

Research Article



Valuation of Peels of Four Industrial Tomato Varieties Grown in Annaba (Eastern Algeria)

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ABSTRACT

Tomato (*Lycopersicon esculentum* Mill) is a solanaceae which occupies a privileged place in the maraicher sector in Algeria. It is rightly seen as a priority species such as the potato, garlic and onion. The industrial tomato sector is flourishing in eastern Algeria and therefore it generates tons of solid residues that can be used to derive bio-polymers, lycopene, oil and food production for the livestock and compost. The aim of this study is to compare the quality of the peels of four tomato varieties grown in open fields in the wilaya of Annaba (east of Algeria). The four varieties are Super strain 3 and Rio Grande (fixed varieties), Fahla and Discrito (improved varieties) vis-à-vis the following parameters: titratable acidity, brix levels, protein, total sugars, polyphenols, ash and antioxidant activity. The results obtained show that the dried peel has an undeniable quality. The statistical analysis showed very highly significant differences for parameters: protein content, ash and antioxidant activity; for the other parameters, the differences were not significant.

Keywords: Tomato, varieties, peels, physical and chemical analyzes.

INTRODUCTION

Tomato cultivation occupies a prominent place in the Algerian agricultural economy.

The total area reserved for it is about 32962 Ha represented by 63.06% for vegetable tomato and 36.93% for industrial tomato; its production is 3.822731Qx¹. The level of registered returns has undergone a remarkable evolution (8 t/ha in 1970 to 31.4 t/ha in 2009), it represents an undeniable interest to the national agricultural economy by its weight in the country's GDP. All current varieties on the market are mostly fixed and few hybrid varieties.

The aim of this study is to compare the quality of the peels of four tomato varieties vis-à-vis the following parameters: titratable acidity, brix levels, protein, total sugars, polyphenols, ash and antioxidant activity.

Tomato varieties were grown in open fields during 2011 in the wilaya of Annaba, one of the main producing areas of industrial tomatoes in Algeria.

These are: Super 3 strain and Rio Grande (fixed varieties); Fahla and Discrito (improved varieties).

MATERIALS AND METHODS

The seeds of the four tomato varieties used for commercial production, were provided by the seeds distributors, seeding and planting took place in agricultural farm in El Karma station located in the wilaya of Annaba in the northeast Algerian according to a Latin square experimental design.

Preparation of peels

The tomatoes were harvested in the period from June to August 2011. The sampling was carried out on seven homogeneous rows of each variety.

The fruits were randomly selected several schemes at various heights and orientations.

They were harvested at full maturity, washed, cleaned and immediately came under hot running water (about 90 °C) for 10 minutes and then under jet of cold water to soften and facilitate the detachment of the peel.

Tomato peels, thus obtained, were dried over aerated surfaces. After drying, the peels were packed in food bags and stored in a dry, dark place at room temperature.



The tomato crop in Algeria annually generates tomato residues estimated at 1.305 million tons/year². The sub tomato processing industry's products consist of peel, seeds, a little of pulp and peduncles sometimes mixed with stems and few leaves.



Parameters studied

The overall composition of the tomato, titratable acidity, Brix and the ash content were determined directly after harvest. The other parameters (total sugars, total polyphenols, protein and antioxidant activity), were determined in the dried peels after storage for one year.

Overall composition of Tomato

It was conducted on 10 randomly selected fruits on which were determined the relative shares in peel, seed and pulp.

Titrateable acidity

The principle of the method is based on the titration of the acidity of an aqueous solution (prepared from 25g of dried tomato peels) with sodium hydroxide solution in the presence of phenolphthalein as a color indicator³. The titrateable acidity is expressed in grams of citric acid per 100g of fresh material.

$$A\% = (100 \times 100 \times V1) / (V0 \times M \times 10) \times 0.07 = 175 \times [V1 / (V0 \times M)]^{4,5}$$

M: mass in grams taken; V0: volume in milliliters of the sample and V1: volume in milliliters of 0.1N NaOH solution.

0.07: Conversion factor equivalent titrateable acidity in citric acid.

