Yuzuncu Yil University
Journal of Agricultural Sciences
(Yüzüncü Yıl Üniversitesi Tarım Bilimleri Dergisi)
https://dergipark.org.tr/en/pub/yyutbd

ISSN: 1308-7576 e-ISSN: 1308-7584

Research Article

Imaging Techniques of Tomatoes (*Solanum lycopersicum* L.) Grown with Different Organic and Conventional Fertilizer Applications

Selma KIPCAK BITIK*[1], Suat SENSOY[2]

[1]Van Yuzuncu Yil University, Baskale Vocational School, 65090, Van, Türkiye
[2]Van Yuzuncu Yil University, Faculty of Agriculture, Horticulture Department, 65090, Van, Türkiye

[1]https://orcid.org/0000-0002-0563-1130, [2]https://orcid.org/0000-0001-7129-6185

*Corresponding author e-mail: selmakipcak@yyu.edu.tr

Article Info

Received: 01.12.2022
Accepted: 05.04.2023
Online published: 15.04.2023
DOI: 10.29133/yyutbd.1213160

Keywords

Conventional fertilizer,
Imaging techniques,
Organic fertilizer,
Tomato

Abstract: In this study, which was carried out in field conditions in Van in 2019 and 2020, different image generation methods (biocrystallization method, and circular and rising picture chromatography methods) were used to determine the difference between various organic and conventional fertilizer applications. 3% frozen tomatoes and 16% $CuCl_2.2H_2O$ were applied in the biocrystallization method, 80% frozen tomatoes and 1% silver nitrate solution were used in the circular chromatography method, and 100% frozen tomatoes and 0.5% silver nitrate and 0.5% iron sulfate solution were employed in the rising picture method. In light of the visual findings obtained at the end of the study, it has been determined that there are some differences between organic and conventional fertilizer applications. As the alteration between organic and conventional products; the center number difference in the copper crystallization method; the smoothness of the rings formed in the circular chromatogram and the vividness of the colors; in the rising painting method, it clearly reveals the transitions between colors and the difference in light and dark tones that occur in colors.

To Cite: Kıpcak Bitik, S, Sensoy, S, 2023. Imaging Techniques of Tomatoes (*Solanum lycopersicum* L.) Grown with Different Organic and Conventional Fertilizer Applications. *Yuzuncu Yil University Journal of Agricultural Sciences*, 33(2): 248-258.
DOI: https://doi.org/10.29133/yyutbd.1213160

Footnote: This study was produced from the doctoral thesis of the first author.

1. Introduction

Carbs in tomatoes, organic acids, amino acids, vitamins, various mineral substances, and phenolic compounds have an important place in human nutrition (Georgé et al., 2011; Sönmez and Ellialtıoğlu, 2014; Erdinc et al., 2018). Tomato is one of the most used vegetables in human nutrition. It is known that tomato cultivation is carried out almost everywhere in the world except Antarctica (Özcan, 2016). Tomato is from the Solanaceae family spread to other continents from the New World; it is known that tomatoes enter Türkiye from Adana, and there were numerous studies on it (Şalk et al., 2008; Uçar and Şensoy, 2022). World tomato production is 186 million tons (FAO, 2020). China produces approximately 64 million tons and ranks 1st with a share of 35% of the total world production, while India ranks second with 20 -million tons, and Turkey ranks 3rd with 13 million tons of production (FAO, 2020).

Chemical fertilizers, hormones, and pesticides (İlter and Altındişli, 1998), used unconsciously and excessively in order to meet the food needs of the increasing population, cause pollution of water and air, decrease in soil fertility, destruction of agricultural areas, and serious damage to both human and animal health (Saber, 2001; Hossain et al., 2003; Çakmakcı, 2005; Öztemiz, 2008; Akbay, 2012; Kapakci, 2013).

The most successful way to improve the soil structure and ensure its sustainability is to enrich the soil with organic matter (Tüzel et al., 2011; Zhang et al., 2012). With organic fertilizers, the physical and chemical structure of the soil is improved, and the vital activities of living things and microorganisms living in the soil are increased. Thus, soil quality, fertility, and continuity are ensured (Beşirli et al., 2009; Nesmeyanova et al., 2013; Patil et al., 2014; Ragozo et al., 2014; Xie Feng et al., 2014). With the start of microorganism activities in the soil, various events such as the mineralization of nutrients important for plant growth, nitrogen fixation, phosphorus solubility, and prevention of harmful microorganisms occur (Altın and Bora., 2005; Alagöz et al., 2020).

In recent years, to reveal the difference between organic and conventionally grown products, a new method of creating images, which was used by some researchers and has become increasingly important, has been used (Andersen et al., 1999; Balzer-Graf, 1999; Koepke et al., 2001; Huber, 2006; Abdollahi, 2008; Kuşçu, 2008; Unluturk et al., 2014). As a result of quantitative analysis, it was not observed between organic and conventional products in some methods; on the other hand, the pictures obtained from the products in question with these methods may differ. Image creation methods can be grouped under three main headings as biocrystallization method, circular chromatogram method, and rising picture method (Abdollahi, 2008; Kuşçu, 2008).

