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Quality characteristics of Tomato Fruits for processing based on chemical composition and functional compounds in response to fertilization rate with potassium humate.

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ABSTRACT

The present investigation is one part of a research work on the agricultural and processing factors affecting the quality characteristics of processed tomato products specially juice and paste. This study concerned on the influence of fertilization rate of tomato crop with potassium humate on the quality characteristics of tomato fruits based on their chemical composition and functional compounds. A field experiment was conducted on tomato cultivar; (SV 8320 TD' F1 Hybrid) were treated with potassium humate at the levels of 25, 50 and 75 kg/Fed. Chemical analysis of the full ripe tomato fruits showed that fertilization with potassium humate slightly improved the fruit contents of total solids, total soluble solids sugars and ash while, total acidity, pH, protein and fat showed no changes. Moreover, the improving effect of fertilization was more pronounced on tomato contents of the functional compounds. It was found that vitamin C, total carotenoids, lycopene, β- carotene, flavonoids and phenolic compounds considerably increased due to fertilization with potassium humate. The improving effect was more pronounced at the high levels of potassium humate. The antioxidant activity of tomato fruits was also improved as a result of fertilization with potassium humate.

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1. INTRODUCTION

Tomato (*Solanum Lycopersicum)* is ranks as the second most important vegetable crop after potato in the world. (**Cherono and Workneh, 2018, Mujtaba and Masud, 2014, and Pinheiro *et al*., 2015).** Egypt considers one of the top most tomato growing countries and ranks as the fifth largest producer country in the world accounting for more than 4.0% of the global tomato production. According to the latest statistical statement **(FAO STAT, 2019)**; the area cultivated with tomatoes in Egypt is around 450,000 acres with a production of 7,297,108 tons at the year 2017.

Tomato is one of the most popular vegetable that consumed as fresh or processed products and represents an important source of several valuable nutrients and non-nutrients components. Tomato is considered as part of healthy diet regime as they are low in fats and are without any harmful cholesterol. Nutrients like vitamins (A, C and E), minerals (K, Mn, Ca, Cu and Zn), and folate are present in significant concentrations in tomatoes **(Chaudhary *et al.,* 2018 and Tan *et al.*, 2010).**

Tomatoes also contain significant amounts of several phytochemicals that are identified as functional compounds such as vitamin C, carotenoids (lycopene, phytoene, and β-carotene), flavonoids and polyphenolic compounds **(Canene-Adams *et al*., 2005, Chaudhary *et al.*, 2018 and Tan *et al.*, 2010).** The functional compounds are healthy benefit compounds that reduce the risk of specific diseases or other health concerns. The functional compounds are defined as bioactive non- nutritive compounds that may provide desirable healthy benefits beyond basic nutrition to reduce the risk of major chronic diseases **(Liu 2004)**. High consumption of fruits and vegetable, including tomato and its derivatives, has great positive benefits on consumer health.

Tomatoes are processed into several products included; juice, sauce, paste, ketchup, soup, canned tomato, and dehydrated tomato as slices or powder **(Capanoglu *et al*., 2008, Beckles, 2012, Mujtaba and Masud, 2014, Pinheiro *et al*., 2015**). Among these products; tomato paste is one of the most important consumption products worldwide The quality characteristics of the processed tomato products are mainly judged by their good sensory attributes and high nutritional value **(Cañadas-López *et al.*, 2018 and Xaplanteris *et al.,* 2012**).

Agriculture and food processing sectors are closely connected industries in the food system structure. Agriculture is the industry that supplies the major raw materials with good quality for the food industry. The high consumption of tomatoes as fresh fruits and processed tomato products resulted in the development of agricultural operations with the aim of increasing production yield and improving quality characteristics.