Determination of soluble solids (Brix)

is the soluble solids of an aqueous solution having the same refractive index (RI) that the analyzed product⁶, this solution test at a temperature of 20 °C and conversion, by means of a table of the refractive index in dry soluble residue (expressed as sucrose) is measured by refractometer Abbe (CEE.1764/84). The refractometer must be adjusted to give a temperature of 20 °C distilled water for a refractive index of 1.330⁷ If the determination was carried out at a temperature of 20 °C ± 0.5 °C, the following corrections are necessary:

$$n_D = n_p + 0.00013 (t - 20).$$

n_p far found at a temperature of 20 °C ± 0.5 °C

Ash content

2 g of comminuted tomato peel is put into a muffle furnace set at 550 ± 15 °C for 5 hours until obtaining a gray, light or whitish color³. We express organic matter by the following formula:

$$OM\% = [(M1-M2) / P] \times 100.$$

OM is the organic matter (%).

M1 is the mass of the test samples + capsules.

M2 is the mass of capsules + ashes.

P is the mass of the test sample.

The ash content (Cd) is calculated as follows:

$$Cd = 100 - \% OM^8.$$

Dosage of soluble sugars

The total soluble sugars (sucrose, glucose, fructose, their methylated derivatives and polysaccharides) are assayed by the method of Dubois (1956)⁹. The extraction of soluble sugars is carried out from a maceration of 100mg tomato peel powder in 80% ethanol.

The concentration of soluble sugars is determined after reading of the optical density measured with a spectrophotometer at 480 nm wavelength; the levels of soluble sugars are expressed in g/100 g DM¹⁰.

Dosage of proteins

The assay of the total soluble protein of tomato peel extracts was performed according to the method (Bradford, 1976)¹¹. It is a colorimetric method for determining the concentration of a protein solution from the change in the coloring Coomassie blue when it binds to protein. Subsequently reading the optical density was made by a spectrophotometer at 597nm. A calibration curve is plotted, using BSA (Bovine Serum Albumin). The results are expressed in g of protein per 100 g of dry matter (DM)⁵.

Determination of polyphenols

The assay was performed following the method described by Singleton (1999)¹². A comprehensive determination by spectrophotometer is made from the tomato peel methanol extract with Folin-Ciocalteu reagent; the results were read on a spectrophotometer at 765 nm. The concentration of total phenolics in mg gallic acid equivalent (GAE) per g of tomato peel is determined by reference to the calibration curve obtained using gallic acid as standard.

Evaluation of the antioxidant activity

Test of antioxidant power by reducing the DPPH radical (diphénylpicryl-hydrayl).

To study the anti-radical activity of tomato peel extracts (obtained for the determination of total polyphenols using methanol as extraction solvent), we opted for the method using DPPH as a relatively stable free radical, according to the protocol described by (Mansouri)¹³. In this test the antioxidants reduce the DPPH with a purple to a yellow compound. The intensity of the color is inversely proportional to the ability of antioxidants in the medium to provide protons. Briefly, a volume of 25µl peel extracts of tomato or standard solutions (ascorbic acid, BHT) are added to 975 µl of methanol solution of DPPH (2, 4 mg/100 ml methanol). The mixture is left in the dark for 30 min and discoloration relative to the negative control (blank) containing only the DPPH solution. The measurement is determined at a wavelength of 517 nm¹⁴; a high absorbance reflects significant oxidation and therefore low absorbance means high antioxidant activity.



The anti-radical activity is estimated by the equation:

$$\% \text{ of radical-scavenging activity} = \frac{[\text{Abs } 517 \text{ control} - \text{Abs sample } 517]}{\text{Abs } 517 \text{ control}} \times 100.$$

The IC₅₀ values (inhibitory concentration 50% in mg/ml) are calculated by the linear regression method from the curve [% inhibition = *f*(concentration)].

Statistical analysis

All assays were repeated three times and the results were treated by analysis of variance (ANOVA) at a controlled factor and repeated measures with statistical software (Minitab 16) using Tukey test at 5 %.

