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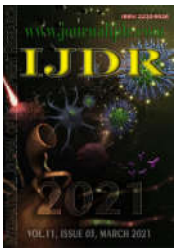

RESEARCH ARTICLE OPEN ACCESS

PROCESSING OF TOMATOES (*SOLANURN LYCOPERSICUM* L) THAT WOULD BE DISCARDED IN CEASA/PR AND IN A RURAL PROPERTY IN THE REGION OF MARINGÁ-PR

***[1]Giuliano Patrick Rasera, [2]Daniele Fernanda Felipe, [2]Graciene de Souza Bido and [2]Anny Rosi Mannigel**

[1]Master's degree student in the Master Program in Science, Technology and Food Safety of University Unicesumar, Avenue Guedner, 1610, Maringá, Paraná, Brazil; [2]PhD, Professor in the Master Program in Science, Technology and Food Safety, University Unicesumar, Avenue Guedner, 1610, Maringá, Paraná, Brazil

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****Corresponding author:***
Giuliano Patrick Rasera

ABSTRACT

Tomato is considered one of the most important vegetable species, because in addition to its use *in natura*, it can also be processed in several ways, such as extract, pulp, sauce and peeled tomato. This article aimed to evaluate the processing of tomatoes from the Paraná's Supply Center (CEASA) in Maringá/PR and from a rural property located in the region of Maringá/PR. To perform the study, samples of tomatoes were collected and their quality was assessed by means of physical-chemical, microbiological analysis and determination of lycopene content. The fresh tomato sample collected at CEASA - Maringá showed a pH of 4.40, a titratable acidity of 0.28 mg of NaOH/g and soluble solids in a Brix degree of 4.20%; the fresh tomato sample collected on the rural property had a pH of 4.30, a titratable acidity of 0.29 mg NaOH/g and soluble solids in a Brix degree of 3.90%. The fresh tomato sample collected at CEASA, in Maringá, had a lycopene content of 6.24 mg/100g, whereas tomato sauce processed with the same tomato had a lycopene content of 5.16 mg/100g, a standard result as the literature says. Sensory analysis was executed from the duly processed tomato sauce, using the 5-point hedonic scale, which was found that tomato sauces made with tomatoes that would be discarded at CEASA and on a rural property showed 83.35% acceptance among the evaluators.

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INTRODUCTION

Hunger is a social problem that affects millions of Brazilians. Even if it is possible to identify successful actions in the fight against hunger and also in the development of healthier and more sustainable agricultural models, in recent years, according to the Food and Agriculture Organization of the United Nations (FAO), in its report on Food Security in the world, the malnutrition curve in Brazil, in 2019, which until then was declining, started to grow (FAO, 2019). Practices that promote the reuse of food and prevent waste are tools to reduce hunger (UN, 2017). Brazil is one of the largest food producers in the world, but it faces difficulties in relation to the waste present in all stages of the production chain, culminating in the final consumer. Waste is verified in harvesting, transportation, industrialization, In total, 26.3 million tons of food are wasted annually (PHILERENO; DALEGRAVE, 2017). Of the products sold within the Supply Centers of Paraná S/A (CEASA) the tomato (*Solanurn lycopersicum* L.) corresponds to 9% of all quantity sold and holds the rank of second most traded product in quantity. Tomato is the product that generates the highest revenue in CEASA/PR, reaching more than 127 million reais in revenue in 2017 within CEASA in Curitiba, which demonstrates the great importance of the product economically. Due to the high rate of commercialization, in addition with its perishability, tomatoes are one of the vegetables that present a high rate of waste within supply centers (DOSSA; DENCK, 2018). At CEASA/PR, products that are not sold by boxers are donated to the Food Bank or even discarded in the trash. Many of these foods are suitable for consumption and have only aesthetic characteristics that make them unfit for sale, such as tomatoes (CEASA, 2018). The

selected and distributed free of charge to assistance entities and families in situations of food and nutritional insecurity, previously registered, as a way of complimenting the daily meals of this population (MACEDO, 2020). With the reuse of food, it is possible to avoid waste, improving the diet of people who suffer from hunger (SAMPAIO; FERST; OLIVEIRA, 2017). In view of the extreme waste of food in the country, it is necessary to adopt measures that lead the population to practices of conscious consumption in relation to food. By reusing food and developing new products and preparations, it is possible to stimulate sustainable technological alternatives, which can be applied both in the domestic and industrial environment (CARVALHO; BASSO, 2016).

