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BY-PRODUCTS OF TOMATO PROCESSING AS A SOURCE OF FUNCTIONAL COMPOUNDS

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ABSTRACT

By-products of tomato processing represent a major disposal problem for the industry concerned. The exploitation of by-products of tomato processing as a source of functional compounds and their application in food is a promising field considering that with the food market the innovative secter of functional foods is growing fast and becoming more important.Tomato seed contained the highest values of protein(28.03%)**,** and ether extract(20.83%), while tomato skin had the high value of crude fiber (55.42%) ,and ash (3.86%). Tomato seed meal contained avaliable amount of alkaloids, total phenolic, saponin, while tomato skins had the high content of carotenoids and lycopene. These substances had an antioxidants or anticancer effect. So, the presence of these compounds in tomato wastes allow their application in food processing to obtain healthy products. Physical and chemical properties of tomato seed oil indicated that oil had 0.923 specific gravity, 1.478 refractive index, 114.165 iodine value, 90.476 peroxide value and 3.685 free fatty acids.The results reveled that tomato seed oil contained 79.99% unsaturated fatty acids. Linoleic acid (18:2 ω6) is the major fatty acids was in a concentration of 56.67% followed by oleic acid (18:1 ω9) 18.37%. Results indicate that tomato seed contained higher levels of some essential amino acids i.e. phenylalanine, leucine, isoleucine and lysine than those by FAO/WHO (1993). Lysine was found to be the first limiting amino acid, while phenylalanine was the second limiting amino acid in the defatted tomato seed and skin meal. So,tomato seeds were good source for most essential amino acids such as phenylalanine, leucine, isoleucine and lysine which were higher than those given in FAO/WHO.

Keywords: Tomato by-products, tomato oil seed, phytochemical compounds,fatty acids, amino acids, functional food ingredient

INTRODUCTION

One of the main of problems of industry is the management of waste and their conversion in " products " of higher value. Modern technologies eco-compatible, promote the use of food waste to obtain biopolymers that can reused in the same sector of the raw materials (Strazzullo *et al*., 2003 and Vagi *et al*., 2007). Tomato is one of the most common vegetables in Egypt. The processing of tomatoes for different products generats wastes, which include seeds, skins and other fibrous wastes. When these wastes remain unutilized, they not only add to the disposal problem, but also aggravate environmental pollution (Al-Wandawi *et al*.,1985 and El-Framawy, 2002). Tomato wastes remaining after processing represent about 20% of the original fresh tomato (Arad *et al*., 1996). Tomato processing wastes have not efficiently been utilized although they contain valuable quantities of protein, fat and dietary fiber. Seed is the predominant component of tomato waste which represent 50-55% of all wastes (Shams El Din and Abd El- Kader, 1997). Altan *et al.*, (2008) reported that the use of tomato processing by-product coud provide gaining valuable substances and the same time reduce the waste disposal problem. Nowadays, the food and agricultural products processing industries generate substantial quantities of phenolics rich by products, which could be valuable natural sources of antioxidants to be employed as ingredients. Some of these by products have been the subject of investigations and have proven to be effective sources of phenolics antioxidants (Balasundram *et al*., 2006 and Peschel *et al*., 2006). There is a growing interest in the use of natural antioxidants as bioactive compounds in food and such food have been termed " functional foods " (Hertog *et al*., 1993). According to Hasler (1998), the term functional foods was first introduced in Japan in the mild 1980s and refers to processed foods containing ingredients that aid specific bodily functions in addition to being nutritious. Functional foods are defined as any modified food or food ingredient that may provide a health benefit beyond the traditional nutrients, it contains (ADA,1993 and Milner,1998) and reduction of risk of diseases (Ashwell,2002). According to ADA (1993), it can be describe the " functional foods " by several terms, these terms include : chemopreventive agenta, designer food, functional food, nutraceulical, pharma foods, phytochemical and food supplements.Phytochemicals including phenolics, carotenoids, flavonoids, dietary fiber, fatty acids and saponins are suggested to be the major bioactive compounds contributing to the health benefits of fruit and vegetables (Yang *et al*., 2004), these phytochemicals may be present in small amounts but may be very important to the health of consumers (Lako *et.al*.,2007). Polypenols not only show antioxidant activity but other properties such as anticancer, antiallergic, antimutagenic and antiageing activity (Jayaprakasha *et al*., 2003). George *et al.,* (2004) determined the total phenols of fresh tomato fruits. They found that tomato fruits are rich in phenolic compounds, since it contained from 9.2 to 22.0 mg free phenolic substances per 100 gram of tomato pulp (fresh wet weight). They added that tomato peels had significantly higher phenolic contents than that of the pulp. Tomato skin and seed showed better antioxidant activities in hydrophilic and lipophilic extracts than that of tomato pulp (Toor and Savage, 2005).

