or proteins. They are therefore recommended in dietetics as low-calorie foods that help obese people lose weight, like chilli peppers [40] and aubergines [34].

There is no significant difference at the 5% threshold between the reducing sugar content of the African tomato (0.79%) and that of the salad tomato (0.81%). They are low compared to that of the Tounvi tomato variety from Benin (2.03%) observed by Dossou et al., 2007[22].

The total sugar content of the African tomato (1.74%) is significantly higher than that of the salad tomato (1.63%). These contents are lower than those of the aubergine S aethipicum gilo (2.10%) highlighted by Niamké et al., 2019[23].

The energy value of the African tomato (23.65Kcal/100g) is higher than that of the salad tomato (15.63kcal/100g). They are lower than those of chillies (39.95Kcal/100g) and peppers (29.21Kcal/100g) [27].

The polyphenol content of the African tomato (123.64 mg/100g) is higher than that of the salad tomato (101.98 mg/100g). These levels are higher than those of aubergine S. aethiopicum gilo

[23]. Polyphenol composition differs from one tomato variety to another. The differences obtained may be due to variability in chemical composition [41]. These differences may also be due to the growth stage of the plants studied and/or the collection season, and the nature of the sampling site [42]. The presence of antioxidants may also reflect a response to stress (scarcity of rainfall, unfavourable soil quality, which are associated with an increase in tannin levels) [43]. Thus, depending on the efforts made by the plant to adapt to environmental conditions, the quantity of antioxidant decreases or increases. Current literature suggests that long-term consumption of a diet rich in polyphenols protects against certain cancers, cardiovascular disease, type 2 diabetes, osteoporosis, pancreatitis, gastrointestinal problems, lung damage and neurodegenerative diseases [44,45,46,47].

There is no significant difference between the flavonoid content of African tomatoes (55.59 mg/100g) and salad tomatoes (53.16 mg/100g). These levels are higher than those found in hot peppers (4.36 mg/100g) [27]. Flavonoids can neutralise free radicals and reduce the risk of cancer by stopping cell growth in tumours [48].

The vitamin C content of African tomatoes (12.49 mg/100g) is higher than that of salad tomatoes (10.52 mg/100g). These levels are lower than in kiwi fruit (92.7 mg/100g) [49]. Vitamin C plays several roles in the body. It contributes to the health of bones, cartilage, teeth and gums. It also protects against infection, accelerates healing and promotes the absorption of iron. It is also involved in hormone metabolism and the breakdown of cholesterol, as reported by Mourey, 2004[50].

Carotenoids are particularly well-known for their antioxidant properties. Various studies have demonstrated the antioxidant functions of these pigments. They are capable of regulating the proper functioning of our immune system. Essentially, they protect us from oxidative damage caused by free radicals. Free radicals are responsible for skin ageing, heart disease, neurodegenerative diseases and many tumours. Thanks to their antioxidant properties, carotenoids can be used in the treatment or prevention of certain diseases: Treatment against the development of cancerous tumours, improving eyesight in cases of macular degeneration or cataracts, diseases related to diabetes and obesity, prevention against cardiovascular disease, treatment of digestive problems [51].

African and salad tomatoes contain anti-nutrients such as phytates and oxalates, but in small quantities.

The phytate content of African tomatoes (2.92 mg/100g) is higher than that of salad tomatoes (2.23 mg/100g). These levels are lower than those of aubergine S. aethiopicum gilo (27.74 mg/100g) and aubergine S. melogena (23.74 mg/100g) highlighted by Niamke et al., (2019) [23]. The multiple negative charges possessed by phytates give them a strong binding capacity, which results in the formation of complexes with proteins and multivalent cations, thus reducing their bioavailability [52].

The oxalate content of African tomatoes (9.19 mg/100g) is higher than that of salad tomatoes (6.79 mg/100g). These levels are lower than those of hot peppers (301.89 mg/100g) and

peppers (377.66 mg/100g) studied by Niamké et al, (2022) [27]. Oxalates reduce calcium absorption by the intestines and colon and lead to the formation of calcium kidney stones [53,54]. Phytates and oxalates are effectively inactivated by cooking foods or heat treatment [55].

The results of this study showed the presence of several minerals, the most important being potassium for each of the tomatoes. The potassium content of the salad tomato (309.11 mg/Kg) is higher than that of the African tomato (260.25 mg/Kg). Potassium regulates heart rate and blood pressure, the body's water content and neuromuscular excitability. The daily intake of potassium is 2000 mg/day for an adult and 1600 mg/day for a child according to NRC (1989) [56]. With this potassium content, consumption of salad and African tomatoes would respectively provide 15.45% and 13.01% of an adult's requirements and 19.32% and 16.25% for children, which is interesting.