Among the agricultural factors included; weather conditions, production systems, irrigation, cultivars, ripening stage and harvest time; fertilization is one of the most important factors that affect chemical composition quality in tomato production. The commercially available fertilizers supply the essential elements in a variety of chemical forms. Numerous mineral fertilizers have been developed to supplement soil nutrients and to meet the high requirements of crops. They are generally mineral salts, except for some organic chemicals such as urea, which are easily converted into salts (**Mani, 2017**). The advantages of the commercial fertilizers are their high water solubility, immediate availability to the plants, high concentration of nutrients, and the uniformity and accuracy with which specific amounts of available nutrients can be applied (**Mani, 2017, Sugiyanto, 2011, Vaneeckhaute *et al.*, 2013).**

Humic materials are composed of complicated organic mixtures which are linked together in a random manner, resulting in complex materials. Humic acid is a natural acidic organic polymer that can be extracted from humus found in soil, sediment, or aquatic environments **(Alvarez-Puebla *et al.*, 2005, Selim *et al.*, 2014, and Saiz-Jimenez, 1996).**

The fertilizer potassium humate (K-humate) is a natural material that can improve soil physical and chemical properties and nutrient dynamics (**Kumar *et al.*, 2013; Abd-All *et al.*, 2017**).

The present investigation is a first part of a research work on the agricultural and processing factors affecting the quality characteristics of processed tomato products specially juice and paste. This study concerned on the influence of fertilization of tomato crop with potassium humate on the quality characteristics of tomato fruits based on their chemical composition and functional compounds since review of literature revealed no studies had been carried in this field.

2. MATERIALS AND METHODS

Materials:

Tomato seeds:

Tomato seeds; variety ('SV 8320 TD' F1 Hybrid) produced by Seminis grow forward company were imported from the company of Fine Seeds International S.A.E.

Tomato fruits: The fully ripe tomato fruits collected from the different fertilization treatments were sorted to remove the infected fruits and carefully transferred to the laboratory at the department of Food Science and Technology, Faculty of Agriculture, Fayoum University for chemical and processing experiments.

Field Experiment

The imported tomato seeds were hand sown in individual 209-cell Styrofoam flats (2.6 cm × 2.6 cm × 7.0 cm; 25 cm^3 per inverted pyramid cell; Seedling, El-Amryya, Alexandria, Egypt) containing growth media consisting of 50% peat moss + 50% vermiculite (v/v) on July 15th, 2017 and July 16th, 2018. Thirty days later of seed sowing, each year, seedlings were transplanted into the field on rows at in-row spacing of 50 cm. The experimental design used was a split-plot in randomized complete blocks with three replications. Potassium humate levels (0, 25, 50 and 75 kg/fed)

were randomly distributed in the main plots. Separate potassium humate treatments were soil applied. All the other agronomic practices such as cultivation, irrigation and pests control that recommended in the commercial production of tomato according to Market-Led Agrarian Reform, MLAR, were performed whenever it was necessary as**.** Tomato fruits were harvested after 120 days

Analytics Methods Chemical Composition:

Total solids, total soluble solids (TSS), titratable acidity, sugars, protein, fat and ash contents were determined according to **A.O.A.C. (2012)**. The pH value was measured using digital pH meter (Adwa AD 1030) according to the method of **Pearson (1976).**

Functional Compounds:

Vitamin C (ascorbic acid) was determined using 2, 6 Dichlorophenol indo phenol method as described in Association of Vitamins. **Rai, and KC, (2007).** The dye was standardized by a standard solution of ascorbic acid.

β- Carotene was determined according to the procedures described by **Lichtentaler and Wellburn (1985).**

Lycopene was determined spectrophotometrically by extraction with hexane/ethanol/acetone and absorbance measurement at 503 nm as described by **Gordon and Diane (2007) and Godwin, et al., (2015).**

Total flavonoids were determined using the method of **Ordonez *et al.*, (2006).**

Total Phenolic Compounds were quantified using the colorimetric method of Folin–Ciocalteau reagent as described by **Singleton and Rossi (1965).**

Antioxidant activity was assessed by radical scavenging ability using stable DPPH radical as described by **Akowuah *et al.*, (2005).**

3. RESULTS AND DISCUSSION

Chemical Composition of Tomato Fruits:

The nutritional value of tomato is essentially determined by its chemical composition. The ripe tomato fruits of the variety 8320 were chemically analyzed for the chemical composition and the results obtained are given in Table (1).