With the increasing consumer awareness day by day, the taste and aroma properties, biochemical contents, nutritional contents, pesticide residues, nitrate nitrite accumulation, the effects they have left on the soil, human health, etc., of the products obtained by organic and conventional agriculture it is seen that comparisons have been made in many subjects such as (Abdollahi, 2008; Kuşçu, 2008; Ninfali et al., 2008; Hallmann, 2012; Mditshwa et al., 2017; Suja et al., 2017; Erdinc et al., 2018). While many features are revealed separately with quantitative analysis, these features are stated as reflecting the whole with picture creation methods.

The aim of the study was to determine whether the difference between the two cultivation methods used by some organic and conventional fertilizers can be distinguished by using image formation methods in the Rio Grande tomato variety grown under field conditions in 2019 and 2020.

2. Material and Methods

2.1. Materials

The seeds of the Rio Grande standard tomato variety, the main material of the study, were obtained from Yalova Atatürk Horticultural Research Institute. Chemical fertilizer (18:18:18 NPK compound fertilizer), plant activator containing seaweed, organic mineral fertilizer, solid worm, and liquid worm were obtained from private companies. Cattle manure was obtained from farmers residing in the Van-Tusba district, sheep manure from the Van-Edremıt district, and chicken manure from the Van-Gurpınar district.

Tomato seeds were sown on 11.04.2019 in viols containing sterile peat: perlite mixture at a ratio of 2:1 in the greenhouses of Van Yuzuncu Yil University, Faculty of Agriculture, Department of Horticulture. The healthy seedlings were planted on 08.06.2019 in the first year and on 14.06.2020 in the second year. The field experiment was established in the village of Göllü, which has a latitude of 38.7202^o and a longitude of 43.3124^o, within the borders of the Tusba district of Van, in a randomized block design with 4 repetitions, a control group, and 8 different fertilizer applications, with a total of 9 applications.

The study area consisted of 36 plots in total. The plots were prepared with a length of 7 m x 6 m, and a 1.5 m distance was left between the blocks and the plots. Tomato seedlings were planted at intervals of 100 cm x 50 cm on the rows. There were 84 plants were used in each plot and a total of 336 plants were used for one application. The drip irrigation system was used for irrigation.

2.1.1. Fertilizer applications

1. Control application (No fertilizer)
2. Chemical fertilizer (CF) (based on 12 kg da^{-1}N: 12 kg da^{-1} P_2O_5: 18 kg da^{-1} K_2O) 1st Year (as a base fertilizer compound fertilizer of 18N:18P:18K, potassium sulfate, and triple super phosphate were applied); the rest of the nitrogen was divided into two and applied in the flowering and fruit setting periods as ammonium sulphate.
3. Chemical fertilizer (CF) (12 kg da^{-1}N: 12 kg da^{-1} P_2O_5: 18kg da^{-1} K_2O)+ Plant activator (100 ml of plant activator (seaweed) in 100 liters were sprayed four times in 20 days intervals after planting).
4. *Organomineral fertilizer (based on 11 kg da^{-1}N: 11 kg da^{-1} P_2O_5:, 11kg da^{-1} K_2O)
5. *Solid vermicompost 1. Year (589 kg da^{-1}); 2.Year (590 kg da^{-1})
6. *Liquid vermicompost 1. Year (84.82 l da^{-1}); 2.Year (85.89 l da^{-1}).
7. *Sheep manure 1. Year (784.67 kg da^{-1}); 2.Year (786 kg da^{-1}).
8. *Cattle manure 1. Year (1528.57 kg da^{-1}); 2.Year (1531.16 kg da^{-1}).
9. *Chicken manure 1. Year (435.93 kg da^{-1}); 2.Year (436.67 kg da^{-1}).

*: In all applications, the fertilizer rates were adjusted approximately to be equivalent to the amount of chemical fertilizer nitrogen.

2.2. Methods

2.2.1. Samples preparation for imaging techniques

For each application, 10 fruits were taken randomly from the fruits harvested from the 6 plants in the middle, and they were pureed and stored at -20 °C until the analysis day. Frozen tomato samples of fertilizer applications were homogenized with the help of a blender. Then the extract is centrifuged at 4000 rpm for 20 minutes. After centrifugation, the extract was filtered using coarse filter papers, and obtained filters were employed in imaging techniques (biocrystallization method, circular chromatography, and rising picture method).

2.2.1.1. Biocrystallization method

The biocrystallization method, which is described as the method of sensitive copper chloride crystallization, has been modified according to Balzer-Graf and Balzer (1991). The copper chloride solution was prepared at a concentration of 16% and the sample extract at a concentration of 3%. Each sample was prepared in triplicate. Petri dishes were left to dry in the climate room of Van Yüzüncü Yıl University, Faculty of Agriculture, Department of Horticulture, in a flat place at 25-30 °C and 60-65% relative humidity conditions. After approximately 14-16 hours, the crystal patterns formed by drying on the petri surface were evaluated.

2.2.1.2. Circular chromatography method

The circular chromatogram method was modified according to Balzer-Graf (1999). In the circular chromatogram method, 1% $AgNO_3$ solution and 80% concentration sample extract were used. The colors and patterns that emerged due to the drying of the paper emerged in a period of a few hours to a few days.

2.2.1.3. Rising picture method

This method, called the capillary rising picture method, capillary dynamolysis, or steigbild, has been modified according to Balzer-Graf (1999). In the method, 100% tomato extract, silver nitrate 0.5 %, and iron sulfate were prepared at 0.5% concentrations. In this method, a certain amount of sample extract is given to the chromatography paper. After the drying stage, the silver nitrate solution was added to a height of 1 cm from the sample extract, and after the second drying period, the iron sulfate solution was given to a total height of 12 cm.

