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DIFFERENCES IN SOME PROPERTIES OF COMMERCIAL AND HOMEMADE TOMATO PASTES

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ABSTRACT

This study is designed to indicate some properties and concentration of some heavy metals in four types of canned tomato paste product (TP) with two types of homemade (HM). The canned tomato paste was purchased from the local market in Sulaimani, Kurdistan-Iraq, during 2021-2022. The highest of pH, moisture %, and Lycopene mg/kg were obtained from HM1 (4.94, 77.6 %, 280.983 mg/kg), and the lowest were obtained from TP4 (2.84) for pH, TP2 (66.02 %) for moisture, and TP3 (105.248 mg/kg) for lycopene. Moreover, the maximum of Brix and T. sugar % were obtained from TP1 (28.9 and 3.733 %), and the minimum Brix was recorded from HM1 (18.30), minimum T. Sugar % (1.433 %) from HM2. In addition, the T. acidity % and T.S % ranged between (1.963 – 2.66 %), (22.4 – 33.2 %). The heavy metals in tomato paste were indicated by using (Inductive couple plasma optical spectrometry ICP). The results obtained from this study were compared to the FAO/WHO and CODIX, 2009 standard limit levels. The HM1 was recorded the highest concentration of Fe, Zn, Pb, Ni, Cu, and Cr (59.34, 79.76, 0.169, 9.913, 23.646, and 2.437 mg/kg), and the concentration of Fe, Zn, Ni, Cu, Mn, Cr were above the level limits. Also, the highest concentration of Mn, Cd, Se, As, and Sn ranged between (12.06 – 8.86 mg/kg), (0.89 – 0.046 mg/kg), (0.077 – 0.048 mg/kg), (0.0.96 – 0.011 mg/kg), and (0.132 – 0.085 mg/kg). These results indicated that tomato paste safe to consumption, thus recommended to find the best way to producing the tomato paste to decreasing the contamination by heavy metals.

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INTRODUCTION

Tomato (Solanum lycopersicum L.) is one of the most consumed agricultural products in the world because it has a wide variety of uses in the food industry, and it is essential for human nutrition due to its rich content of bioactive and aroma compounds tomatoes are considered a significant source of vitamins (vitamins C and E), carotenoids (lycopene), and phenolic compounds such as flavonoids, which provide phytonutrients to the human diet, are associated with the prevention of chronic degenerative diseases. Also, they provide a considerable amount of potassium, fiber, calcium, iron, and small amounts of magnesium, thiamine, riboflavin, and niacin (Luna-Guevara *et al*., 2014) .

Despite, tomato contains macro and micro minerals that up taking from the soil, fertilizer, irrigation water, erosion, and precipitation (Flat & Collector, 2015). Also, the concentration of heavy metals accumulated in tomato and transferred to the human through the tomato processing including tomato paste (Yenisoy-Karakaş, 2012). Thus, the heavy metals hazardous to the human by consumption of the contaminated food according the content level of the metals (Debastiani *et al*., 2021). For instance, Lead is essential for the human but very hazardous for the kidney and nervous system, and the excessively of copper and zinc also affected on the anural, kidney, and nephritis (Ndem & Usen, 2018) .

Many factors affect the chemical composition of tomatoes; for example, genetics (cultivar variety), environment (light, temperature, mineral nutrition, and air composition), and cultural practices (ripening stage at harvest and irrigation system) (Srivalli *et al*., 2016). The most important quality standards for tomatoes are red color, firm, juicy texture, and good flavor. These properties are manifested in total soluble solids (TSS), juice content, acidity, and vitamin C content (Tiwari and Shrestha, 2015) .

Tomatoes can be consumed fresh or processed to canned whole peeled tomatoes. They can also be processed into juices with different concentrations, puree, or paste (Sobowale, 2012). The largest part of the tomato crop is processed into tomato paste, which is considered one of the main ingredients in many products such as soups, sauces, and ketchup (Landbouwcatalogus, 1995) .