Table 1. The Proximate Chemical Composition of Tomato Fruits; Variety ('SV 8320 TD' F1 Hybrid)

Compound	Proximate Chemical Composition*
Moisture (%)	94.00
Total Solids (%)	6.0
Total Soluble Solids, TSS (%)	5.2
Total Sugars (%)	3.41
Reduced Sugars (%)	2.96
Non-Reduced Sugars (%)	0.42
Total Titratable Acidity (%)	0.60
pH Value	4.27
Protein (%)	0.30
Lipid (%)	0.70
Ash (%)	0.55

*****_On wet weight basis._

Chemical analysis of tomato fruits (unfertilized control sample) showed that total solids and total soluble solids (TSS) were 6.0 and 5.2%, respectively. Soluble solids in tomato fruits are mainly composed of sugars and organic acids as well as some polysaccharides such as pectin. The total sugars, reducing sugars and non-reducing sugars of tomato fruits were determined by 3.41, 2.96 and 0.42%, respectively. These data showed that total sugars represent about 88% of the TSS. It has been reported that sugars content of tomato accounts for 50-75% of total solids of the fruit **(Zhao et al., 2016, Bastías *et al.*, 2011 and Alsina *et al.*,**

2015).

The results also showed that total acidity and pH value of tomato fruits were 0.60% was 4.27, respectively. The total acidity is primarily caused by citric acid content of the fruits and the optimum pH value for ripe tomatoes has been reported to be around 4.25 (**Monti, 1980, Anthon *et al.*, 2011).** Protein, lipids and ash contents of tomato fruit were 0.30, 0.70 and 0.55%, respectively. In general, chemical composition of fruits and vegetable depends on several factors included; cultivation area, environmental and climate conditions, agricultural treatments, fruit variety, maturity at harvest (**Anthon *et al.*, 2011, Abushita et al., 2000; Thompson et al., 2000, Giovanelli et al., 1999, Davies et al., 1981**, **Monti, 1980 and Hobson, 1981).**

Functional Compounds of Tomato Fruits:

Tomato fruits were analyzed for their content of functional compounds and results obtained are shown in Table (2).

Table 2. Functional Compounds of Tomato Fruits.

Compound	Concentration*
Vitamin C (mg/100g)	26.60
Total carotenoids (mg/100 g)	37.70
Lycopene (mg/100 g)	31.82
β- carotene (mg/100 g)	1.88
Total Flavonoids (mg/g)	18.74
Total Phenolic Compounds (mg GAE/g)	1.30

*****_On wet weight basis._

Vitamin C (L-ascorbic acid) is one of the most important antioxidants in fruits and vegetables, exerting a crucial role in the detoxification of reactive oxygen species generated in human body. Data shown in Table (2) indicated that vitamin C content was determined by 26.60 mg/100g of tomato fruit. It has been reported that red tomatoes contained approximately 14 - 19 mg of vitamin C per 100g depending on the cultivar, growing conditions and ripening stage **(Olivera *et al.*, 2013; Ilahy, 2013 Nunes, 2008, Suarez, 2008 and Abushita et al., 2000)**. Carotenoids are well known as natural antioxidants involved in reducing the risk of development of several types of diseases such as diabetes, gastrointestinal and cardiovascular diseases. (**Preedy and Watson, 2008, Rao and Rao, 2007 and Hyman et al., 2004)**. Data given in Table (2) showed that total carotenoids content of tomato fruit variety "SV 8320" was 37.7 mg / 100g of the fruit. Lycopene is the major fraction of total carotenoids followed by β- carotene (Provitamin A). The results showed that lycopene was determined by 31.82 mg/100 g while β-carotene was only 1.88 mg/100gm of tomato fruit. Depending on the genotype, environmental conditions and other factors, **Paolo , et al. (2018)** stated that lycopene concentrations in ripe tomato fruits of standard cultivars ranged from 7.8 to 18.1 mg/100gm, while β-carotene, (the second main carotenoid present in tomato), was about 1.2 mg/100g of the fruit.