Abushita *et al*., (1997) studied tomato 's carotenoids as antioxidant compounds. They fractionated tomato carotenoids using HPLC into 14 components. The main constituents were lycopene, the red color of tomato fruits, in addition to β-carotene and lutein. The importance of β-carotene is related to its capability to act as a natural antioxidant in human and animal bodies. The carotenoids are mainly found in skin, the amounts of lycopene and β- carotene are three times higher in skin and at least five times higher in tomato waste than in other tomato products according to Al-Wandawi *et al.*, (1985). Baysal *et al.,* (2000) clearly stated that a large quantity of carotenoids is lost as waste in tomato processing. Also, Larrauri (1999) and Wolfe *et al.,* (2003) reported that peels are the major by-products obtained during the processing of various fruits and vegetables were shown to be a good source of polyphenols, carotenoids and other bioactive compounds which posses various beneficial effects on human health.

Tomato contains carotenoids in high amount (around 5.1-6.3mg/100g fresh weight), the main constituent is lycopene (70-80%) which provides the intensive red colour in tomato fruit (Vagi *et al.,* 2007) .The carotenoids are mainly found in skin, the amounts of lycopene and β-carotene are three times higher in skin and at least five times higher in tomato waste than in other tomato products according to Al Wandawi *et al*.,(1985).The explotation of by-products of tomato processing as a source of functional compounds and their application to foods is promising considering that within the food market, the innovative sector of functional foods is growing fast and becoming more important and to obtain healthy products. Askar and Treptow (1998) showed that tomato seed oil has attracted interest since it is rich in unsaturated fatty acids especially in linoleic acid, which may play an important role in decline the risk of cardiovascular diseases (Hasler,1998). Functional foods have become part of the common vocabulary and increasingly, part of the food menu (Kalaitzandonakes, 2002; Schieber *et al.*, 2001). The purpose of this study is to determine the chemical compostion, some phytochemical compounds, fatty acids and amino acids in tomato wastes (seeds and skin) and to highlight the potential of tomato by-products or wastes as a source of functional compounds.

MATERIALS AND METHODS

1-Materials:

Tomato industrial waste products were obtained from El Nasr Company for Food Preservation (Kaha), Egypt. Tomato seeds were separated in water, then seeds and skin washed twice with tap water and sun dried at ambient temperature (~ 30 ºC) for one week. Dried wastes were milled by " Moulinex " miller (France) to a fin powder. The powders were kept in polyethylene bags and stored in freezer (-18 ° C) for analysis. Lycopene was obtained from Sigma Chemical Co. (St.Louis,Mo, USA).

2- Methods:

Proximate composition of tomato wastes:

Moisture, crude protein (Kjeldahl method using digestive powder catalyst, K_2SO_4+ $CuSO_4$, protein factor 6.25), crude fat (petroleum ether,40-60 ºC,extractables by Soxhlet method), ash, and crude fiber were determined as described in AOAC (1995), while total carbohydrates were calculated by difference.