The reuse of food is a way to reduce the number of people who suffer from hunger. This is the first point presented as the Millennium Development Goals established by the United Nations (UN), in 2000, (UNITED NATIONS, 2017). The topic is extremely important, as currently food waste is a serious problem in the country, and estimates show that from production in the field to the final consumer, food waste reaches 30% of everything that is produced in Brazil (FAO, 2018). Thus, the research studies a current topic that needs research, which is socially important because it is a set of actions that aim to improve the quality of life of the population. The objective of this work was to evaluate the processing of tomatoes from CEASA/PR and from rural properties located in the region of Maringá/PR.

MATERIALS AND METHODS

This study has an exploratory character and aims to enable greater knowledge about the problem of food waste and reuse, focused on tomatoes discarded at CEASA in Maringá and on a rural property in the same city, since it is a subject unknown. The research has a qualitative and quantitative approach, and it's objective is to obtain a deeper understanding of the topic. The study was submitted to and approved by the Ethics Committee. The work was carried out between October 2020 and January 2021. Initially, tomatoes (Solanurn lycopersicum L.), variety "Italiano" were collected at CEASA in the city of Maringá, located in the northwest of the state of Paraná, as well as the collection of discarded tomatoes in a rural property located in Aquidaban (district of the city of Marialva/PR) (Latitude: 23° 35'00.1"S; Longitude: 51° 54'01.1"W), where the tomato is produced in greenhouses and marketed in the region. The collected tomato showed a ripe maturation stage, with red color and ideal texture for processing. The amount of tomatoes collected was 5 kilograms at CEASA/PR and 5 kilogram at the rural producer. The collected tomatoes were placed in plastic packages and stored in the refrigerator at a temperature of 1 to 5°C. The determination of the pH of the collected tomatoes was measured using the potentiometric method, calibrating the pH meter with buffer solutions of pH 4.0 and 7.0 (GALVÃO et al., 2018). The content of soluble solids (ºBrix) was determined by direct reading on a digital refractometer. The acidity level was evaluated by titration method in simple acid-base titration (1g of sample diluted in 30mL of distilled water, containing 4 drops of the phenolphthalein indicator in the solution and then titration with NaOH until turning with a pink color). The results were expressed in citric acid concentration (DOS SANTOS et al., 2018). The bromatological analysis was made in triplicate at the Ambientale and ALax laboratories located in the city of Maringá/PR. The analysis of lycopene content in tomatoes was performed according to the methodology of Rodrigues-Amaya (2001) and the extraction quantification was performed by spectrophotometry (CARVALHO et al., 2005). Initially, in samples of 5.0g, 40mL of acetone were added, and then the mixture was stirred for 1 hour using a 200rpm shaker. Vacuum filtration was performed with the aid of a Kitassato wrapped in aluminum foil to prevent the photo-oxidation of the pigments. Each sample was washed with acetone for three more times, aiming at the total extraction of the pigments. To the separating funnel was added 45mL of petroleum ether. The pigments were transferred in small fractions, followed by distilled water to the separation funnel, discarding the lower phase.

