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Physico-Chemical and Technological Characteristic of Tomato and Orange Peels Byproducts

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Abstract

This study aimed to utilizing from by-products of two major sectors of food industries, i.e. tomatoes pomace (TPP) and orange peels waste (OPP). Therefore, chemical composition, functional characteristics, total phenol, total flavonoid, antioxidant activity, amino acids and fatty acids of all by-products samples were evaluated. Also, soft wheat flour (SWF) was evaluated, where it could be mixed with OPP and TPP to produce some functional bakery products.

The results showed that fat, protein, and fibre in TPP were higher than those found in SWF or OPP. Also, ash content of OPP reached to 9.43%, while it declined to 4.58% and 0.62% in TPP and SWF, respectively. Also, OPP had higher Calcium, Potassium, Phosphorus, Sodium and Iron compared to TPP and SWF. While, TPP had higher Magnesium and Zinc.

Furthermore, OPP and TPP characterized with their higher functional properties compared to SWF. TPP had highest phenolic and flavonoid compounds followed by OPP and SWF samples. OPP and TPP were regarded as superior sources of both essential and nonessential amino acids if compared to SWF. Tomato seed oil contained 21.97% saturated fatty acids and 78.03% unsaturated fatty acids. In contrast, the tomato peel oil contained 31.79% saturated fatty acids and 68.22% unsaturated fatty acids. The ratio between essential and nonessential amino acids were 1:1.59 and 1:2.11 for OPP and TPP; respectively.

On the other hand, most functional properties of OPP had higher values compared to wheat flour. Whereas, swelling ability, water holding capacity, and oil holding capacity of OPP recorded 20.74 ml water/gm, 16.05 gm water/gm, and 1.65 gm oil/gm, respectively.. From the obtain results it could be recommend to use OPP and TPP as a functional food additive to several bakery products.

Keywords: Physico-chemical, functional properties, wheat flour, tomato pomace powder, orange peel powder

Introduction

Food industries produce huge amounts of food wastes especially vegetable and fruit. The demand to improve the value through converting these wastes to new products is grew [1, 2]. Food wastes considered neither a cost nor a benefit, and thereby used as animal feed or sent for composting. The processing of tomato to produce puree, juices, ketchup, sauces, and dried powders lead to a significant amount of waste in the form of tomato pomace, which includes seeds and skin. Tomato processing wastes, particularly seeds, are tanks of health-promoting macromolecules, such as bioactive peptides, carotenoids, polysaccharides, phytochemicals (flavonoids), and vitamins (α-tocopherol). Health properties of these compounds make these bioactive components suitable candidates for the development of feeder products. Utilization of bioactive components can improve the economic feasibility of the tomato processing industry and may help to reduce the environmental pollution [3]. Citrus fruit considered as well-known promising source of multiple beneficial nutrients for human beings [4]. Orange peels, which are the main wastes of the citrus processing industry, are rich in pectin, cellulose, hemicellulose [5]. The fruits and vegetables wastes are inexpensive and a good source of dietary fibre [6]. So, citrus peels may provide a health benefit beyond the traditional nutrients they contain, as well as prevent diet-related diseases, e.g. metabolic syndrome, type II diabetes, coronary heart disease, obesity, hypertension and certain types of cancer [7].

Fruit and vegetable wastes are naturally rich with bioactive compounds like antioxidants, phenolic compounds, minerals, vitamins, and fiber. The peels, seeds and other wastes of numerous fruit can be used as functional foods [8]. Fruit by-products contain phytochemicals such as phenolic compounds, vitamins, minerals, dietary fiber, and other bioactive compounds. The polyphenolic compounds found in fruit promote human health development. The phenolic compounds are the secondary metabolites of fruits that can act against free radicals and oxidative stresses, and thus they are known as antioxidants [9, 10]. The objective of this study aimed to minimizing the waste of orange and tomatoes industries through producing functional food additives of OPP and TPP. To reach the objective of this research the obtained OPP and TPP were evaluated through determination their chemical and mineral composition, functional properties (such as swelling capacity, water holding capacity, and oil holding capacit), total phenols, flavonoids, antioxidant activity, fatty acids, and amino acids of the tomato and orange powders.

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1. Materials and methods

1.1. Materials

Tomato pomace (peel and seeds) and Orange waste (Citrus sinensis) of Balady orange variety were obtained from Kaha Company for Preservative Foods Kaha, Kalyobia, Egypt.

Wheat Flour (72% extraction) was obtained from the North Cairo Flour Mills Company, Egypt.

All used chemicals were of analytical grade and were procured from Al-Gomhouria Chemical Company, Egypt.