Determination of some phytochemical constituents in tomato wastes*:*

Alkaloids were determined according to Clarke (1970). Dried tomato waste powder (1 g) was extracted with 20% glacial acetic acid in ethanol for 4 hours, the extract was concentrated at room temperature and its alkaloids content was precipitate with addition of concentrated NH_4OH (34%), the precipitate was collected, washed with 1% NH_4OH, dried in an electric oven at 60 ºC for constant weight and weighted. Results were expressed as mg alkaloids /g tomato wastes. Phenolic compounds were determined by the method described by Jindal and Singh (1975). Five grams of dried tomato waste powder was extracted by 95% ethanol, sample 0.1 ml was mixed with

0.1 ml of Foline reagent, 0.1 ml of 20% anhydrous sodium carbonate, absorbance of colored mixture was measured at 650 nm using spectrophotometer (JENWAY 6300),a stander curve was prepared by pyrogallol. Saponin was estimated according to the method described by Hiai *et al.,* (1975) using 8% vanillin in ethanol and 72% sulphuric acid. Carotenoids were determined in tomato wastes according to the method of Pott *et al.,* (2003). Standard curve was performed under the same conditions using standard β- carotene. A method developed by Lin and Chen (2003) was used for analysis of lycopene by High performance liquid chromatography (HPLC) (National research centre, Dokki,Cairo). The HPLC system model(Water 486) UV detector set at 254nm and the data recorded by Millennium Chromatography Manger software 2010 (Waters, Milford MA 01757) was used. Reverse phase C18 Nova pack C18 column 3.9x150mm,10µm (Waters U.S.A.) was used. An isocratic mobile phase system of acetonitrile: methanol: 2-propanol (44:54:2 by vol) was used (Stahl *et al.*, 1993). Peak identification was based on retention time and published absorbance spectral data. Lycopene content was calculated as mg per 100g sample.

Characteristics of tomato seed oil:

Total lipids of tomato wastes were extracted with a mixture of chloroform : methanol (2:1, v/v) according to the method of Folch *et al.,* (1957).

Physical properties:-

Refractive index, specific gravity and colour were determined according to AOCS (1989). Colour was measured by using Lovibond tintometer in 1 inch cell.

Chemical characteristics :-

Free fatty acids (FFA), peroxide value (PV), and iodine value (IV) were determined according to AOCS (1989).

Fatty acid composition:

Fatty acid methyl ester (FAMA) was prepared by sulphuric acid in methanol as esterifying reagent (AOAC,1965). The FAMA was analysed by using Gas Liquid Chromatography (GLC) (Fac.of Agric.,Alexandria Unvi.) Model, Hp(Hewlett Packard) 6890 GC, equipped with FID detector and glass column 30m xo.32mm i.d, under the following condition:- column Hp.5 (5%dimethyl, 95% diphenyl poly-siloxane, nonpolar, column temp.150-180 ° C at 2 ° C / min, Detector temp. 250 ° C Injector temp., Injection volume 1ml, N_2 flow rate 0.8ml / min.

Amino acid determination:-

Amino acids content were determined as described by Moore *et al.*, (1958) using Beckman Amino Acid Analyzer instrument (Beakmann,model 110 CL- USA). Amino acid score(AAS) was calculated using the following equation:-

AAS%= [g amino acid of sample] / [g same amino acid of FAO/WHO reference protein] x100

Statistical analyses:

The data obtained were subjected to analysis of variance according to SPSS, (1997). Significant differences among individual means were analyzed by Duncan , s multiple range test (Duncan,1955).

RESULTS AND DISCUSSION

1-Chemical composition of tomato wastes:

From Table (1), it could be noticed that tomato seeds had higher contents of protein, ether extract and carbohydrate (28.03, 20.83 and 27.83%,respectively), than those of tomato skin (10.16, 4.60 and 25.96%,respectively), while the latter wastes contents of ash and fibers (3.86 and 55.42%, respectively) were higer than those of the aforementioned tomato seeds (3.59 and 19.72% respectively). These results are in agree with the data obtained by Attia *et al.*,(2000); Persia *et al.*,(2003) and Abd Raboh, Fatma (2007). Persia *et al.*,(2003) found that gross chemical analysis of tomato seed was 8.5% moisture, 25.0% crude protein (Nx6.25), 20.0% fat, 3.1% ash, 35.1% total dietary fibers, 0.12% calcium and 0.58% phosphorous.