Tomato paste can be produced traditionally at home. In this process, the washed fresh tomatoes are blended, filtered, and evaporated in a boiler under atmospheric conditions until it reaches a desired consistency and color. Most of the produced tomato paste using the previous method is less concentrated than industrial tomato paste. So, to evaporate the excess humidity from tomato paste is obtained after sunlight exposure (Devseren *et al*., 2021). On the other hand, the industrial production of tomato paste includes washing, crushing, sorting, passing through a pulper and fine screen, evaporation, boxing, pasteurization, and cooling steps. These applications prevent the activity of microorganisms and enzymes, decrease moisture content, and concentrate the product (Kelebek *et al*., 2018) .

In the commercial production of tomato paste, two different methods can be used: hot break and cold break (Kelebek *et al*., 2018). In the hot break process, the crushed tomatoes are heated to at least 90 °C, by which the pectolytic enzymes present in the tomatoes are inactivated. In the cold break process, the crushed tomatoes are heated to 40-60 °C (Landbouwcatalogus, 1995). The paste produced by the hot break has a poor color compared to cold break. However, the paste produced by the hot break is preferred in the production of ketchup, sauce, and other paste product (Kelebek *et al*., 2018).

Processed and cooked tomatoes do not lose their health benefits. For example, in cooked and processed tomatoes, lycopene is more readily absorbed than in fresh tomatoes (Shatta, 2017). Furthermore, tomato by-products are rich in numerous compounds for instance antioxidant and colorant characteristic as carotenes (lycopene, β-carotene, phytoene, phytofluene, and lutein), phenolic compounds (phenolic acids and flavonoids), vitamins (ascorbic acid and vitamin A) and glycoalkaloids (tomatine) (Domínguez *et al*., 2020). The objective of this study is to compare the physicochemical properties of homemade tomato paste with four types of commercial tomato pastes.

MATERIALS AND METHODS

Sampling

Samples of tomato paste of four different tomato paste-producing companies were purchased from local markets, where people directly purchased and consumed. Two other samples of tomato paste were homemade (traditional way) in November 2020, and then transported to the lab for analysis.

Preparation of homemade tomato paste

Different sizes of fresh tomatoes were washed. Then, they are cut into two parts, and inedible parts were removed. Then, they were transferred into an electrical blender to obtain tomato juice. The tomato juice was strained using a filter and divided into two parts. The first part of tomato juice was spread on a tray, and then it was exposed to the sun for 3 days to be concentrated with continuous stirring to avoid burning by the sun heat. The Brix of the tomato juice was measured using hand refractometer continually until the brix reached (18-19), and the final product of tomato juice was (2 kg) (Ordóñez-Santos *et al*., 2008). The second part was concentrated using a stove with continuous stirring to avoid burning until the brix reached (19-18).

Physicochemical analysis

For all tomato paste samples, the following tests were conducted starting with percentage of titratable acidity (TA) using direct titration with (0.1 N NaOH), and using phenolphthalein as an indicator, and continued until the color of the diluted tomato paste turn pink (Mulindwa, & Nkedi-Kizza, 2018). The pH of the tomato paste was determined by a pH meter (JORGE *et al*., 2017). Total soluble solid (ºBrix) of tomato paste was determined by hand refractometer at room temperature (Chippy AK, 2021). Also, the moisture content (wet basis) was determined using an oven drier (Ashebir, & Gretzmacher, 2009).

Determination of lycopene

Lycopene was extracted using two parts of hexane and one part of ethanol with acetone (v/v) mixture with slight modifications. For analyzing lycopene in tomato paste, samples were subjected into the following steps:

1. tomato paste samples (0.001 g) were dissolved in (1 ml) of distilled water, and the vortexed samples were place in a water bath at 30˚C for 1 hour. Then, 8.0 ml of hexane: ethanol: acetone (2:1:1) were added.
2. tomato paste samples were capped, and vortexed directly, then incubated out from the bright light .
3. the tomato pastes samples allowed to stand for 10 minutes until the bubbles disappears, and the paste separated, and finally absorbance of samples was determined at 503 nm by spectrophotometer (State model).
4. The lycopene levels were calculated according to the following equation reported by (Suwanaruang, 2016).