Methods:

Tomato pomace (consisting of peel and seeds) powder preparation:

Tomato processing wastes were gathered following the extraction of juice by cold-break procedures. The tomato pomace was dehydrated at a temperature of 50℃ for 12 hours in an oven with circulating air (SHEL LAB 1370FX, USA). Afterward, they underwent a milling process and were sieved using a mesh size of 110. The resulting material was then placed in polyethylene bags and stored at a temperature of -18 ℃ until it was ready for use. This methodology was described by **Isik and Topkaya [11]** and **Curutchet *et al* [12].**

Preparation of orange by-product (peel and pulp) powder:

The waste derived from orange peel and the residual pulp left after extracting the juice. The material underwent a series of steps including washing, cutting, and drying in an air oven (SHEL LAB 1370FX, USA) at a temperature of 72 ºC for three hours. The temperature was then reduced from 72 ºC to 64 ºC, and the drying process continued for an additional 24 hours until complete drying was achieved. The dried material was then finely powdered through milling, and passed through 60 mesh sieves for sieving. Finally, it was stored in polyethylene bags and kept under cooling at 4˚C up till use.

Water holding capacity:

Water holding capacity (WHC) was determined according to the method developed by **Pla *et al*. [13].** Cleaned centrifuge tubes were weighed (W). The samples (0.5 g) (W1) and 7 mL distilled water were then poured into the centrifuge tubes. The tubes were subjected to incubation at a temperature of 60 ℃ for 30 minutes, followed by immersion in cold water for an additional 30 minutes. The tubes underwent centrifugation with a force of 2683 g for 15 minutes. Subsequently, the liquid portion above the sediment, known as the supernatant, was extracted. The centrifuge tubes, now holding the sediment (referred to as W2), were then reweighed. The calculation of WHC was performed using the following equation.

$$WHC\ (g/g) = (W2 - W)/W1$$

Oil holding capacity:

Oil holding capacity (OHC) was determined according to the method described by **Robertson *et al*. [14].**

Swelling capacity (SWC):

Swelling capacity refers to the ability of a substance to increase in size or volume when it absorbs or takes in another substance. The swelling capacity (SWC) was quantified using the bed volume technique outlined by Navarro-González *et al*. **[15].** A quantity of approximately 0.2 g of the sample material was measured and placed into a glass cylinder with a volume of 50 mL, which has markings indicating different volume levels. After adding de-ionized water to reach a final volume of 50 mL and vigorously stirring the mixes, the material was left overnight at room temperature for equilibration. The measured volume of the enlarged sample was recorded. The results of the SWC were quantified by calculating the ratio of the volume (in mL) of the swollen sample to the weight (in g) of the initial dry sample. Triplicate measurements were taken for all WHC, OHC and SWC.

Chemical composition:

Chemical analyses were carried out to determine moisture, protein, fat, ash, and crude fiber were determined acceding to the method of AOAC **[16]**. Total carbohydrate was determined by difference, as follows:

$$\text{Total carbohydrates} = 100 - (\%\ \text{protein} + \%\ \text{fat} + \%\ \text{ash} + \%\ \text{crude fibre}).$$

Caloric value:

The total calories of the samples were calculated according to James **[17]** as follows: Total calories (Kcal/100 g) = (Fat × 9 Kcal) + (Protein × 4 Kcal) + (Carbohydrate × 4 Kcal).

Minerals content:

Macro- and microelements were determined in SWF, TPP, and OPP by the dry ashing method, according to Jones *et al* **[18].** Potassium (K) and sodium (Na) were determined by the flame photometric technique. Magnesium, iron (Fe), and zinc (Zn) were determined by inductively coupled plasma (ICP) emission spectroscopy [19].

Total phenol, total flavonoid and antioxidant activity were determined as follows:

Extraction:

Methanol was used to make extracts for total phenolic, total flavonoids, and antioxidant activity. One g. from each sample was combined with 100 mL of methanol and blended using the Ultra-Turrax homogenizer. The homogenates were stored at a temperature of 4 ℃ for 12 hours, followed by centrifugation at a speed of 10,000 rpm for 20 minutes. The liquid portion that remained after the solid particles settled was collected and kept at a temperature of -20 ℃ until it was examined.

Determination of total phenolic content:

The total phenolic content was measured using the Folin-Ciocalteu technique, as described by **Zilic *et al* [20].**

Determination of total flavonoid content:

The total flavonoid content was conducted using the method described by **Zilic *et al* [20]**, which involved the utilisation of an aluminium chloride (AlCl3) colorimetric test.