2.2.2. Examining patterns

The crystal patterns formed in the glass petri dish, the circular chromatogram, and the patterns obtained from the ascending picture methods were taken with the Cano 7d DSLR digital camera. The evaluation of the photographs was made according to the morphological features of the crystals, and the colors and patterns that emerged in the circular chromatogram and ascending picture method.

3. Results and Discussion

3.1. Biocrystallization images

The zones formed in biocrystallization are demonstrated in Figure 1. Pictures obtained by the biocrystallization imaging technique in frozen tomato pulps are given in Figure 2. The biocrystallization method was prepared by choosing the most appropriate sample concentration and copper solution, taking into account the previous studies on tomatoes.

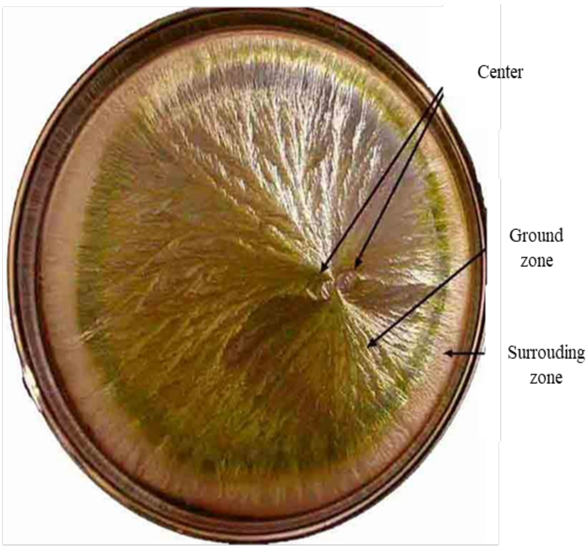

Figure 1. Regions formed in biocrystallization imaging (Abdollahi, 2008).

To determine the different products between organic and conventional fertilizer applications, when the cryptograms were examined in the study conducted in 2019 and 2020, deformation and quality loss in the crystal structure were observed in both organic and conventional samples. It is seen that the number of crystal centers obtained in CF+plant activator application and organomineral fertilizer, excluding chemical fertilizer, is higher than in the organic samples. Due to the quality loss of frozen tomatoes during storage, breakage, and deformation are observed in the crystal branches. When organic and conventional frozen samples are compared, there are still differences between organic and conventional samples although the cryptograms of frozen samples do not reveal as much difference as the cryptograms of fresh samples. However, it is more difficult to reveal crystalline differences due to deformation in organic and conventional samples than in fresh samples. As a matter of fact, in a study by Abdollahi (2008), the cryptograms of fresh, frozen, and pulp-treated samples were examined, and it was determined that the crystal structures of fresh samples more clearly reflected the difference between organic and conventional. He determined that the frozen samples did not form strong crystals as they were exposed to losses during storage. It is quite difficult to reveal the difference between organic and conventional crystals in frozen tomatoes and tomato pulp compared to the fresh sample. In the present study, the samples were frozen and kept at -20 ºC until the day of imaging techniques. It has been determined that the crystal structures of organic fertilizers in solid vermicompost, sheep manure, and chicken manure applications form smoother, tighter, and more lively tissues compared to conventional fertilizers. Although it was frozen, it was determined that there were differences, though not very obvious, in tomato samples grown with organic and conventional fertilizer applications.