Tomato also contains considerable concentrations of flavonoids and phenolic compounds which were determined by 18.74 and 1.30 mg/g of the fruit, respectively. The flavonoids and phenolic compounds comprise a large and diverse group of compounds in tomato are regarded as potentially useful compounds, with implications for inflammation, cardiovascular diseases and cancer. (**Bovy et al., 2007 and Slimestad and Verheul, 2009).**

Tomato components of vitamins C, lycopene, β- carotene, flavonoids and phenolic substances, are mainly responsible for the antioxidant capacity of raw tomatoes. The antioxidant activity of tomato fruits under investigation was assayed and the results were expressed as Ec50 (Inhibition %) and Anti Radical Power, (ARP = 1/Ec50). The results shown in Table (3) indicated that Ec 50 (Inhibition %) was 0.219% and the value of Anti Radical Power was 4.566.

Table 3. Antioxidant Activity of Tomato Fruits

Particular	Value
Ec 50 (Inhibition %)	0.219
Antiradical Power (ARP)**	4.566

ARP** *= 1/Ec50*

Effect of Fertilization with Potassium Humate on Chemical Composition of Tomato Fruits

Fertilization is especially important for tomatoes that will be used for paste production. Proximate chemical composition of tomato fruits as affected by the fertilization with potassium humate at the levels of 25, 50 and 75 kg/Fed is given in Table (5). The total solids of tomato fruits increased from 6.00 % for the control untreated sample to 6.07, 6.19 and 6.21% for samples fertilized with 25, 50 and 75 kg/Fed of potassium humate, respectively and TSS for the same samples were 5.30, 5.32 and 5.44%, respectively, while TSS of the control was 5.20%. The increases in (TS) and (TSS) were estimated by (2.3 – 4.6%) and (3.1 – 3.5%), respectively in samples treated with 50 and 75 kg/Fed, respectively in comparison with unfertilized control sample. These improvements in TS and TSS are very important in selecting tomato fruits for processing.

Also, it was found that total sugars contents for samples fertilized with 0, 25, 50 and 75 kg/ Fed of potassium humate were respectively, 3.41, 3.43, 3.51 and 3.54%. Also, ash content of fertilized samples increased from 0.51% in the control sample to 0.54, 0.60 and 0.66% in samples treated with 25, 50 and 75 kg/Fed of potassium humate, respectively.

The total titratable acidity of the control sample was 0.60% while it was 0.66 - 0.7 % for the fertilized samples. Values of pH almost showed no changes due to fertilization since the values were 4.24 - 4.28. The fertilization with potassium humate also showed no effects on tomato contents of protein and lipids. **(Karakurt *et. al.*, (2009), Kazemi (2013)** and **Kazemi (2014).**

Table 4. Effect of Fertilization of Tomato Crop with Different Levels of Potassium Humate on Chemical Composition of Tomato Fruits.

Compound*	Level of potassium humate (kg/Fed) 0	25	50	75
Moisture (%)	94.00	94.03	93.81	93.79
Total Solids (%)	6.0	6.07	6.19	6.21
Total Soluble Solids (%)	5.2	5.30	5.32	5.44
Total Sugars (%)	3.41	3.43	3.51	3.54
Reduced Sugars (%)	2.96	2.98	3.01	3.07
Non Reduced Sugars (%)	0.42	0.59	0.60	0.64
Total Titratable Acidity (%)	0.60	0.66	0.60	0.64
pH	4.27	4.28	4.24	4.25
Protein (%)	0.30	0.35	0.33	0.35
Lipid (%)	0.70	0.69	0.68	0.71
Ash (%)	0.51	0.54	0.60	0.66

******On wet weight basis.*

Effect of Fertilization with Potassium Humate on Functional Compounds of Tomato ruits.

Tomato fruits obtained from the crop fertilized with different levels of potassium humate were analyzed for their contents of vitamin C, total carotenoids, lycopene, β- carotene, total flavonoids and total phenolic compounds and results obtained are illustrated in Figures (1 – 6).