$$Lycopene\left(\frac{mg}{kg}\right) = Abs\ at\ 503nm \times 537 \times 8 \times \frac{0.55}{0.10} \times 172\ or, Abs\ at 503nm \times 137.4$$

Mineral analysis

The minerals contents were determined in samples, by followed the procedure of (Rasheed, & Hama, 2020), by using the nitric-perchloric method for digestion. The minerals were measured using an inductively coupled plasma mass spectrophotometer (ICP-MS) (Thermo Fisher Scientific iCAPQ, Bremen, Germany) at the laboratory of environmental analyses from the division of agriculture and environmental science, at the University of Nottingham, United Kingdom. The analysis was conducted in triplicate and the results were converted to (mg/kg).

Determination of total sugar

The total sugar content was determined by spectrophotometer according to (Ekşi & Özhamamcı, 2009). About (1 gm) of tomato paste was mixed with (1 ml) of (5 %) aqueous solution of phenol, and (18 ml) of distilled water and the mixture was shaken. After that (5 ml) of concentrated sulfuric acid (97 %) was added. It was placed in (60 °C) water bath for (30 minutes), filtered using filter paper, and then (1 ml) of solution was placed in cuvette tube and transferred to UV-visible spectrophotometer at (490 nm).

Determination of Total Phenol

Spectrophotometer was used for the determination of total phenol in the tomato paste. Five milliliters of tomato paste were taken, then dissolved in (15 ml) of (95 %) ethyl alcohol and HCl (1.5 N) percentage (15:85), then the samples were stored in the refrigerator for 24 hours. After that, the samples were filtered using Whitman filter paper. The determination of total phenol was measured by UV-visible spectrophotometer at (280 nm) (Ranganna S., 1986).

Statistical analysis

The data from the results represent means of three replications for each used parameters, and the data were analyzed by using XLSTAT software under windows program (version, 7.5.2). Also, one way (ANOVA) with Duncan's multiple range tests were applied at ($p<0.05$) to establish multiple comparisons.

RESULTS & DISCUSSION:

Physicochemical properties

The data in Table (1) summarized the numerous properties of different tomato pastes. The pH value of different tomato pastes showed that unsignificant differences, and pH ranged between (3.84 – 4.94). Moreover, tomato considered as acid foods (Srivalli *et al*., 2016), due to the optimum range of tomato paste pH is about (3.8 – 4.3) (Sobowale *et al*., 2012). Also, the lower pH of tomato paste prevents the activity of microorganisms, that cause spoilage of tomato paste, the pH level in this study agrees with most studies conducted on tomato paste, and they were recorded (4.87 – 5.30) (Sobowale *et al*., 2012), (3.9 – 4.14) (Srivalli *et al*., 2016), (4.0 -4.1) (Luna-Guevara *et al*., 2014). The correlation of pH with other physicochemical properties positively correlation with percentage total acidity, and the oBrix Table (2). Also, pH is negatively correlated with total sugar and lycopene.

Despite, the brixcontent ranged between (18.20 to 28.90), the brix of the tomato juice of homemade tomato paste measured by hand refractometer continually until the oBrix became (18-19), as well as the homemade tomato paste obrix recorded the lowest value compared to the commercial tomato paste. In addition, the brix value was statically different between (HM1, and HM2) with commercial tomato pastes.

Table (1): the physicochemical properties of different tomato pastes.

Samples	pH	oBrix	Moisture %	T.S %	Lycopene mg/kg	Total sugar %	Total acidity %
HM1	4.94a	18.20b	77.60a	22.40c	280.983a	2.053ab	2.120a
HM2	4.13a	18.40b	77.09a	22.91c	251.389b	1.433b	1.963a
TP1	4.88a	28.90a	66.05c	33.95a	224.237c	3.733a	2.120a
TP2	4.16a	28.80a	66.02c	33.98a	115.808d	2.284ab	2.160a
TP3	4.10a	27.60a	69.01b	30.99b	105.248f	1.848ab	2.600a
TP4	3.84a	27.50a	69.01b	30.99b	108.821e	2.111ab	2.660a

The results of obrix were obtained were agree with Sobowale *et al*., (2012) who recorded (25-26) in different tomato pastes. In addition, the obrix content was positively correlated with T.S (r2= 0.99), also positively correlated with total sugar and total acidity. As well as, it strongly, negatively correlated with moisture ((r2= -0.99), otherwise negatively correlated with lycopene.