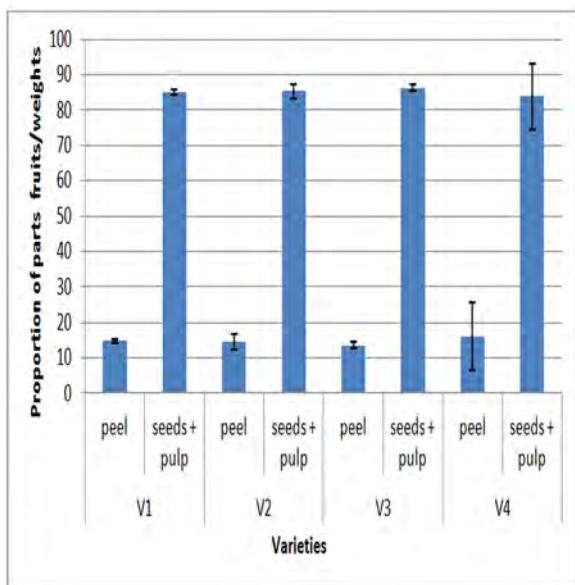
RESULTS AND DISCUSSION

Overall composition of the tomatoes

From Figure 1, we see that the pulp and seeds ranged from 86.34 ± 0.92% for the variety Discrito to 83.90 ± 9.35% in Fahla variety. The analysis of variance to a single factor does not show any significant difference (P>0.05). Tukey's test gives off a single homogeneous group A for all varieties.

With regard to the peels, the proportions vary from 16.09 ± 9.35% for the variety Fahla to 13.65 ± 0.92% for the variety Discrito. The analysis of variance shows no significant difference (P>0.05). Tukey's test gives off a single homogeneous group A for all varieties.

These results are similar to those reported by Zidani⁵ and Larid¹⁵.



V1: Super strain 3; V2: Rio grande; V3: Fahla; V4: Discrito

Figure 1: Tomato fractions (%)

Titrateable acidity (%)

The acidity values obtained from dried peels were of 6.3% ± 0.7 for varieties Discrito and Fahla and respectively, 5.83% ± 1.06 and 5.6 ± 1.21% for Rio Grande and Super strain 3 varieties (Fig 2).

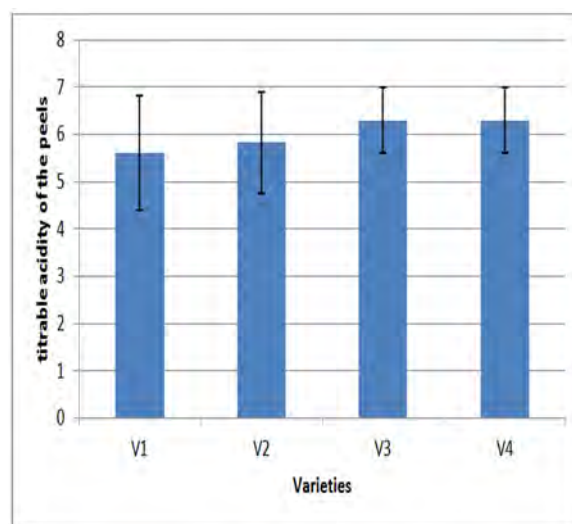


Figure 2: Titratable acidity (%).

The results show no significant difference in the analysis of variance and they are similar to those found in studies of Larid¹⁵ and Zidani⁵ with 5.18 and 5.82% respectively.

Indeed, during the ripening of tomatoes, the acid content (mainly citric and malic acid) decreases for increasing the sugar content, so harvested ripe tomatoes have a low acid content. Thus, the residues from these tomatoes will have a low percentage titrateable acidity, it is the same when the acidity is expressed in grams of citric acid per 100g of product^{15,16}. However our results show a relative increase in acidity and could be related to the partial fermentation of the samples, due to the drying time, and the enzymatic activity of the pectin during the initial phase of drying as outlined by Okanlawon¹⁷.

Determination of soluble solids (% Brix)

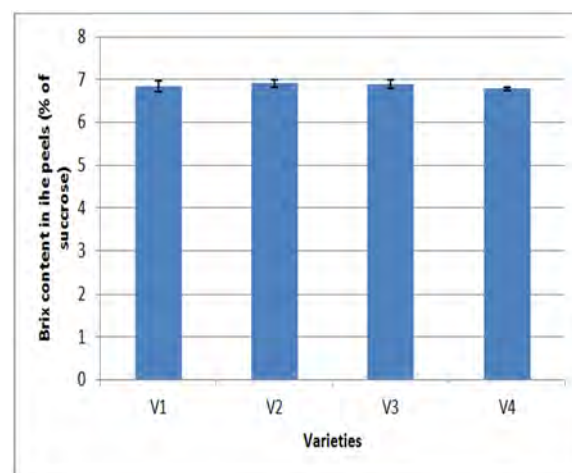


Figure 3: Brix in peels (% sucrose).