Vitamin C

Figure (1) indicated that vitamin C content increased as the level of potassium humate increased. Data showed that vitamin C from 26.60 mg/100g in control sample up to 27.53, 28.92 and 30.48 mg/100g in samples fertilized with 25, 50 and 75 kg/Fed, respectively. The maximum increase in vitamin C estimated by about 15% was found in sample treated with the higher level (75 kg/Fed) of potassium humate fertilizer. Similarly, **Afzal, et al. (2015)** reported that potassium nutrition significantly improved ascorbic acid contents of both tomato cultivars particularly at the high levels of potassium.

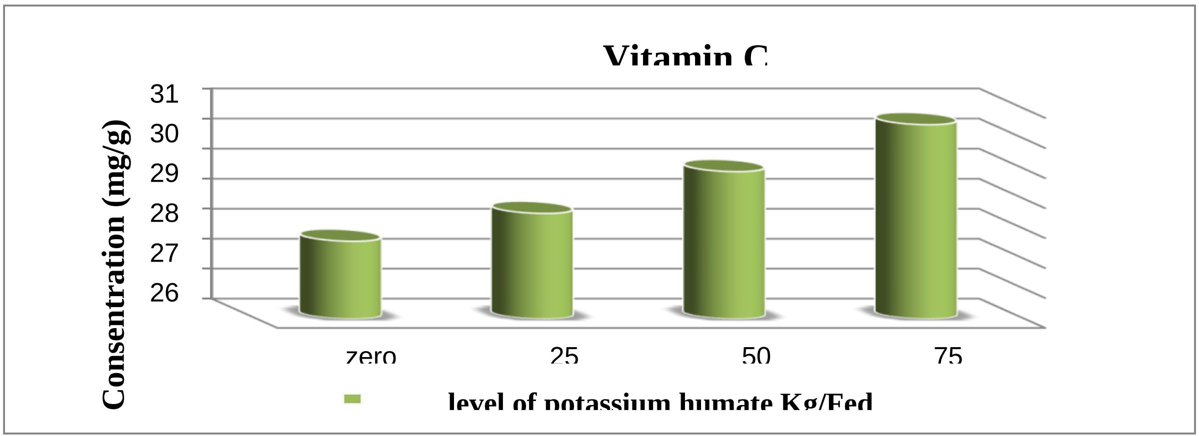

Figure 1. Vitamin C content of Tomato Fruits as Affected With Different of Potassium Humate

Total Carotenoids, Lycopene and β- Carotene

The total carotenoids also showed noticeable increases in tomato fruits due to the fertilization with potassium humate. Data showed that total carotenoids content of control unfertilized sample was 37.70 mg/100g of the fruit while samples fertilized with 25, 50 and 75 kg /Fed of potassium humate contained 38.32, 39.53 and 40.09 mg/100g of fruit, respectively. Moreover, lycopene the most important carotenoid fraction showed more considerable improvement due to fertilization with potassium humate. The greatest increase estimated by about 13% was found in sample fertilized with75 kg/Fed of potassium humate (32.99/100g) in comparison with the amount of 29.22 mg/100g in unfertilized sample. β-carotene contents were determined by 1.88, 1.92, 1.94 and 2.00 gm/100g of fruit samples treated with 0, 25, 50 and 75 kg/Fed, respectively. Positive correlations were found between tomato fruit contents of lycopene, β- carotene and the level of potassium fertilizer **(Afzal et al., 2015)**.