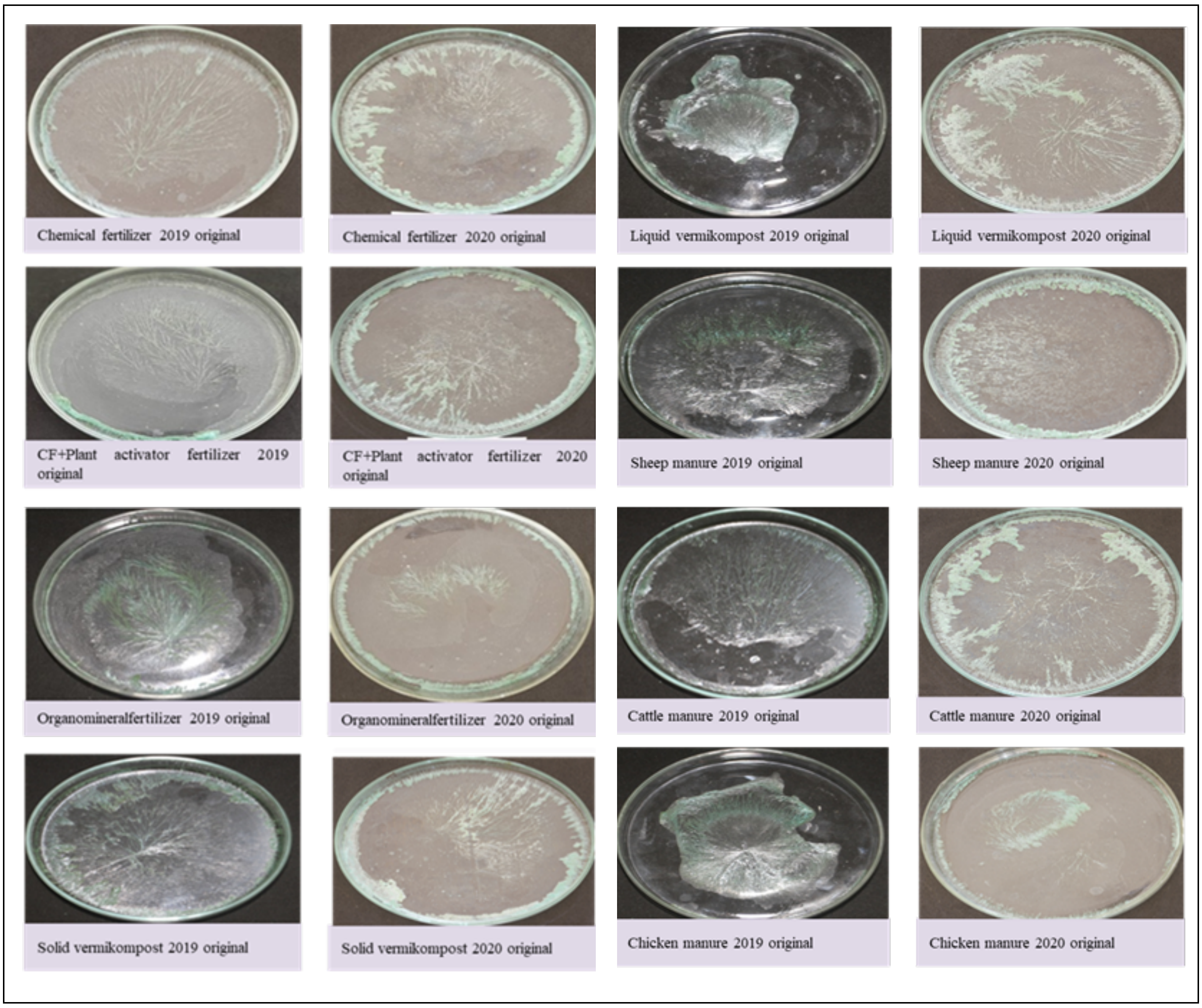

Figure 2. Crystallization images of some frozen tomato samples in 2019 and 2020 (3% frozen tomatoes, 16% $CuCl_2.2H_2O$).

3.2. Circular chromatography images

As seen in Figure 3, circular chromatogram images are seen to consist of four regions: the central zone, the middle (ground) zone, the edge zone, and the end zone (Medina Saavedra et al., 2018). Pictures obtained in the circular chromatogram imaging technique applied to frozen tomato pulps are given in Figure 4.

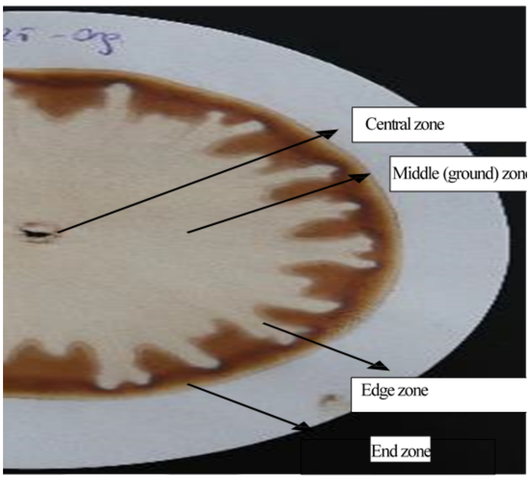

Figure 3. Regions formed in circular chromatography imaging (Medina Saavedra et al., 2018).

The patterns formed in the chromatograms differed in 2019 and 2020, the end zone formed in 2019 was dark brown, and the edge zone was not very clear; In 2020, it is seen that the end zone is light brown and the edge zone is more prominent and clear.

It has been determined that the patterns obtained from the five different organic fertilizers studied show almost the same characteristics, and the patterns obtained in 2020, in particular, are smoother, clearer, and clearer than those obtained from conventional fertilizers. The central and middle zone of the organic and conventional frozen tomato sample chromatograms were separated from each other in both years and in 2019, they acquired a color close to lilac; In 2020, it is seen that it has an orange color. When the edge zone is examined; N: P: K (12:12:18), which is one of the conventional examples, shows almost non-existent patterns in the application, while in CF+ plant activator and organomineral applications, it is seen that there are close to each other and more prominent structures in the second year. In organic fertilizer applications; when the patterns obtained in 2020 are smoother and more distinct, and the corrugated (indentation) structure is examined, it is seen that they are longer than the conventional samples. Among the organic fertilizer applications, especially the patterns obtained from the sheep manure application are clearer than both conventional fertilizer and other organic fertilizer applications, pronounced, and the indentations were determined to be longer. In the tip region, it was observed that the samples obtained from conventional fertilizer applications took a lighter brown color in the second year compared to organic fertilizers, conventional fertilizer applications other than organomineral were longer and irregular, and the color formed in the tip area was darker and shorter in organic fertilizer applications. In light of the data we have obtained, the images obtained from the circular imaging technique in the second year, excluding cattle manure, are smoother than conventional applications, and the rings formed between the center and the periphery are more prominent. The fact that the tip is darker in the circular imaging technique is due to the protein amount of the products grown with organic fertilizer.