Table (2): Shows the Person's Correlation Coefficient matrix of some properties in different tomato pastes.

Parameters	pH	Brix	Moisture %	T.S %	Lycopene mg/kg	Total sugar %	Total acidity %
pH	1						
Brix	0.257	1					
Moisture %	-0.167	-0.990**	1				
T.S %	0.167	0.990**	-1**	1			
Lycopene mg/kg	-0.464*	-0.778*	0.712*	-0.712*	1		
Total sugar %	-0.247	0.556*	-0.617*	0.617*	0.080	1	
Total acidity %	0.562*	0.525*	-0.398	0.398	-0.775*	-0.118	1

* Significant correlation at level (0.05), ** Significant correlation at level (0.01).

The percentage of moisture and total solid (T.S) in this study showed significant differences between various tomato pastes. The percentage of moisture in tomato paste is between (77.60 – 66.02 %). Also, the lowest T.S were obtained with homemade tomato paste (22.40, 22.91 %), respectively. Thus, the other T.S in commercial tomato paste is in range (30.99 % to 33.98 %). Likewise, the percentage of moisture and the T.S are strongly, negatively correlated to them (r2= -1) due to the increase in the moisture from tomato paste hence to decreased the T.S in tomato paste, and negatively correlated with total sugar and total acidity. And the moisture positively correlated with lycopene. Moreover, the T.S were positive correlation with total sugar and total acidity, as well as negatively correlation between lycopene.

The lycopene (mg/kg) in tomato paste is more important to human health because of protection against some different type of cancer, as well as it is participated in the serum of human body (Olajire, Ibrahim, Adelowo-Imeokparia, & Abdul-Hammed, 2007). In addition, the maximum lycopene was obtained from this study (280.983 mg/kg) from HM1, and the minimum lycopene was obtained from TP3 (105.248 mg/kg). Moreover, the value of lycopene shows significant differences between various type of tomato pastes . These results are similar to those reported by (Olajire *et al*., 2007), as well as (Alda *et al*., 2009). The lycopene results negatively correlated with total acidity, T.S, pH, and oBrix, as well as positively correlated with moisture content**.**

Total sugar content in various tomato pastes showed significant differences at (p< 0.05). However, the total sugar values ranged between (1.433 - 3.733 %). Thus, the percentage of total sugar is significantly in a positive correlation with oBrix, and T.S, while significantly in a negative correlation with pH and moisture. Furthermore, the value is agreed with those reported by (Sobowale *et al*., 2012), as well as (Lin *et al*., 2005), and (Vitalis *et al*., 2020).

The total acidity in tomato pastes showed that no significant differences, and in range (1.969 – 2.66 %). Also, the total acidity positively correlated with pH, T.S, and oBrix, and is significantly in a negative correlation with moisture and lycopene.

Heavy metal content

In last years, contamination of foods by heavy metals has been increased, and that is cause some cancer disease in North part of Iraq (Kurdistan region) (Al-Mezori & Hawrami, 2014; Marouf, 2018). However, heavy metals at a low level in human body are essential from most of biochemical and physiological function, while it is hazardous and non-biodegradable in nature, and they also contaminated the food and environment (Flat and Collector, 2015; Uroko *et al*., 2019). In addition, most of the heavy metals participate in human body, especially blood, bone, skin, muscles, etc. (Nadir, Al-Zubaidy, Al-Rawi, & Ibrahim, 2020). However, the exposure of heavy metals and accumulated in human body cause some diseases (Flat & Collector, 2015).