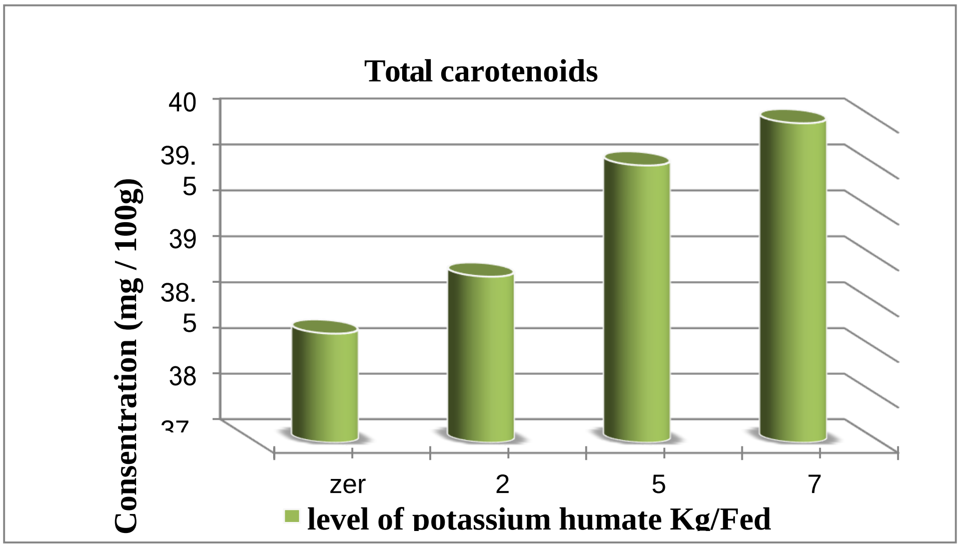

Figure 2. Total Carotenoids Content of Tomato Fruits as Affected with Different Levels of Potassium Humate.

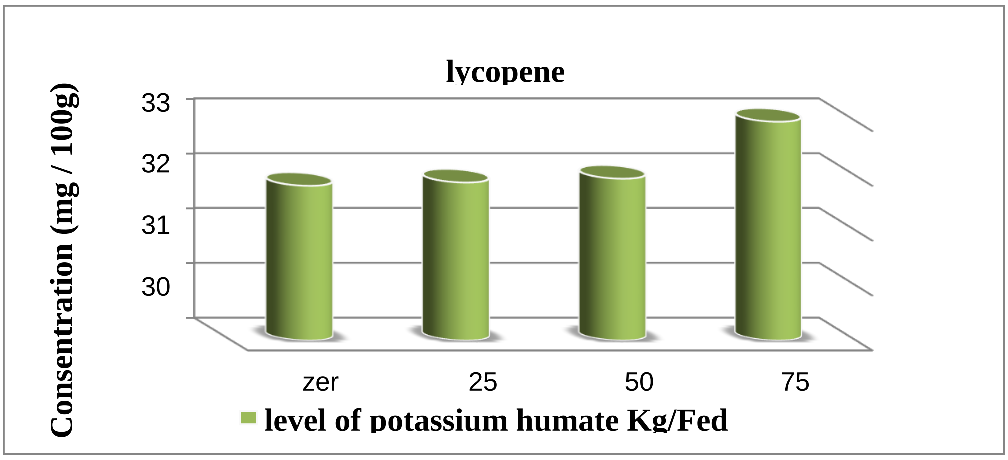

Figure 3. Lycopene content of tomato fruits as affected with different levels of potassium

humate.

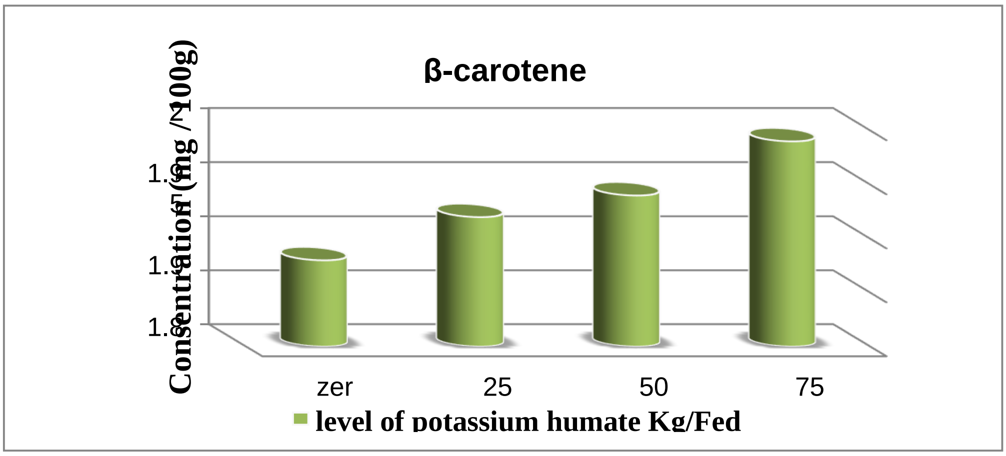

Figure 4. β- Carotene Content of Tomato Fruits as Affected with Different of Potassium Humate.