Actually, when the protein content of 2020 is examined (data is available in the thesis), it has been determined that the protein content is higher in organic fertilizer applications than in conventional applications, except for chicken manure. In the circular chromatogram technique, circular small and light-colored rings indicate biomaterials, and the shapes extending from the periphery to the center show the protein quality and amount in the sample (Pfeiffer, 1960). In a study in which a circular chromatogram was used for protein detection with different fertilization conditions, it was stated that chromatograms obtained from organic fertilization were more frequent and deep (Knorr, 1982). Reported that in the circular chromatogram technique, circular small and light-colored rings indicate biomaterials, and shapes extending from the periphery to the center indicate the quality and amount of protein in the sample. Kucukyasar (2019), reported that the vivid dark color formed at the ends of circular chromatograms indicates high protein and enzyme activity. Velimirov (2003) stated that in the chromatograms obtained from organic apple samples, the widths of the corrugations are narrower and a more vivid orange color is dominant in the end region. In the images obtained from the studies performed on fresh and frozen red pepper and tomato samples, it was determined that the corrugations formed in the organic chromatograms differed from the conventional ones and were in a deeper and narrower structure (Abdollahi, 2008; Kuşçu, 2008). As a result of some previous studies, they stated that dark gray spots occur between dark brown corrugations in organic chromatograms, while light brown corrugations appear in conventional chromatograms (Knorr, 1982; Abdoollahi, 2008; Kuşçu, 2008).

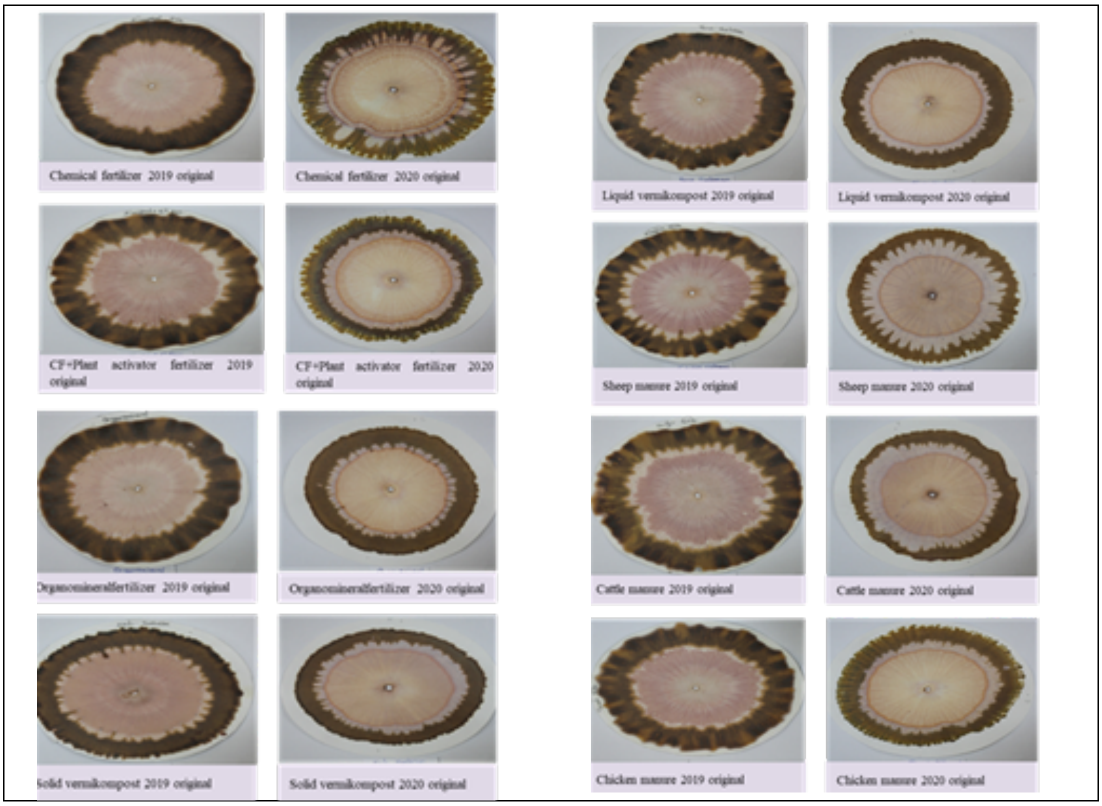

Figure 4. Circular chromatogram of some frozen tomato samples in 2019 and 2020 (80% frozen tomatoes, 1% silver nitrate solution).

3.3. Rising picture chromatogram

The patterns formed when the image is viewed from bottom to top in the rising picture chromatogram consist of the lower region (ground), thin white line, bowl region, tailing region, fall region, branches, and drops (Figure 5).

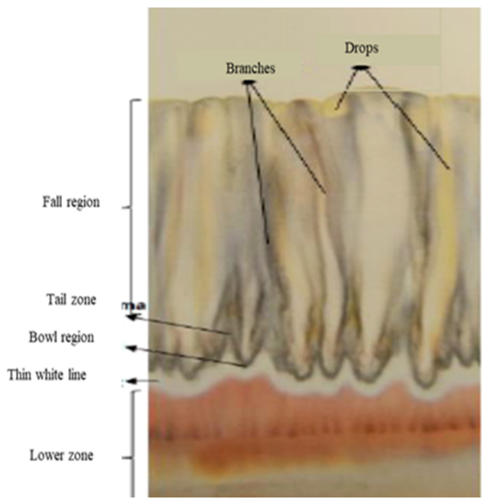

Figure 5. Regions formed in rising picture chromatogram (Kucukyasar, 2019).