Heavy metals recorded in commercial and homemade of tomato paste are appeared in Table (3). From previous table, the significant differences between different tomato pastes at (P≤0.05). HM1 product recorded the highest levels for six metals: Fe (59.34 mg/kg), Zn (79.799 mg/kg), Pb (0.169 mg/kg), Ni (9.913 mg/kg), Cu (23.645 mg/kg), and Cr (2.437 mg/kg) but the lowest level for As (0.011 mg/kg). By contrast, PT2 brand recorded the highest values for Mn (13.06 mg/kg), As (0.096 mg/kg), and Sn (0.132 mg/kg). The maximum concentration estimated for Cd (0.189 mg/kg) obtained from HM2 product whereas the maximum concentration of Se (0.077 mg/kg) was obtained in PT1 product. In addition, PT3 brand of tomato paste recorded the minimum concentration for five metals: Fe (49.97 mg/kg), Se (0.048 mg/kg), Ni (0.351 mg/kg), Cr (0.243 mg/kg), and Sn (0.1 mg/kg). Conversely, PT1 product recorded the minimum concentration for Cd (0.046 mg/kg), Mn (8.086 mg/kg), and Zn (14.811 mg/kg). Also, the lowest level of Pb (0.022 mg/kg) and Se (0.048 mg/kg) were obtained from PT4 product.

The concentration levels of Fe, Mn, and Ni, recorded in this experiment are above the tolerable limit intake for all types of tomato paste. The concentration levels of Cd, Se, As, Cr, Sn, Pb, and Cu were recorded from tomato paste are below limits levels. Besides, levels of Zn in HM1 and HM2 are above the tolerable limit intake.

Table (3): represents the heavy metal content in different tomato pastes (mg/kg).

Samples	Fe	Cd	Mn	Zn	Pb	Se	Ni	As	Cu	Cr	Sn
HM1	59.340[a]	0.149[b]	9.063[b]	79.766[a]	0.169[a]	0.064[a]	9.913[a]	0.011[b]	23.645[a]	2.437[a]	0.092[c]

HM2	54.797^{b}	0.189^{a}	8.577^{b}	75.290^{b}	0.154^{a}	0.076^{a}	8.176^{a}	0.016^{b}	21.729^{a}	2.175^{a}	0.085^{c}
TP1	58.613^{ab}	0.046^{f}	8.086^{b}	14.811^{d}	0.025^{cd}	0.077^{a}	0.401^{b}	0.029^{b}	5.850^{d}	0.543^{bc}	0.123^{a}
TP2	60.040^{a}	0.083^{e}	13.060^{a}	19.365^{c}	0.069^{b}	0.073^{a}	2.384^{b}	0.096^{a}	8.690^{c}	0.429^{bc}	0.132^{a}
TP3	49.970^{c}	0.135^{c}	8.960^{b}	15.397^{d}	0.040^{c}	0.048^{b}	0.351^{b}	0.026^{b}	5.809^{d}	0.243^{c}	0.100^{bc}
TP4	57.430^{ab}	0.095^{d}	9.210^{b}	15.666^{d}	0.022^{d}	0.048^{b}	0.530^{b}	0.015^{b}	6.103^{c}	0.283^{c}	0.108^{b}
DI*	40	0.5	5.0	30	1.0	0.1	0.2	0.1	3.0	2.5	250

*DI= daily intake for canned food by (World Health Organization, 1985; CODEX, 2009; Devseren *et al*., 2021; FAO and WHO, 2001).

The result of Fe obtained from this study is higher than standard limits of FAO/WHO, while it is related to the tomato used to produce the paste, growing technic of tomato, and the process of tomato paste (Hobson and Grierson, 1993; Flat and Collector, 2015). And, the results disagree with Uroko *et al*., (2019) who recorded (3.176 – 7.651 mg/kg) for Fe and who determined the content of some heavy metals in tomato paste in Nigeria. Also, Fe levels recorded in this study agree with Boadi *et al*., (2012) who dedicated some heavy metals in canned tomato paste in Ghana. However, results of Pb agree with recorded date by (Boadi *et al*., 2012), as well as the level of Pb, Cd, and As agree with Hadiani *et al*., (2014) who worked on some Iranian canned tomato paste and disagree with those researchers recorded of tomato paste such as (Boadi *et al*., 2012; E Onwuka *et al*., 2019).