Table (1): Chemical composition of tomato processing wastes (on dry weight basis)

Components(%)	Tomato skin	Tomato seeds
Moisture	7.86 ± 0.01^{b}	9.05 ± 0.02^{a}
Crude protein	10.16 ± 0.08^{b}	28.03 ± 0.04^{a}
Ether extract	4.60 ± 0.07^{b}	20.83 ± 0.11^{a}
Ash	3.86 ± 0.06^{a}	3.59 ± 0.01^{b}
Crude fiber	55.42 ± 0.02^{a}	19.72 ± 0.12^{b}
Total carbohydrate*	25.96 ± 0.10^{b}	27.83 ± 0.03^{a}

*** Total carbohydrate calculated by difference**
M±SD= mean and standard division of triplicate trails
In a column, means having the same superscript letters are not significantly different at 5% level

2-Phytochemical compounds of tomato wastes:

Alkaloids content of tomato seed was significantly ($p < 0.05$) different according to the type of tomato wastes (Table 2). The results indicated that the average value of alkaloids content in tomato seed meal was 114.16 mg/ g,whereas tomato skin had 3.48 mg/g, So the lower alkaloids content was detected in tomato skins. The presence of such amount of alkaloids in tomato processing waste has an effective role since it could be effective as an antimicrobial substances (Mohamed *et al*.,2000).

The resuts in Table (2) show that total phenloic compounds varied according to the type of tomato waste, whereas, the highest value(32.38 mg/g) was found in tomato seed meal followed by tomato skin (28.76 mg/g). These results are in agree with those reported by Atta *et al.*,(1988). It is well known that phenolic compounds especially, polyphenols are oxygen-scavengers and act as natural antioxidants as well as they have antimicrobial activity (Kapoor and Kaur,2002). Recycling of the by-products has been supported by the fact that polyphenols have been located specifically in the peels (Wolfe *et al*.,2003). Furthermore the tomato wastes extracts coud be suitable as functional ingredients in the food industry (Milo-Ohr, 2004). Tomato seed meal contained 7.11mg saponin/100g, whereas was 3.66mg/100g in tomato skin. Abd El-Hamid *et al.*,(2001) reported that saponin may use as food additives and the best solvent to extract saponin is an (50% v/v) aqueous ethanol.

From the tabulated data (Table 2), it could be noticed that the average of carotenoids content of tomato skin was (18.26 mg/g dry weight) the significantly highest among the tomato seed which was 12.55 mg/g. It is well known that carotenoids have a role of natural antioxidant that can protect the biological system against harmful free radicals (Rao *et a*l.,2006 and Tiziani *et al*.,2006). Tomato skin containded 31.16 mg/g lycopene, while the lowest one was (0.98 mg/g) found in tomato seed meal. Topal *et a*l.,(2006) extracted lycopene from tomato skin wastes via supercritical carbon dioxide. The maximum yield extract was 1.18mg/g sample. They added that solubility of lycopene was different according to drying conditions.

Table (2): Phytochemical compounds of tomato processing wastes

Samples	Alkaloids mg/g	Total phenolic mg/g	Saponin mg/g	Carotenoids mg/g	Lycopene mg/g
Tomato seed	114.17±0.21 ^{a}	32.38±0.071^{a}	7.11±0.141^{a}	12.55±0.021^{b}	0.98±0.20^{b}
Tomato skin	3.18±0.112 $^{\mathbf{b}}$	28.76±0.121^{b}	3.66±0.061^{b}	18.26±0.011^{a}	31.16±0.121^{a}

M±SD= mean and standard division of triplicate trails
In a column, mean having the same superscript letters are not significantly different at level

Characteristics of tomato seed oil:

The results in Table (3) show that the physical properties including refractive index, density and colour as well as chemical characteristics including iodine value, peroxide value, free fatty acid and acidity of tomato seed oil. From these results, it can be noticed that both of refractive index and specific gravity of tomato seed oil were 1.4780 and 0.923 respectivly are in the line with those reported by Lazos *et al.,* (1998). Also, refractive index was few higher than that found by Moharram *et al*., (1984) who reported that refractive index of tomato seed oil was 1.46. Giannelos *et al.*, (2005) reported that the density of tomato seed oil was o.9151 Kg/l and iodine number was 124.o. Moreover, the crude fat of tomato seed was dark greenish in colour and had Lovibond colour value of 75 yellow, 5 red and 8.2 blue. From the results in the same Table, it coud be noted that iodine value of tomato seed oil, which indicates the unsaturation of fatty acids was found to be 114.165, this means that tomato seed oil could be a semi dry oil. These results are in agreement with Moharram *et.al.*, (1984) who reported that iodine value of tomato seed oil ranged from 114-118. Several studies (Al-Wandawi *et.al.,* 1985; Roy et.al., 1994; Giannelos *et.al*., 2005) showed that tomato seeds contain 18-27% oil that show physicochemical characteristics similar to any-but mainly to cotton seed- conventional oil. It is a semi drying oil consisting of 18-22% saturated (palmitic and stearic acids) and 78-82% of unsaturated fatty acids (linoleic, oleic and arachidic acids). The present results shows that peroxide value of crude oil of tomato seed was 90.476 meq./Kg, higher than that found by Abd-Raboh, Fatma (2007) who reported that peroxide value of tomato seed oil was 90.63 meq./Kg. Free fatty acids content (as % oleic acid) and acidity % of crude tomato seed oil were 3.685 and 7.333 % respectively higher than recorded value by Abd-

Raboh, Fatma (2007) who reported that free fatty acids of tomato seed oil was 1.05. Tomato seeds contain 18-27% oil that shows physic-chemical characteristics similar to any-but mainly to cotton seed conventional oil (Vagi *et al*., 2007)

Table(3): Some physical properties and chemical characteristics of tomato seed oil

Characteristic	
Physical properties:-	
Refractive index at 28 ° C	1.4780±0.010
Specific gravity at 28 ºC	0.923±0.020
Lovibond colour value	(75Y,5R, 8.2B) *
Chemical characteristics:	
Iodine value	114.165±0.110
Peroxide value (as meq./Kg)	90.476±0.120
Free fatty acid (as oleic acid %)	3.685±0.210
Acidity (%)	7.333±0.110

Y= Yellow, R= Red, B= Blue
*** M±SD= mean and standard division of triplicate trails**

Fatty acid composition of tomato processing wastes lipids:

Although tomato seed make up 0.5-0.6% of the weight of tomato fresh fruits and contain 18-33% fat (Takasova *et.al.,*1995), it looks as a waste in the processing of tomato products. Thus, tomato seed must not be nutritionally neglected.

Fatty acid composition of tomato processing wastes lipids is shown in Table (4). Linoleic acid (18:2ω6) was the major fatty acids in tomato seed oil followed by oleic (18:1ω9) and palmitic acids (16:0). Palmitic acid was the major saturated fatty acids and represents 75.36% of saturated fatty acids followed by stearic acids in tomato seed lipids, whilst linoleic (18:2ω6) fatty acid was the major unsaturated fatty acids and amounted to 73.60% of the unsaturated fatty acids in tomato seed. Unsaturated /Saturated fatty acid ratio of 3.86 was found in the tomato seed lipids, while linolic/ olic ratio was 3.08. These results are in agreement with those reported by different investigators (Shams El-Din and Abd El-Kader,1997; Lazo *et al*.,1998 and Abd Raboh, Fatma, 2007).

The high percentage of unsaturated fatty acids (especially essential fatty acids which is known as omega-3, omega-6, omega-9 fatty acids) in tomato seed oil could be fall the oil in the category of edible and healthy oils. Therefore, the oil could be used as salad oil and for different application such as hydrogenation and shortening industries. Tomato seed oils seem to be suitable for blending with vegetable oils, stearin manufacturing, confectionery industry or/and in the soap industry.