It is seen that the regions formed in the second year of the rising picture images obtained in the study and the thin yellow and white lines formed between these regions are more clearly separated than in the first year (Figure 6). In the 2019 images of the ground area, it is seen that a matte coloration occurs in organic fertilizer applications, darker and more vivid colors are formed in conventional fertilizer applications, but the thin yellow line is not very clear in both organic and conventional manure applications. However, it was photographed that the thin yellow line occurred prominently in the second year. In the pictures obtained from conventional fertilizer applications, it is seen that a thin yellow line is formed in the ground region in the second year, followed by a white thin line. The bowl area is formed and has a vivid dark brown color. It has been determined that tailing, branching, and drops are more prominent in the first year. It was seen that gray tones are more dominant in the decline region in the second year.

It was determined that the yellow line formed in the soil area in organic fertilizer applications was not very pronounced compared to conventional fertilizer applications, and the coloration in all regions was dominated by dull and gray tones. Since the thin white line is wider than in conventional applications and the tailing region is clear, the bowl region has a recessed structure. In almost all organic fertilizer applications, it has been photographed that the branches forming the fall zone become clear towards the tailing zone, but there is no clarity where the drops have entered each other.

Kucukyasar (2019), reported that in the chromatograms created by the rising picture method of potatoes obtained by organic and conventional applications, organic applications took a darker, more pronounced color in the ground region, a very intense gray color in the tailing region, and indistinct branching in the fall region. Schilperoord (2004) examined the ascending picture chromatograms of wheat samples grown as a result of organic and conventional applications and found that for organic wheat samples, a burgundy-colored wavy region, more dense and narrow, red bowl structures were formed in the lower region, and more vivid colored drops were formed in the fall region for conventional samples. Fresh red pepper samples grown with organic and conventional fertilizer applications were examined by imaging techniques, It has been reported that in fresh peppers obtained from conventional fertilizer applications, the width of the bowl area is wider, the tail area is clear, the thin white line separating the ground and the bowl area is wider, and the drop formations in the fall zone are darker and wider (Kuşçu, 2008). In a study that adhered to organic and conventionally grown green olives, the images obtained from the rising image chromatograms also determined that the ground region had different colors in the samples obtained from both applications, the conventional applications samples had wider bowl structures and the thin white line was more prominent and wider (Kucukyasar, 2019). It has been reported that the thin white line separating the ground and bowl area is wider and the drop formations in the fall zone are darker and wider (Kuşçu, 2008).

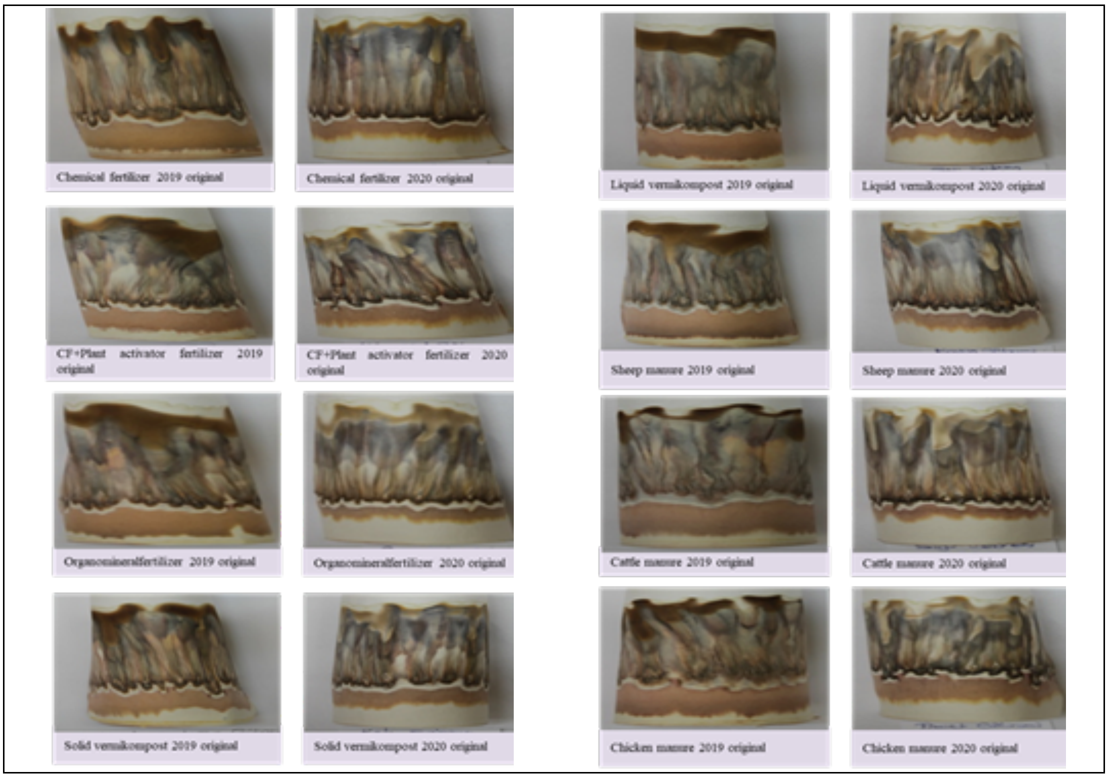

Figure 6. Rising picture chromatogram of some frozen tomato samples in 2019 and 2020 (100% frozen tomatoes, 0.5% silver nitrate, 0.5% ferrous sulfate solution).