The Brix is the soluble solids content and which represents the sugar content in large part. For samples of dry peel, Brix rates recorded resemble one another; they vary from 6.91% ± 0.08 among the variety Rio to 6.79 ± 0.03% in Discrito variety (Fig 3). The variance analysis confirms this result, since no significant differences were revealed. These values, however, seem important compared to those found by Louati¹⁶ (5.58% to 5.88%) in

dried peels, or even to those found in fresh tomatoes (5 % to 7%)¹⁸.

Ash contents (%)

Ash content represents the total amount of inorganic salts in a sample. The recorded values were (8.33 ± 0.05 , 7.5 ± 0.1 , 4.5 ± 0.2 and $6.16 \pm 0.12\%$ of dry matter) respectively in the dried peels of the varieties Super strain 3, Rio Grande, Fahla and Discrito (Fig 4), these results are much higher than those found by other authors (3.1%)¹⁹ and However, they are comparable to 8% and 8.78% (MS) found by Zidani⁵ and Larid¹⁵.

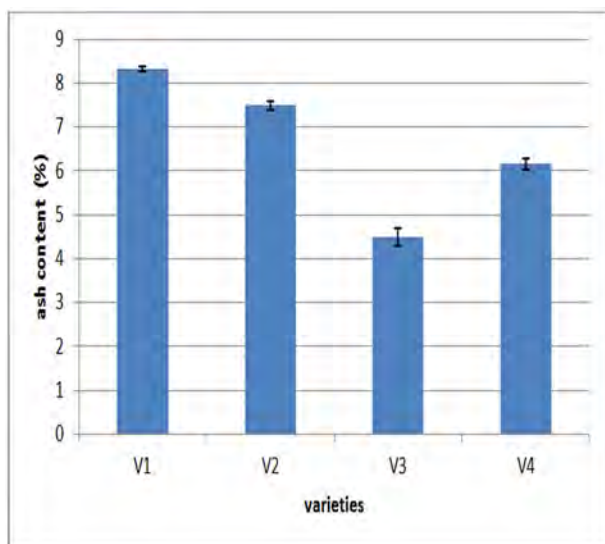


Figure 4: Ash contents in the tomato peels (%).

The statistical analysis for this parameter shows that there is a very highly significant difference ($P \leq 0.001$) among the four samples. Tukey's test identified four homogenous medium groups (A, B, C, D). In the order, the major group average (8.33%) consists of the variety Super strain 3, followed by the second and third group of successive averages include both varieties Rio grande and Discrito and finally the last group on the weak (4.5%) and presented by Fahla variety.

The marked difference in the ash contents could be related mainly to the influence of the genetic origin of each variety (old or hybrid).

Soluble sugars

The amounts of total sugars in the dried peel were ranged from 0.67 ± 0.03 to $0.94 \pm 0.3\text{g} / 100\text{g MS}$ (Fig 5). The analysis of variance revealed no significant difference.

These values are considerably lower than that recorded by Larid¹⁵ ($3.87\text{g}/100\text{g}$ of dry matter)¹⁵ but close to the one recorded by Zidani⁵ ($1.15\text{g}/100\text{g}$).

The small amount of sugar found in our samples is related to the non-enzymatic browning reaction that causes decreased levels of total sugars, reported in many studies^{20,21}.

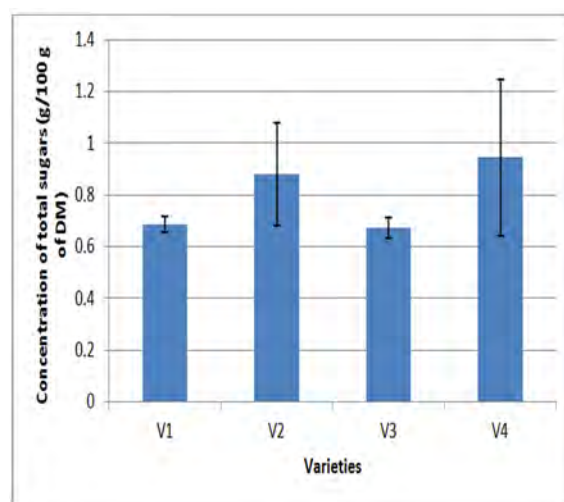


Figure 5: Concentrations of total sugars (g/100 g DM).

On the other hand, this result may be due to the storage time, because according to Dandjouma²² the sugar level is stable during drying but may vary during storage.