Linoleic acid (18:2 omega- 6) is the parent compound for the omega-6 series of polyunsaturated fatty acids and α-linolenic acid (18:3 omega-3) is the parent compound for the omega-3 series (Webb,2006). It is now generally accepted that small amounts of omega-3 polyunsaturated fatty acids are also essential in their own right for normal physiological functioning. Whilst omega-6 fatty acids predominate in the membranes of liver cells and platelets, there are high and fatty stable concentrations of long chain omega-

3 fatty acids in brain and retinal membrane phospholipids in most mammals (Webb,2006). So tomato seed oil which contains high percentage of linoleic acid (18:2ω6) are good example for functional foods. Vagi et al.,(2007) reported that tomato seed oil is a semidrying oil consisting of 18-22% saturated (palmitic and stearic acids) and 78-82% of unsaturated fatty acids (linoleic, oleic and arachidic acids).The results indicate that palmitoleic acid ($C_{16:1\omega 7}$) had the highest value comparing with other fatty acids in tomato skin oil.

Table (4) : Fatty acid composition of tomato processing wastes lipids

Fatty acids (%)	Symbol	Tomato seed oil	Tomato skin oil
Caproic	**C6:0**	0.078	0.067
Caprylic	**C8:0**	0.051	0.051
Capric	**C10:0**	0.034	0.030
-	**C11:0**	0.019	nd
Lauric	**C12:0**	0.031	0.15
Tridecanoic	**C13:0**	0.12	0.16
-	**C15:1**	0.23	nd
Palmitic	**C16:0**	15.41	0.14
Palmitoleic	**C16:1ω7**	0.57	18.61
Margaric	**C17:0**	0.12	0.17
Stearic	**C18:0**	4.59	0.52
Oleic	**C18:1ω9**	18.37	0.098
Linoleic	**C18:2ω6**	56.67	nd
Linolenic	**C18:3ω3**	2.45	0.23
Gadoleic	**C20:1ω9**	0.32	nd
Elaeostearic	**C20:3ω6**	0.11	0.58
Eicosapentaenoic	**C20:5ω3**	0.06	0.44
Erucic	**C22:1**	0.17	0.17
Decosadienoic	**C22:2ω6**	0.05	nd
Decosahexaenoic	**C22:6**	-	0.33
Total saturated	**%**	20.45	1.27
Monounsaturated	**%**	19.66	18.87
Polyunsaturated	**%**	59.33	1.59
Total unsaturated	**%**	78.99	20.46
Unsat/Sat	**-**	3.86	16.16
Linoleic/Oleic	**-**	3.08	-
Unknown	**%**	0.559	78.27

nd: not detected

Amino acid composition of tomato wastes:

The amino acid composition of tomato wastes (seeds and skins) is presented in Table (5). Lysine, leucine and isoleucine occurred at higher levels in the tomato seeds (but leucine and lysine only in tomato skin) than those of the FAO/WHO reference protein (FAO, 1993). Tomato seed protein has been found to have a high lysine content, therefore, coud substantially improve the protein quality of cereal products, which are low in lysine (Brodowski and Geisman,1980). Also, Cantarella *et.al.,*(1989) foud that tomato seed protein is rich in lysine i.e.80-100g/KgN and can supplement products that are deficient in this amino acid, such as cereal (Yaseen *et al*.,1991). The studies (Sogi, 2001) showed that tomato seed protein contains approximately 13% more lysine than soy protein which would allow it to be used in fortifying low lysine foods.Glutamic acid was the most predominant amino acid followed by aspartic and arginine. The amino acid scores (AAS%) in defatted tomato processing wastes are shown in Table (5). The resuts in this table indicate that threonine was found to be the first limiting amino acid, whilst valine was the second limiting amino acid in the defatted tomato seeds and skin meal. It was also found that lysine and phenylalanine were the first and second limiting amino acids in the defatted total tomato processing wastes meal ,respectively. Shams El Din and Abd El Kader (1997) found that valine, methionine and cystine were the first, second and third limiting amino acids in the tomato seed meal, Meanwhile methionine, cystine and threonine were the first, second and third limiting amino acids in the total tomato by product meal. These results indicate that seeds and skin meal from processed tomato fruit could be used as a source of protein.Different investigations indicated that no antinutritional factors or harmful constituents have been reported in tomato seed(Rahma *et al.*,1986) and that makes it a better source of protein than other non conventional sources.