The samples were washed four more times to completely remove the acetone. The solution of the pigments in petroleum ether was transferred to a volumetric flask, completing the volume to 100mL with petroleum ether. The reading on the spectrophotometer was performed at a wavelength of 470nm (RODRIGUEZ-AMAYA, 2001). Carotenoid analysis generally consists of sampling and sample preparation, extraction and partition with a solvent, saponification and washing, concentration or evaporation of the solvent and quantification in a spectrophotometer (NELLIS; CORREIA; SPOTO, 2017). The analysis of the lycopene content was made in the laboratories of the Center for Science and Food Quality of the Institute of Food Technology (ITAL) located in the city of Campinas/SP. The sample was submitted to laboratory analysis with the purpose of verifying the microbiological standards accepted for food, according to Resolution RDC nº 331, of December 23, 2019 of ANVISA (BRAZIL, 2019). The following tests were done: Coliforms, Salmonella sp, Staphylococcus Coagulase Positive, Molds and Yeasts. In the microbiological analysis to count molds and yeasts, seeding in Potato Dextrose Agar was used, with incubation of 25ºC for five days. In the quantification of total aerobic mesophilic bacteria, seeding on Plate Count Agar (PCA) was used, with a 24 hour incubation at 37°C. For the determination of total and fecal coliforms, the Most Likely Number technique was used. In the analysis of total coliforms, the Lauryl Tryptose (LST) Broth was used, with a 48 hours of incubation at 35°C. From the presumptive test, the Bile Green Brilliant Lactated Broth was used for the confirmatory test, with incubation for 24 to 48 hours at 35°C. The counting of faecal coliforms was performed in Broth Escherichia coli with incubation of 24 hours at 45°C. For research on Salmonella sp., pre-enrichment was carried out with buffered peptone water and incubation for 24 hours at 36ºC and, subsequently, enrichment with Rappaport-Vassiliades broth and cystine selenite, the first one being incubated at 35ºC and the second at 42ºC for 24 hours.

After this process, the plating was performed on shiny green agar-BG and Xylose Lysine Deoxycholate Agar incubated for 24 hours at 36ºC (SPRENGER, 2016). For the analysis of Coagulase Positive Staphylococci, counting was performed using the Spread Plate technique. 0.1mL aliquots from the 10-1, 10-2 and 10-3 dilutions were pipetted into a series of Baird Parker Agar (BP) plates. The spreading of the inoculum on the plate was done using the Drigalski strap and, afterwards, the incubation was done at a temperature of 35ºC for 48 hours. After the end of time, the number of black colonies was counted, and the results were expressed in colony-forming units (CFU/mL) (SÁTIRO; ARAGÃO; SERQUIZ, 2018). The microbiological analysis was done in triplicate at the Ambientale laboratory located in Maringá/PR. The processing of tomatoes in the form of tomato sauce was prepared following the Minimum Processing Manual for Fruits and Vegetables of the Brazilian Agricultural Research Corporation (EMBRAPA) (MORETTI, 2007) . The processing of tomato samples followed some steps: (A) fruit selection; (B) sanitization through washing under running water; (C) sanitization by immersion in solution with sodium hypochlorite at a concentration of 200 mg.L-1 (100 mL of 2% sodium hypochlorite, in 10L of water), for 5 minutes; (D) cutting the tomatoes into 0.5 cm slices; (E) packing the slices in expanded polystyrene trays; (F) sterile bag packaging to collect 540mL food samples; (G) storage in a refrigerator at a temperature of 1 to 5 °C (SILVA et al., 2011). The preparation of the tomato sauce, followed other steps: (A) sautéed in olive oil, garlic and chopped onion, over low heat (160°C) for 5 to 7 minutes; (B) chopped tomatoes added, a pinch of sugar, salt and black pepper; (C) cooked, until the sauce gets smooth (20 minutes), over low heat (160°C); (D) packed the tomato sauce in disposable plastic containers of 500mL with a lid; (E) stored in the freezer at freezing temperature (-18 C) (WRIGHT; TREUILLE, 2010). The tomato processing was done in a home kitchen, observing all rules of hygiene and food safety. Sensory analysis of the final product (tomato sauces) was done through the application of the 5-point Hedonic Scale Acceptance Test, which the taster describes his acceptance for the preparation, according to words established with gradual variation, which starts from attributes such as liked or disliked (BRASIL, 2005).