5. Conclusion

The components (vitamin C, antioxidant capacity, etc.) that can be determined by analyzing them one by one with analytical methods have brought a different perspective in that they reflect the entire sample with holistic methods.

Painting methods could be applied very easily because they are both easy and repeatable to reveal the difference between organic and conventional products. However, since both organic and conventional crystals are deformed in frozen products, especially in tomatoes, the crystal branches formed began to resemble each other. However, the change in the number of centers in the Biocrystallization method, the smoothness of the rings formed in the circular chromatogram and the vividness of the colors, the transitions between the colors and the light and dark tones in the colors in the ascending dyeing method reveal the difference between organic and conventionally grown tomato fruits.

Acknowledgments

This study was a part of the first author's Ph.D. thesis and funded by the Yuzuncu Yil University Scientific Research Projects Coordination Unit as the project numbered FDK-2019-8157.

References

Abdollahi, F. (2008). *Organik ve konvansiyonel domates ve ürünlerinin ayırt edilebilme yöntemleri ve kalite farklarının incelenmesi*. (Ph.D), Ege Üniversitesi, Fen Bilimleri Enstitüsü, Gıda Mühendisliği Anabilim Dalı. İzmir, Türkiye, 2-221.

Akbay, F. (2012). Farklı azot dozlarında yetiştirilen marulda (*Lactuca sativa* L.) paenibacillus polymyxa uygulamalarının verim, bitki gelişimi ve besin elementi içeriğine etkisi. Yüksek lisans tezi, Atatürk Üniversitesi, Fen Bilimleri Enstitüsü, Bahçe Bitkileri Anabilim Dalı Erzurum, Türkiye, 4-5

Alagöz, G., Özer, H., & Pekşen, A. (2020). Raised bed planting and green manuring increased tomato yields through improved soil microbial activity in an organic production system. *Biological Agriculture & Horticulture*, *36* (3), 187-199.

Altın, N., & Tayyar, B. O. R. A. (2005). Bitki gelişimini uyaran kök bakterilerinin genel özellikleri ve etkileri. *Anadolu Ege Tarımsal Araştırma Enstitüsü Dergisi*, *15* (2), 87-103.

Andersen, J. O., Henriksen, C. B., Laursen, J., & Nielsen, A. A. (1999). Computerised image analysis of biocrystallograms originating from agricultural products. *Computers and Electronics in Agriculture*, *22* (1), 51-69.

Balzer-Gaf, U. & Balzer, F.M. (1991), Steigbild Und Kupferchloridkristallisation-Spiegel Der Vitalaktivitat Von Lebansmitteln-Lebensmittel- Qualitat Ganzheithiche Methoden Und Konzepte Stiftung Ökologie Und Lundbau Ed: A. Meier- Ploeger and Vogtman Germany,163-210 (Öztürk'tan, 2003).

Balzer-Gaf, U., (1999). Vital-quality: quality research with picture- forming methods. *6th IFOAM Organic Trade Conference,* Florence, Italy, 179-188.

Balzer-Graf, U. R., Köpke, U., & Geier, U. (2001). *Research on quality in organic agriculture by picture forming methods,* Understanding the Quality of Organic Horticultural Products (Short Course on). Izmir, Turkey, 15-26 May.

Beşirli, G., Sönmez, İ., Keçeci, M., & Güçdemir, İ. H. (2009). Organik domates yetiştiriciliğinde yeşil gübreleme ve bazı besin maddelerinin toprak yapısı üzerine etkisi. 1. *GAP Organik Tarım Kongresi*, *17* (20), 583-591.

Çakmakcı, R. (2005). Bitki gelişimini teşvik eden rizobakterilerin tarımda kullanımı. *Atatürk Üniversitesi Ziraat Fakültesi Dergisi*, *36* (1), 97-107.

Erdinc, C., Ekincialp, A., Gundogdu, M., Eser, F., & Sensoy, S. (2018). Bioactive components and antioxidant capacities of different miniature tomato cultivars grown by altered fertilizer applications. *Journal of Food Measurement and Characterization*, *12* (3), 1519-1529.

Fao, 2017. Food and agriculture organizatioan. http://www.fao.org/faostat/en/#data/QC. Accessed: 23.08.2022.

Georgé, S., Tourniaire, F., Gautier, H., Goupy, P., Rock, E., & Caris-Veyrat, C. (2011). Changes in the contents of carotenoids, phenolic compounds and vitamin C during technical processing and lyophilisation of red and yellow tomatoes. *Food Chemistry*, *124* (4), 1603-1611.

Hallmann, E. (2012). The influence of organic and conventional cultivation systems on the nutritional value and content of bioactive compounds in selected tomato types. *Journal of the Science of Food and Agriculture*, *92* (14), 2840-2848.

Hossain, M. A. (2000). Studies on application methods of Manda 31 for turmeric (Curcuma spp.) cultivation. *Sci. Bull. Agr. Univ. Ryukyus*, *47*, 137-144.

Huber, M. (2006). The 2005 Louis Bolk Milk Study, A Pilot Study in Search of Parameters for Quality and Health, Organic Food Quality and Health Workshop, BioFach Fair Nuremberg, February 16th, 2006, p. 11.

İlter, E., & Altındişli, A. (1998). *Ekolojik Tarım ve İlkeleri. Ekolojik (Organik, Biyolojik) Tarım.* (Aksoy, U., Altındişli, A., -eds), 1-6s, Ekolojik Tarım Organizasyonu Derneği, Bornova, İzmir.