Protein

Tomato peel samples showed grades ranging from 2.24 ± 0.05 to $4.65 \pm 0.3\text{g}/100\text{g}$ of dry matter (Fig 6). This result, evaluated by analysis of variance, revealed a very highly significant ($P \leq 0.001$) and Tukey's test identified three groups of successively homogeneous medium (A, B, B, C), the first on the content $4.6\text{g}/100\text{g}$ of DM presented by Super strain 3, the second group involving both varieties Fahla and Discrito finally the group corresponding to the low ($2.24\text{g}/100\text{g}$ of DM) and including the Rio grande variety.

The values obtained are much lower than those reported by Knoblich²³ ($10.00\text{g}/100\text{g}$), Anonymous²⁴ ($18.4\text{g}/100\text{g}$) and ($13.85\text{g}/100\text{g}$)¹⁵, however protein levels in our samples remain high compared to $0.08\text{g}/100\text{g}$ obtained by Monika²⁵.

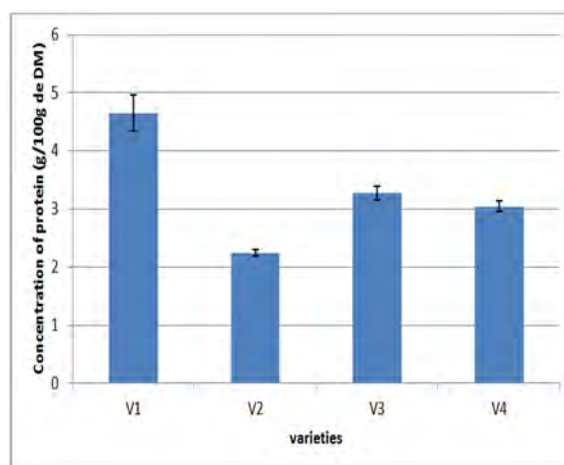


Figure 6: Protein contents in the peel (g/100 g of DM).

The loss of protein contents is due to the storage period and the drying method according to Zani²⁶.

Total polyphenol content

The determination of total polyphenols gives an overall estimate of the content in various classes of phenolic compounds contained at the hydroalcoholic extract powder of dried peels. According to our results, the maximum value of the polyphenol concentration was 14.5 ± 2.64 mg GAE/g of DM recorded at Rio grande variety, while the minimum value (10.04 ± 0.5 mg GAE/g of DM) was noted in Discrito variety (Fig 7).

Statistical analysis revealed no significant difference ($P \leq 0.05$) for this parameter, while Tukey test gives only a homogeneous average group A, for all varieties.

Recorded polyphenol levels are far below those reported by Larid¹⁵ (GAE 52.82 mg/g of DM), which are themselves largely lower than those reported by Navarro^{19,14} and with 158.1 mg and GAE 462/100g of DM respectively. According to Moco²⁷⁻²⁹, the flavonoids are among the types of tomato major phenolic compounds which are highly localized in the tissues of the epicarp.

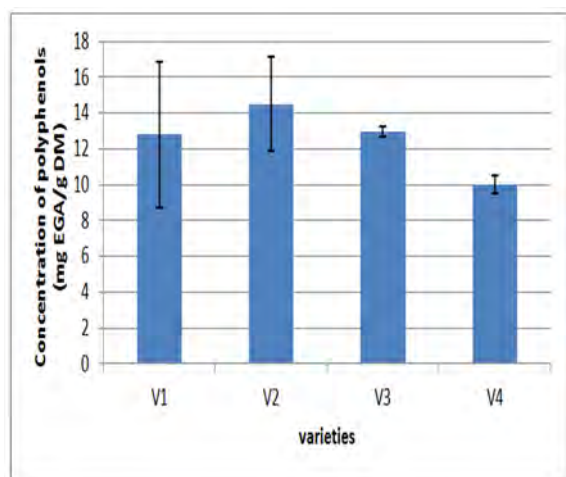


Figure 7: Concentrations of polyphenols in the peel (mg GAE/g of DM).

Comparing the content of polyphenols in tomato peels with that of other fruits such as elderberry (1.54%), kiwi (0.273%), plums (0.2%), grapefruit (0.425%), apples (0.217%) and orange (0.217%)³⁰, could justify the use of tomato peels as a source of natural antioxidants and thereby, a functional food.