Despite, the range of Sn, Zn concentration in tomato paste were lower than found by (David, Ştefãnuţ, Balcu, & Berbentea, 2008). The concentration of Ni, Cu, and Cr from the HM1 and HM2 much higher compared to other canned tomato paste, which may relate to the technical of production and the equipment used in the product processes. Makki and Ziarati, (2014) obtained (2.23 -10.99 mg/kg) of Cu from the Iranian canned tomato paste. And Debastiani *et al*., (2021) reported that the concentration of Cu and Mn ranged between (0.4 -1.7 mg/kg) for Cu, and (0.6 – 1.8 mg/kg) for Mn. Also, the concentration of Cu, Mn, Cr, and Ni were recorded by Ndem and Usen, (2018) in canned tomato paste, and they are lower than those results obtained in this study. In addition, the range of Pb, Se, and As concentration in tomato paste were lower than that found by Yenisoy-Karakaş, (2012) who recorded (1.07 – 4.53 mg/kg) for Pb, (0.02 -0.04 mg/kg) for Se, and (0.25 – 0.29 mg/kg) for As.

Besides, some of the heavy metals under limitation levels directly affect to the human health, such as Zn, Fe, Mn, Pb, Cu, Se, As, Ni, and Cr (Yenisoy-Karakaş, 2012; Ndem and Usen, 2018; Leite *et al*., 2022). Moreover, Cu and Mn are essential for human, while Pb is essential for human, but exist of Pb in human body is toxic to the nervous system and kidney (Leite *et al*., 2022). In addition, human body needs Ni, Cr, and Cu few concentrations. Otherwise, human body needs Zn to all metabolic processes, and some of the heavy metals accumulated in a human body cause some disease (Ahmad Bhat, Hassan and Majid, 2019; Leite *et al*., 2022). The sources of canned food contamination by heavy metals associated with a wide range of sources such as those in field area of crops (chemical fertilizers, pesticides, fungicides application, harvested equipment, and irrigation) and canned process because most of equipment consist of metals, industrial, care, dust, and diesel generator (Flat & Collector, 2015).

The person’s correlation matrix of heavy metals in tomato paste are presented in Table (4) The results of the study show the very good correlation coefficient between (Mn and As) (r= 0.92), Zn with Pb, Ni, Cu, and Cr (r=0.977, 0.988, 0.99, and 90.964), as well as Pb has a good correlation coefficient with Ni (r=0.991), Cu (r=0.980), and Cr (r=0.964). In addition, Ni strongly correlated with Cu and Cr (r= 0.997 and 0.982), while Cu is strongly in a positive correlation with Cr (r= 0.989). However, Cd was showed negative correlation with Sn (r= - 0.903), as well as Se was showed no correlation with other heavy metals.

Table (4): shows the person's correlation coefficient matrix of heavy metals in different tomato pastes.

Heavy Metals	Fe	Cd	Mn	Zn	Pb	Se	Ni	As	Cu	Cr	Sn
Fe	1										
Cd	-0.453	1									
Mn	0.390	-0.227	1								
Zn	0.115	0.783*	-0.238	1							
Pb	0.145	0.772*	-0.051	0.977**	1						
Se	0.504*	-0.087	0.132	0.328	0.372	1					
Ni	0.214	0.732*	-0.107	0.988**	0.991**	0.357	1				
As	0.349	-0.428	0.920**	-0.410	-0.225	0.331	-0.294	1			
Cu	0.169	0.761*	-0.161	0.996**	0.989**	0.355	0.997**	-0.340	1		
Cr	0.176	0.714*	-0.275	0.993**	0.964**	0.392	0.982**	-0.418	0.989**	1	
Sn	0.481	-0.903**	0.595*	-0.750*	-0.656*	0.218	-0.661*	0.774*	-0.701*	-0.706*	1

* Significant correlation at level (0.05), ** Significant correlation at level (0.01).