Total Flavonoids.

The fertilization of tomato crop also resulted in increasing the total flavonoids. The results illustrated in Figure (5) showed that samples fertilized with 25, 50 and 75 kg/ha of potassium humate contained 18.94, 19.00 and 20.35 mg/g of fruit, respectively with increases estimated by 1.07, 3.74 and 8.59%, respectively comparing with the control sample which contained 18.74 mg/g.

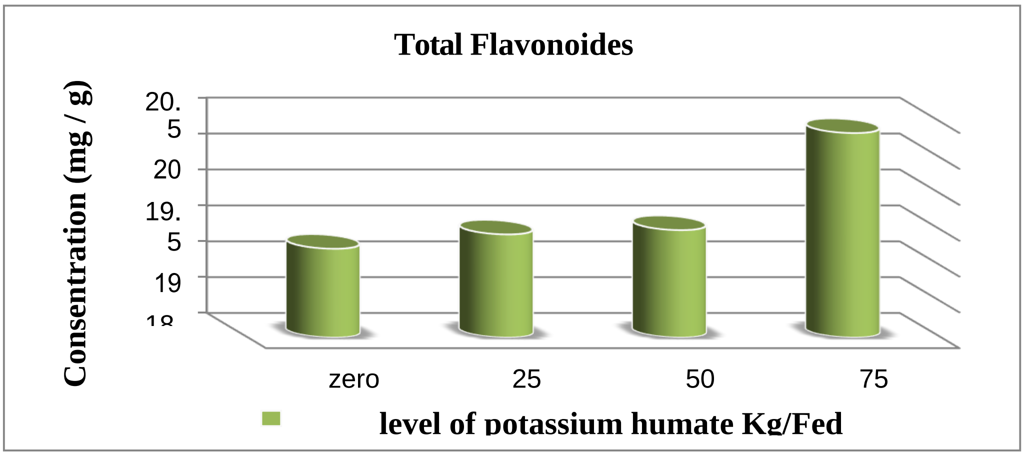

Figure 5.Total flavonoids of tomato fruits as affected with different of potassium humate.

Total Phenolic Compounds:

Figure (6) illustrates the total phenolic compounds of tomato fruits as affected with fertilization with potassium humate. It was observed that phenolic compounds increased as the level of potassium increased. Data showed that total phenolic compounds were 1.25, 1.30 and 1.45 mg/g of fruit samples treated with 25, 50 and 75 kg/ha of potassium humate while control sample contained 1.29 mg/g of the fruit. The increases found in samples treated with 50 and 75 kg/ha of potassium humate were estimated by 2.78 and 9.87%, respectively.

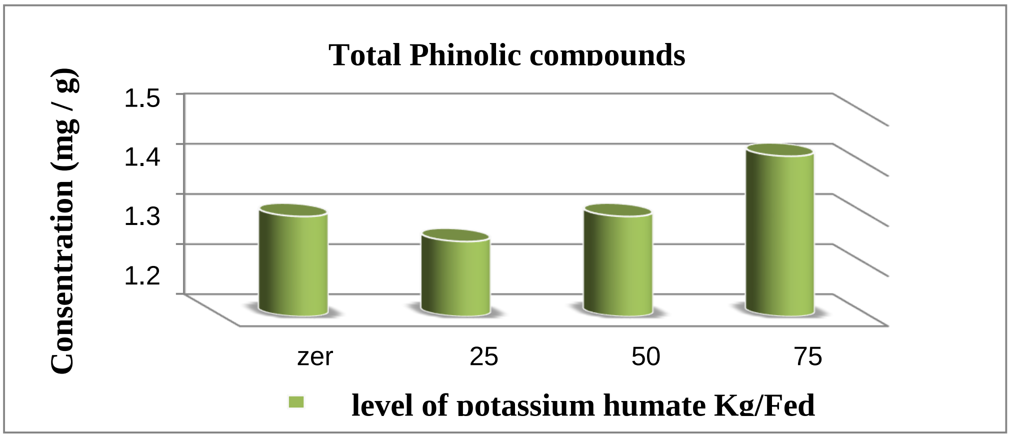

Figure 6. Total Phenolic Compounds of Tomato Fruits as Affected with Different of Potassium Humate.