Evaluation of the antioxidant activity

DPPH radical scavenger effect

DPPH is a free radical allowing us to determine the trapping potential of our tomato peels extracts due to their sensitivity to detect active components at low concentrations³¹⁻³³.

From the anti-free radical activity in percentage curves we were able to deduce graphically the IC50 values of reference antioxidants (BHT and ascorbic acid) and different peel extracts; which are shown in Figure 8.

According to figure 8, the IC50 value of ascorbic acid (0.13 ± 0.0005 mg/ml) is close to that found by Kanoun³³ (0.12 mg/ml) and Benhammou³⁴ (0.11 mg/ml).

The IC50 value of the BHT (50.17 ± 0.02 mg/ml) is equivalent (0.18 mg/ml) with that obtained in the study of Ouibrahim³⁵ and to that reported by Zidani¹⁴. In comparing the IC50 of our peel extracts to those of ascorbic acid and BHT, we noticed a very important antioxidant activity of Fahla peel's extract ($IC_{50} = 0.15 \pm 0.001$ mg/ml) which is intermediate between the ability of trapping the radical DPPH of BHT and ascorbic acid, followed by the peel extract of both varieties Discrito and Super strain 3 which show antioxidant activities almost equivalent to each other and also interesting with respectively (0.19 ± 0.01 and 0.20 ± 0.02 mg/ml). The peel extract of Rio grande variety seems to be the worst performing with an IC 50 of 0.27 ± 0.01 mg/ml. It is two times less active than ascorbic acid and it has on about half of the activity expressed by the BHT and peel extract the variety Fahla.

The variance analysis shows a very highly significant difference ($P \leq 0.001$), it is confirmed by Tukey test which revealed six homogeneous groups in order (A, B, BC, BCD, CD and D). The first group represents the highest value of IC50 (0.27 mg/ml) represented by the variety Rio grande, the second and third groups include closer and lower values (0.20, 0.19 mg/ml) respectively on varieties Super 3 strain and Discrito. The fourth and fifth groups showed lower IC50 respectively represented by BHT and Fahla variety (0.17, 0.15 mg/ml), the last group represents the lowest IC50 value recorded in the acid solution ascorbic which shows the highest antioxidant activity.

Few studies have examined the antioxidant power of tomato peel extracts. But we can note, according to the trapping method of free radical DPPH, that our varieties showed good antioxidant activity except Rio variety that showed low activity. This could be explained by enzymatic degradation and/or non enzymatic brown pigments substances (brown)^{36,37} and due probably to incorrect storage.

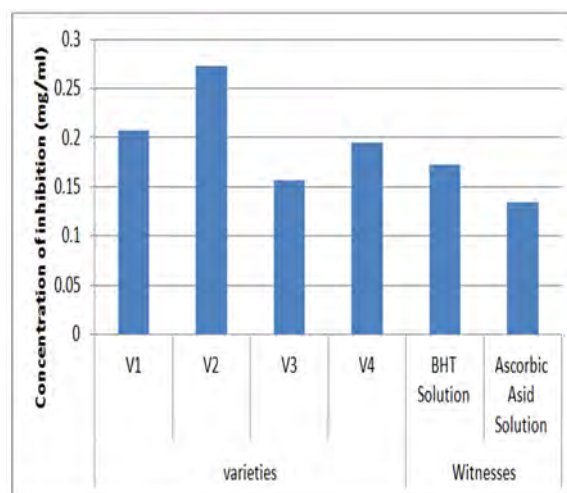


Figure 8: Inhibitory concentration IC50

CONCLUSION

Industrial tomato crop is very developed in eastern Algeria. It is used to produce Double concentrated tomato paste and annually generates tons of waste that is not valued.

The aim of this study was to compare the quality of the peels of four tomato varieties grown in open fields in the wilaya of Annaba (east of Algeria). Two fixed varieties: Super strain 3 and Rio Grande and two improved varieties: Fahla and Discrito vis-à-vis the following parameters: titratable acidity, brix levels, protein, total sugars, polyphenols, ash and antioxidant activity.

In general, the results obtained showed that the tomato peel present significant levels of soluble dry residues, ash (mainly minerals), total sugars, proteins, total polyphenols and a good antioxidant activity.

Therefore these peels can be exploited in the human and animal food industry, and even in the pharmaceutical industry as a source of antioxidants.

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