CONCLUSIONS

Tomato paste is a tomato based product, and had been consumed at a wide range worldwide. Thus, the quality and the quantity of tomato paste and their contamination by heavy metals were studied in this work. Consequently, the human activity is one of the main factors to pollute the nature by heavy metals. In addition, one of the main sources to pollute to human body by canned foot consumption and to tomato paste. It is one of the main canned foods that people eat and use in different type of foods. Moreover, in this study, eleven heavy metals with some physiochemical characteristics were indicated in homemade and commercial tomato paste. The results indicate that the characteristic of physiochemical properties nearly have the same results, but the lycopene and moisture in homemade tomato paste shows the higher than other tomato pastes. However, among all heavy metals, Cd, Zn, Pb, Ni, Cu, and Cr shows the highest concentration in homemade tomato paste, and Zn, Ni, and Cu shows the above limit levels. Consequently, the content of Fe, Mn, and Cu in all type of tomato paste shows the above the limit levels. As a recommendation, the new machine in fabrication of tomato paste processing should be used to safe canned food product to decrease the contamination of food by heavy metals.

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CONFLICT OF INTEREST

The authors state that there are no conflicts of interest with the publication of this work.

الاختلافات في بعض خصائص معجون الطماطم التجارية والمصنوعة محليًا

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الكلية التقنية للعلوم التطبيقية / جامعة سليماني بوليتكنيك / السليمانية / العراق[2,3]

الخلاصة

تهدف هذه الدراسة إلى توضيح بعض خصائص وتركيز بعض المعادن الثقيلة في أربعة أنواع من منتجات معجون الطماطم المعلب (TP) مع نوعين من منتجات معجون الطماطم محلي الصنع (HM). تم شراء معجون الطماطم المعلب من السوق المحلي في السليمانية ، كردستان العراق ، خلال 2021–2022. تم الحصول على أعلى درجة حموضة ونسبة رطوبة وليكوبين ملغم / كغم من (4.94) HM1، 77.6٪ ، 280.983 ملغم / كغم) ، وأدنى من (2.84) TP4 للرطوبة ، (66.02) TP2٪) للرطوبة ، و TP3 (105.248 مجم / كجم) لليكوبين. علاوة على ذلك ، تم الحصول على الحد الأقصى لنسبة السكر والبريكس من (28.9) TP1 و 3.733٪) ، وتم تسجيل الحد الأدنى من Brix من (18.30) HM1) ، والحد الأدنى من T. Sugar ٪ (1.433 ٪) من HM2. بالإضافة إلى ذلك ، تراوحت نسبة الحموضة T و T.S٪ بين (1.963 – 2.66٪) ، (22.4 – 33.2٪). تمت الإشارة إلى المعادن الثقيلة في معجون الطماطم باستخدام مقياس الطيف البصري للبلازما الحثي الثنائي ICP. تمت مقارنة النتائج التي تم الحصول عليها من هذه الدراسة بمستويات الحد المعيارية لمنظمة الأغذية والزراعة / منظمة الصحة العالمية و CODIX لعام 2009. سجل HM1 أعلى تركيز للحديد والزنك والرصاص والنيكل والنحاس والكروم (59.34 و 79.76 و 0.169 و 9.913 و 23.646 و 2.437 ملغم / كغم) ، وتركيز الحديد والزنك والنيكل والنحاس والكروم. كانت Mn، Cr أعلى من حدود المستوى. كما أن أعلى تركيز من Mn و Cd و Se و As و Sn تراوحت بين (12.06 – 8.86 مجم / كجم) ، (0.89 – 0.046 مجم / كجم) ، (0.077 – 0.048 مجم / كجم) ، (0.0.96 – 0.011 مجم / كجم) و (0.132 – 0.085 مجم / كجم). أشارت هذه النتائج إلى أن معجون الطماطم آمن للاستهلاك ، لذلك يوصى بإيجاد أفضل طريقة لإنتاج معجون الطماطم لتقليل التلوث بالمعادن الثقيلة.

الكلمات المفتاحية:

معجون الطماطم محلي الصنع ، الليكوبين ، الحموضة ، ارتباط المعادن.

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