The sensory evaluation was done in the city of Paiçandu/PR with 30 untrained tasters between 20 and 45 years old. These participants read and signed the Informed Consent Form before analysing the samples. The samples were evaluated individually and under white light. Approximately 20g of each sample was served at 60 °C in disposable polypropylene plates encoded with three-digit figures, with a disposable spoon. Tomato sauce formulations were evaluated for acceptance (hedonic scale). Acceptance was verified by the structured 5-point hedonic scale (1 = I hated it to 5 = I loved it), in relation to the global impression (appearance, aroma, color and flavor) (DE SOUZA et al., 2018). For statistical analysis, the data were submitted to the Bio Estat 5.3 program (AYRES et al., 2007), in order to assess the adherence of the variables to the normal distribution. The significant preference or rejection was assessed by analysis of variance (ANOVA) and the comparison between the means by the Tukey test, adopting 5% as the level of significance ($p < 0.05$), (BEIGUELMAN, 2002).

RESULTS AND DISCUSSION

ANVISA's Resolution RDC No. 331, of December 23, 2019, which deals with accepted microbiological standards for food in Brazil and its application, describes the acceptable limits for microbiological analysis of fresh tomatoes ready to be offered to the consumer, as follows: absent for *Salmonella* sp. at 25g and for *Escherichia coli*, assessed by counting Total Coliforms, tolerance for a sample of 102 UFC/g (BRAZIL, 2019). *Salmonella* sp. can contaminate a wide variety of foods, causing dietary diseases, such as salmonellosis and typhoid fever. Usually, the spreading way of these diseases is through the ingestion of water and food contaminated with human feces (DE SOUZA et al., 2015). *Escherichia coli* is considered the best indicator of faecal contamination, and the use of Total Coliform Count is recommended for specific detection of *Escherichia coli* in food (MARQUEZI et al., 2010). Analyzing Table 1, it is possible to verify that the sample of fresh tomatoes collected at CEASA in Maringá, presented a higher amount in the total coliform count than the sample of fresh tomatoes collected in rural properties, a factor that is linked to the greater number of people who handled the tomatoes collected at CEASA.

Table 1. Microbiological analysis of fresh tomatoes collected at CEASA Maringá and in rural property in the region

Microbiological Analysis	CEASA Maringá	Rural Property
Total Coliform Count	$3{,}1x10^{+5}$ UFC/g	< 10 UFC/g
Counting of Thermotolerant Coliforms at 45 °C	<10000 UFC/g	< 10 UFC/g
Mold and Yeast Count	$2{,}5x10^{+3}$ UFC/g	Microorganisms present, but < 400 UFC/g
Staphylococcus Coagulase Positive Count	<100 UFC/g	<100 UFC/g
Detection of *Salmonella* sp.	Absent in 25g	Absent in 25g

For fresh Tomatoes, Brazilian legislation does not require microbiological analysis regarding the count of Molds and Yeasts, Counting of Thermotolerant Coliforms at 45 °C and Counting of *Staphylococcus* Positive Coagulase. Molds and yeasts are contaminants often found in juices, fruit and vegetable extracts, but the current legislation does not require the counting of these pathogens (SPRENGER et al., 2016). Therefore, the tests aimed at the safety of the participants, within the expected standards (DOWNES; ITO, 2001). A similar result was found by Correia (2015), in his study of dehydrated whole mini-tomatoes, based on the microbiological analysis of his samples, verifying the hygienic-sanitary conditions, as well as the product safety. After microbiological analysis, tomato samples from CEASA in Maringá / PR and from a rural property located in the region of Maringá/PR, were subjected to heat treatment, reaching 75°C, being proven effective in reducing of vegetative forms of microorganisms of concern to human health at safe levels (BRASIL, 2019).