The sodium content of African tomatoes (2.88 mg/kg) is higher than that of salad tomatoes (1.77 mg/kg). This result is lower than that reported for breadfruit (*Artocarpus altilis*) from Ghana (690 mg/kg) [57]. Sodium plays an important physiological role in humans on a number of levels, helping to control the volume of the body's extracellular medium (the fluid balance), maintaining the electrochemical gradient in cells, transmitting nerve impulses, muscle contraction and intestinal absorption of certain nutrients. With their low sodium content, tomatoes could be used as a food without fear of health risks for people suffering from high blood pressure.

The magnesium content of salad tomatoes (14.85 mg/Kg) is higher than that of African tomatoes (6.41 mg/Kg). These levels are lower than those of the oblong solo papaya variety studied by Assanvo et al (2022) [37]. Magnesium is recommended for the prevention of certain complications of myocardial infarction [58,59]. Magnesium is essential for calcium metabolism [60].

The calcium content of salad tomatoes (16.28 mg/Kg) is higher than that of African tomatoes (12.06 mg/Kg). These levels are lower than those of cooked Hibiscus sabdariffa seeds (740 ppm) [61]. They are also lower than in onion variety V1053 (6220 mg/Kg) [26]. The phosphorus content of salad tomatoes (27.33mg/100g) is higher than that of African tomatoes (16.82mg/Kg). These levels are lower than in uncooked Colocasia esculenta (208 ppm DM) [62]. A diet rich in calcium and phosphorus helps prevent osteoporosis and also reduces the risk of high blood pressure, colon cancer and prostate cancer [63]. There was no significant difference between the iron content of the African tomato (1.66 mg/kg) and that of the salad tomato (1.91 mg/kg). These levels are lower than those of the aubergine S. aethiopicum gilo (4.44 mg/100g) studied by Niamké et al, ((2019) [23].

Iron plays an important role in the human body. The haemoglobin present in red blood cells absorbs the 70% of iron consumed. This enables oxygen to function properly. This oxygen is then transmitted to the cells. Iron is also found in muscle myoglobin, which stores air. The remaining 30% of iron plays a role in activating the body's metabolisms. It makes a major contribution to producing energy and activating the immune system [64]. Iron deficiency

anaemia affects a third of the world's population. However, excessive iron intake causes colorectal cancer [65]. The iron values of the two (2) varieties of tomato are below the limit of 15 ppm set by the WHO as the limit for iron in food [66].

There was also no significant difference between the manganese content of African tomatoes (0.22 mg/kg) and salad tomatoes (0.16 mg/kg). These levels are lower than those of the aubergine Solanum melogena (2.23 mg/Kg). They are lower than in the onion variety V1320 (25.20 mg/Kg) [26]. Manganese enters the structure of numerous enzymes, in particular superoxide dismutase, which is involved in antioxidant defences. It is also involved in insulin production.

The copper content of salad tomatoes (84 µg/kg) is higher than that of African tomatoes (50 µg/Kg). These levels are lower than in the onion variety V1310 (13.56 mg/kg) [26]. Copper is a "trace element that is essential for the body to function. It is a powerful antioxidant, which helps combat cellular stress in the event of excess oxidation problems. It enables the assimilation of iron, which in turn enables the production of red blood cells. It contributes to the formation of the immune system [67].

There is no significant difference between the zinc content of African tomato (0.18 mg/kg) and salad tomato (0.24 mg/Kg). These values are close to those of aubergine S. aethiopicum anguivi (0.22 to 0.32 mg/Kg) [34]. They are lower than in the onion variety V1319 (22.43 mg/kg) [26].

The molybdenum content of salad tomato (2.13µg/kg) is higher than that of salad tomato (0.87µg/kg). Molybdenum is a trace element found mainly in animal products. It is involved in DNA formation and protein synthesis in the body, and has a positive synergy with iron, zinc and copper [68]. The boron content of salad tomatoes (67.51 µg/Kg) is higher than that of African tomatoes (49.86 µg/Kg). Boron is a trace element that is present throughout the body. In particular, it plays a role in bone formation, the manufacture of red blood cells and immune system cells [69].

CONCLUSION

At the end of our study, we can say that the African tomato has a preponderant content of fibre, protein, total carbohydrates, total sugars, energy values, polyphenols, vitamin C, carotenoids, tannins, phytates, oxalates and sodium. Salad tomatoes, on the other hand, are larger in size and heavier in weight, and contain higher levels of moisture, pH, boron, magnesium, phosphorus, potassium, calcium, copper and molybdenum.

There is no significant difference between the two tomato varieties in terms of circumference, lipid content, reducing sugars, flavonoids, manganese, iron or zinc.

From this study, we can say that the African tomato has a higher nutrient content, while the salad tomato has a high mineral content. In the light of this study, the African tomato deserves more consideration. The anti-nutritional factors are in small quantities and are effectively inactivated by cooking. Incidentally, both varieties of tomato contain fibre, carbohydrates,

lipids, proteins, antioxidants, vitamin C and minerals that are beneficial to the people of Korhogo.

It would be a good idea to study other vitamins (A, B, K, etc.) for both varieties of tomato.

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