Antioxidant Activity:

Based on the increases found in tomato contents of the different functional compounds which are characterized by antioxidant activities due to fertilization with potassium humate, consequently, the antioxidant activity of the fruits was improved (Figure 7).

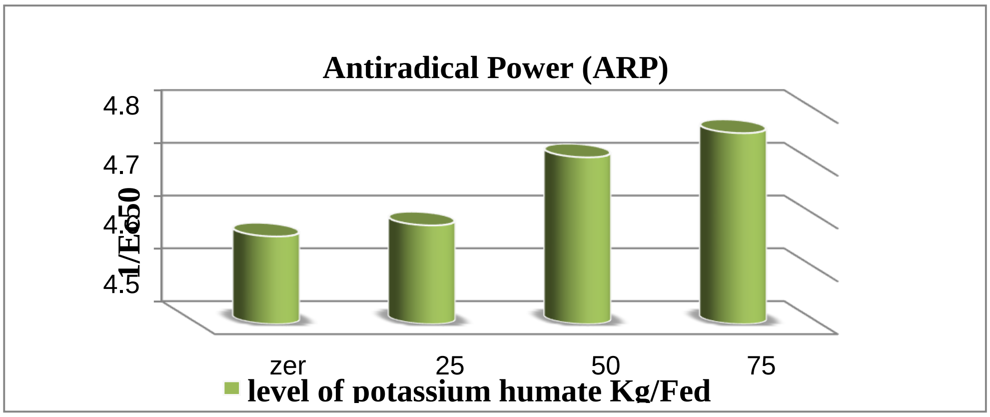

Figure 7. Antioxidant Activity of Tomato Fruits as Affected with Different Levels of Potassium Humate.

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الملخص العربى

صفات جودة ثمار الطماطم للتصنيع على اساس التركيب الكيميائى و المركبات الوظيفية بتأثير معدل التسميد بهيومات البوتاسيوم

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هذا البحث يعتبر أحد أجزاء دراسة بحثية عن العوامل الزراعية و التصنيعية المؤثرة فى صفات جودة منتجات الطماطم المصنعة خاصة العصير و العجينة. و فى هذا البحث تم التركيز على دراسة تأثير معدل تسميد محصول الطماطم بهيومات البوتاسيوم على صفات جودة الثمار من حيث التركيب الكيميائى و المركبات الوظيفية. أجريت تجارب مزرعية على صنف الطماطم (SV 8320 TD’ F1 Hybrid) الذى تم معاملته بهيومات البوتاسيم بتركيزات 25 ، 50 و 75 كج/ فدان. اوضحت نتائج التحليل الكيميائى لثمار الطماطم التامة النضج ان التسميد بهيومات البوتاسيوم أدى الى تحسين مكونات الثمار من المواد الصلبة الكلية – المواد الصلبة الذائبة الكلية – السكريات و الرماد بينما الحموضة الكلية – الـ pH – البروتين و الدهن لم تتغير قيمها. أيضا أثبتت النتائج أن التسميد ادى الى تحسين أكثر وضوحا فى مكونات ثمار الطماطم من المركبات الوظيفية المختلفة. حيث أوضحت النتائج حدوث زيادة كبيرة فى محتوى الثمار من فيتامين ج (vitamin C) - الكاروتينيدات الكلية – الليكوبين – البيتا كاروتين – الفالفونات و المركبات الفينولية. هذه الزيادات كانت اكثر وضوحا فى العينات المسمدة بتركيزات مرتفعة من هيومات البوتاسيوم. و نتيجة للتأثير المحسن للتسميد على هذ المركبات الوظيفية فقد ادى التسميد بهيومات البوتاسيوم الى تحسين النشاط المضاد لالكسدة لثمار الطماطم.