Table 2 shows the results obtained from the bromatological analysis of the tomato samples from CEASA and the rural property. As shown in Table 2, it is possible to verify that the fresh tomato sample collected at CEASA Maringá and the tomato sample *in natura* collected in the rural property presented titratable acidity and pH (hydrogen potential) very close, with no considerable difference between them.

Table 2. Bromatological analysis of fresh tomatoes collected at CEASA Maringá and on the region's rural property

Bromatological analysis	CEASA	Rural Property
Titratable Acidity	0,28 mg of NaOH/g	0,29 mg of NaOH/g
pH	4,40 U pH	4,30 U pH
Soluble Solids (Brix reading)	4,20 %	3,90 %

The pH values found are within the range of recommended values for tomato consumption, since pH values below 4.5 are wanted, in view of the control of microbial proliferation (BARANKEVICZ et al., 2015). The pH values and titratable acidity found in the present study were similar to those found by Shirahige et al. (2010), in the study of productivity and quality of Santa Cruz and Italian tomatoes. In tomatoes, sugars and organic acids are the most important elements for the fruit's flavor, characterizing a quality product. High values of the ratio of total soluble solids to titratable acidity characterize a mild fruit flavor (FERREIRA et al., 2004). As for soluble solids in Brix reading, there was a small change between the results presented, in which the sample of fresh tomatoes collected at CEASA Maringá presented 4.20% and the sample of fresh tomatoes collected in rural properties presented 3.90%. The content of soluble solids, measured in Brix reading, has a direct influence on the fruit's flavor and may change due to external factors such as those caused by fertilization, temperature, irrigation and the cultivar's genetics (MONTEIRO et al., 2008). Due to the fact that the fresh tomatoes collected at CEASA in Maringá have a higher content of soluble solids in Brix grade, the lycopene content was quantified.

Table 3. Analysis of lycopene content in fresh tomatoes collected at CEASA in Maringá and in the sample of tomato sauce processed with tomatoes collected at CEASA in Maringá

Lycopene Content	*In natura* tomatoes from CEASA	Tomato sauce from CEASA
Lycopene	6,24 mg/100g	5,16 mg/100g

Table 3 shows the results obtained in the analysis of the lycopene content in the fresh tomatoes collected at CEASA in Maringá and in the sample of this tomato, which was processed in the form of sauce. Fresh Tomatoes collected at CEASA in Maringá presented a lycopene content of 6.24 mg/100g, while the tomato sauce processed with the same tomato had a lycopene content of 5.16 mg/100g. Thus, there was a loss of 1.08 mg/100g of lycopene in the processing of this tomato. The deterioration of carotenoids, as well as the loss of color, is a common problem in the processing and storage of fruits (RODRIGUEZ-AMAYA, 1999). A research has found that the lower the temperature and the shorter cooking time, the greater is the preservation of these carotenoids (alpha-carotene, beta-carotene and total carotenoids), considering that the heat treatment inactivates the enzymes that act in the carotenoid biosynthesis and stimulates the isomerization and oxidation of these compounds, resulting in losses (SHI; LE MAGUER, 2000). The total amount of carotenoids present in the fruit, as well as the lycopene / beta-carotene ratio is responsible for the reddish color of the tomato (BARANKEVICZ et al., 2015), therefore, fruits such as tomatoes, watermelon, red guava, papaya and pitanga, have a reddish color due to the levels of carotenoids (ALMEIDA FREDA et al., 2018).