Knorr, D. (1982). Use of a circular chromatographic method for the distinction of collard plants grown under different fertilizing conditions. *Biological Agriculture & Horticulture*, *1* (1), 29-38.

Koepke, U., Balzer-Gaf, U.R., & Geier, U. (2001). Research on *Quality in Organic Agriculture by Picture Forming Methods, Understanding the Quality of Organic Horticultural Products* (Short Course on). Izmir, Turkey, 15-26 May.

Kucukyasar, S., Pazir, F. (2019). *Differences between organic and conventional green olives of memecik varieties in terms of physical, chemical and pomological properties,* (Master Thesis) (Unpublished), Ege University, Institute of Science and Technology, Izmır, Turkey.

Kuşçu, A. 2008. *Differentiation methods and quality characteristics of organic and conventional red pepper and ıts products*. (Ph.D), Ege University, Institute of Science, Izmır, Turkey, 211-347

Mditshwa, A., Magwaza, L. S., Tesfay, S. Z., & Mbili, N. (2017). Postharvest quality and composition of organically and conventionally produced fruits: A review. *Scientia Horticulturae*, *216,* 148-159.

Medina Saavedra, T., Arroyo Figueroa, G., & Peña Caballero, V. (2018). Chromatography of Pfaiffer in the analysis of soils of productive systems. *Revista mexicana de ciencias agrícolas*, *9* (3), 665-673.

Nesmeyanova, M. A., Kuznetsova, T. G., & Dedov, A. V. (2013). Role of binary sowing crops with legumes for preserving and improving soil fertility. *Вестник аграрной науки*, *45* (6), 33-37.

Ninfali, P., Bacchiocca, M., Biagiotti, E., Esposto, S., Servili, M., Rosati, A., & Montedoro, G. (2008). A 3-year study on quality, nutritional and organoleptic evaluation of organic and conventional extra-virgin olive oils. *Journal of the American Oil Chemists' Society*, *85* (2), 151-158.

Özcan, M., (2016). *Domateste Muhafaza Yöntemleri*. Turktop. org. tr. 28-31

Öztemiz, S. C. (2008). Organik tarımda biyolojik Mücadele. *Gaziosmanpaşa Üniversitesi Ziraat Fakültesi Dergisi*, 2, 19-27.

Patil, G. D., Kharade, M. S., & Sawale, D. D. (2014). Effect of green manures on physico-chemical properties of soil. *Journal of Agriculture Research and Technology*, *39* (1), 160-163.

Pfeiffer, E. E. (1960). Chromatograms of grain and flour. *Bio-Dynamics*, *54,* 2-15.

Ragozo, C. R. A., Leonel, S., & Tecchio, M. A. (2014). Nutritional balance and yield for green manure orange trees. *Ciência Rural*, *44*, 616-621.

Saber, M. S. M. (2001). Clean biotechnology for sustainable farming. *Engineering in Life Sciences*, *1* (6), 217-223.

Schilperoord, P., (2004). Hat Berggetreide Besondere Qualitäten? Einleitung Überarbeitet, 10p.,(http://www.berggetreide.ch/Archiv/VorstudieQualitaet.pdf).

Sönmez, K., & Ellialtıoğlu, Ş. Ş. (2014). A research related with tomato, carotenoids and factors effecting them. *Derim (Turkey),* 31 (2):107-130.

Suja, G., Byju, G., Jyothi, A. N., Veena, S. S., & Sreekumar, J. (2017). Yield, quality and soil health under organic vs conventional farming in taro. *Scientia Horticulturae*, *218*, 334-343.

Şalk, A., Arın, L., Deveci, M., & Polat, S. (2008). *Özel Sebzecilik*. Namık Kemal Üniversitesi Ziraat Fakültesi, 448.

Tüzel, Y., Öztekin, G. B., Duyar, H., Eşiyok, D., Kılıç, Ö. G., Anac, D., & Kayıkçioğlu, H. H. (2011). Effects of some organic fertilizers and agryl cover on yield, quality and leaf nutrient content and soil productivity in organic lettuce growing. *Tarim Bilimleri Dergisi*, *17* (3), 190-203.

Uçar, C., Şensoy, S., 2022. Validity control of markers used in molecular marker assisted selection in tomato. *Yuzuncu Yıl University Journal of Agricultural Sciences, 32* (2), 300-309.

Unluturk, S., Unluturk, M. S., Pazir, F., & Kuscu, A. (2011). Process neural network method: case study I: discrimination of sweet red peppers prepared by different methods. *Eurasıp Journal on Advances in Signal Processing*, 1-8.

Unluturk, S., Unluturk, M. S., Pazir, F., & Kuscu, A. (2014). Discrimination of bio-crystallogram images using neural networks. *Neural Computing and Applications*, *24* (5), 1221-1228.

Xie Feng, Y., Hon Gen, L., Zheng, L., Yong, W., YingYuan, W., HongFeng, W., & GuoShun, L. (2014). Effects of green manure continuous application on soil microbial biomass and enzyme activity. Journal of Plant Nutrition, 37(4): 498- 508

Zhang, X., Ma, L., Gilliam, F. S., Wang, Q., & Li, C. (2012). Effects of raised-bed planting for enhanced summer maize yield on rhizosphere soil microbial functional groups and enzyme activity in Henan Province, China. *Field Crops Research*, *130*, 28-37.