Table (5): Amino acids composition of tomato wastes compared with FAO/WHO reference protein (g amino acid/100g protein)

Amino acids	Tomato seed meal	Tomato skin meal	*FAO/WHO reference protein	Amino acid scores (%)	
				Tomato seed	Tomato skin
Essential A.A					
Phenylalanine	3.82	3.04	2.8	136.43	108.57
Leucine	5.66	5.03	4.8	117.92	104.79
Isoleucine	4.89	3.37	4.2	116.43	80.24
Lysine	6.36	5.10	4.2	151.43	121.43
Valine	3.07	2.92	4.2	73.10	69.52
Tyrosine	3.37	3.198	4.1	82.20	78.00
Threonine	2.00	1.83	4.0	50.00	45.75
Tryptophane	1.62	1.67	2.2	73.64	75.91
Methionine	2.14	1.60	2.2	97.27	72.73
Non essential.AA					
Aspartic acid	7.98	8.63	-	-	-
Glutamic aci	12.15	13.78	-	-	-
Alanine	2.44	2.17	-	-	-
Serine	3.30	3.42	-	-	-
Glycine	2.90	3.29	-	-	-
Histidine	2.24	1.79	-	-	-
Proline	0.96	1.09	-	-	-
Arginine	4.03	5.22	-	-	-
Cystine	0.11	0.119	-	-	-

* **FAO/WHO(1993)**

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مخلفات تصنيع الطماطم كمصدر للمركبات الوظيفية

سامية الصافي فرج ، أمل عبد الله مطر و سماء محمود السيد
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تعتبر المخلفات الناتجة من تصنيع الطماطم من المشاكل الرئيسية ويمكن أستغلال هذه المخلفات كمصدر للمركبات الوظيفية وتطبيقها في مجال الصناعات الغذائية وانتاج الاغذية الوظيفية والتي ظهرت أهميتها في الاونة الاخيرتز وقد أوضحت نتائج الدراسة أن بذور الطماطم تحتوي نسب مرتفعة من البروتين (% 28.03)والمستخلص الايثري (% 20.86) بينما قشور الطماطم أحتوت نسب مرتفعة من الالياف الخام (% 55.42) والرماد (% 3.86) ايضا أحتوت بذور الطماطم كميات هامة من القلويدات- المواد الفينولية - الصابونين بينما أحتوت القشور كميات هامة من الكاروتينات والليكوبين ومن المعروف أن هذه المركبات لها خصائص مضادة للاكسدة ومضادة للسرطان فوجود هذه المركبات في مخلفات الطماطم تجعلها ذات أهمية كبيرة ويمكن أستخدامها في تدعيم المنتجات الغذائية وأنتاج أغذية صحية مفيدة

وقد أظهرت نتائج الدراسة أن زيت بذور الطماطم له كثافة 923 .0 معامل أنكسار 1.478 رقم يودي114.165 رقم بيروكسيد 90.476 الاحماض الدهنية الحرة 3.685 أيضا أشارت النتائج أن زيت بذور الطماطم أحتوت 79.99% أحماض دهنية غير مشبعة وكان حمض اللينوليك (أوميجا - ٣) هو الحمض الرئيسي يليه حمض الاوليك (أوميجا - ٩) ووجد أن الاحماض الامينية الاساسية الفينايل الانين الليوسين الايزوليوسين والليسين في بذور الطماطم وكانت نسبتها أعلي من تلك المقررة في البروتين المرجعى (القياسى) الصادر عن منظمة الاغذية والزراعة ومنظمة الصحة العالمية (١٩٩٣)