The levels of lycopene obtained from the analyzed tomato samples are similar to those found by Rodrigues-Amaya (2001), and changes in values in the lycopene content can be attributed to several factors, such as: different species and varieties of tomato, season of harvest, type of soil cultivated and state of ripeness of the tomato. Thus,

tomatoes that have a higher ripeness status have higher levels of lycopene, because of biochemical reactions responsible for the release of this carotenoid (DOS SANTOS et al., 2018). The carotenoids present in tomatoes are responsible for the beneficial properties of this fruit, which lycopene has a major contribution in reducing the risk of chronic degenerative diseases. The interest of the scientific community in the antioxidant activity of lycopene is justified by the argument that this powerful antioxidant fights free radicals, slows down aging and can protect against some types of cancer (RAUPP et al., 2009). In Figure 1, the results obtained in the sensory analysis of the tomato sauce made with the tomato collected at CEASA in Maringá and the tomato sauce made with the tomato collected on the rural property are represented.

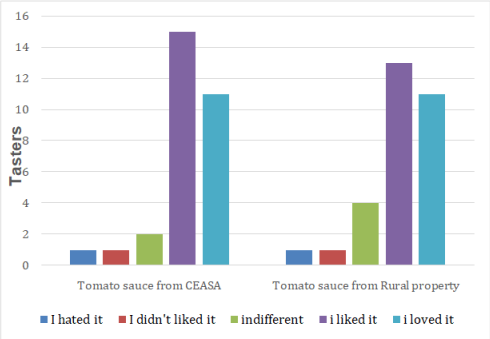

Figure 1. Sensory analysis of the tomato sauce made with the tomato collected at CEASA in Maringá and with the tomato sauce made with the tomato collected on the rural property.

From the results obtained in the sensory analysis using the 5-point hedonic scale, it is possible to say that the tomato sauce samples had adequate sensory characteristics. According to Dutcosky (2007), the 5-point hedonic scale can be used for studies of consumer preference and acceptability, with considerable success. The two tomato sauces analyzed obtained good acceptance in the sensory parameters, and the tomato sauce made with the tomato collected at CEASA in Maringá obtained a slight preference among the tasters, with no statistical difference. The statistical treatment of the analysis of variance (ANOVA) of the results of acceptability showed that the p-value of the samples is 0.721595, so there was no significant difference ($p < 0.05$) between the results obtained for the analyzed tomato sauces, being all accepted by the evaluators. Munhoz et al., (2011) when working with dehydrated tomatoes and assessing the preference and sensory acceptability of canned dried tomato pates with different dipping sauces in a group of 26 untrained evaluators and 3 treatments, showed similar results with no difference significant in the analysis of variance.

In Figure 2, there are the results obtained in the classification in relation to the greater acceptance and less acceptance of the tomato sauce made with the tomato collected at CEASA in Maringá and the tomato sauce made with the tomato collected on the rural property.
The tomato sauce made with tomatoes collected at CEASA in Maringá obtained 86.6% approval and 6.6% rejection which, 6% of the participants were indifferent. The tomato sauce made with the tomato collected on the rural property obtained 80.1% approval and 6.6% rejection, with 13.3% of the participants being indifferent regarding this sauce. The acceptability index (AI) of tomato sauces was 83.35% and, according to Gularte (2009), this index indicates that the analyzed food was accepted by the evaluators, in terms of sensory quality characteristics in a global perception, where the minimum accepted is 70%. In general, there was good acceptance in the sensory parameters, considering that the results are very close. It can be explained based on the fact that both sauces were made with the same ingredients, with only the tomato being altered in the sauce's preparation, which has very similar organoleptic properties. Regarding the organoleptic characteristics of tomatoes, namely flavor and texture, they are related to the good quality of the product,

CONCLUSION

The tomatoes that would be discarded in CEASA/PR and in a rural property in the region are an alternative for the reuse of food, because through the obtained results, it was possible to conclude that the tomatoes presented satisfactory quality in the analyzed aspects. The analyzed tomato had a lycopene content of 6.24 mg/100g and the tomato sauce had a lycopene content of 5.16 mg/100g, being characterized as an excellent source of this carotenoid. Tomato sauces were well accepted by the evaluators (83.35% acceptance rate), making it possible to use them as food.

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