The radical DPPH scavenging activity:

DPPH was assessed by assessing the ability of the extracts to scavenge the stable DPPH* free radical, using the method described by **Hwang and Do Thi [21].**

Phenolic acids profile

Phenolic compounds extraction:

Sample (1g) was introduced into a fast fit conical flask, followed by the addition of 20 ml of a 2M NaOH solution. The flasks were then purged with nitrogen gas and the stopper was resealed. The samples were agitated for 4 hours at ambient temperature. The pH was adjusted to a value of 2 using a 6 M solution of hydrochloric acid (HCl). The specimens were subjected to centrifugation at a speed of 5000 rpm for 10 minutes, resulting in the separation of the liquid portion from the solid residue. The phenolic components were extracted using a mixture of 50 ml of ethyl ether and ethyl acetate in a 1:1 ratio, and this extraction process was repeated twice. The organic phase was isolated and subjected to evaporation at a temperature of 45°C. Subsequently, the resulting samples were dissolved again in 2ml of methanol [22]**.**

Analysis of phenolic compounds:

The examination of phenolic compounds was conducted using HPLC analysis with an Agilent Technologies 1100 series liquid chromatograph that was equipped with an auto sampler and a diode-array detector [22].

Fatty acid composition:

The fatty acid composition was determined by the conversion of oil to fatty acid methyl esters (FAMEs) prepared by adding 1.0 mL of n-hexane to 15 mg of oil followed by 1.0 mL of sodium methoxide (0.4 mol), according to the method of Nzikou *et al* [23] with some modifications. The mixtures were vortexed for 30 seconds and were allowed to settle for 15 minutes. The upper phase containing the FAMEs was recovered and analyzed by gas chromatography (GC-FID). FAMEs were analyzed on a Perkin Elmer (model 8700), fitted with a non-bonded biscyanopropyle siloxane stationary phase, polar capillary column SP-2340 (60 m 0.25 mm), 0.2 mm film thickness and a flame ionization detector. Nitrogen (oxygen-free) was used as a carrier gas at a flow rate of 3.5 mL min^{-1}. Other conditions were as follows: initial oven temperature, 130 °C; ramp rate, 4 °C/min; final temperature, 220 °C; injector temperature, 260 °C; detector temperature, 270 °C; temperature hold, 2 minutes before the run and 17 minutes after the run. A sample volume of 1.0 mL was injected. FAMEs were identified by comparing their relative and absolute retention times to those authentic standards of FAMEs. All of the quantifications were done by a built-in data handling program provided by the manufacturer of the gas chromatograph (Perkin Elmer). The fatty acid composition was reported as a relative percentage of the total peak area.

Amino acid Determination:

The amino acids composition of experimental samples was determined using HPLC-Pico-Tag method according to Millipore Cooperative [24]. The Pico-Tag method was described by Heinrikson and Meredith [25], White *et al*. [26] and Cohen *et al*. [27]. The Pico-Tag method, was developed commercially by Waters Associates, was an integrated technique for amino-acid analysis. Phenyl iso thiocyanate (PITC, or Edman's reagent) was used for pre-column derivatization, while reversed-phase gradient elution high-performance liquid chromatography (HPLC) separates the phenylthiocarbamy (PTC) derivatives which were detected by their UV absorbance. The chromatographic analysis using HPLC was carried out using the following gradient of Pico-Tag solvent A and B (P/N 88108 and 88112). Sample was injected and loaded on Pico-Tag amino acids column (150 x 3.9 mm) stainless steel. Detection of the PTC derivatives is by ultraviolet absorption measurements using a fixed wavelength (254nm) Waters detector. Before injecting of the sample, the illustrated was calibrated by two injections of the standards.

Analysis of Volatile Components using Headspace Gas Chromatography-Mass Spectrometry :

Volatile organic compounds of samples were analyzed using solid-phase micro-extraction (SPME). A quantity of 2g of the sample was weighed into 20mL capacity vials, and then a sodium salt solution of 3% was added. A fused silica SPME fiber covered with 85µm carboxen/polydimethylsiloxane (CAR/PDMS) (Supelco, SIGMA, St. Louis, MO) fiber was used. Vials were heated at 70°C for 20min without stirring. The fibre was exposed to the vial headspace for 10min and then injected into the CG-MS [28]. All analyses were performed on an Agilent 8890 GC System, coupled to a mass spectrometer (Agilent 5977B GC/MSD). Volatile compounds were separated on an HP-5ms fused silica capillary column (30 m × 0.25 mm × 0.25 µm), and the oven temperature program was set as follows: the initial temperature was 40°C, held for 3 min, then programmed from 40 to 160°C at rate 4°C/min, maintained for 5 min and increased to 280°C at a rate of 10°C. Helium was used as the carrier gas at a flow rate of 1mL/ min. The volatiles were injected in the GC with a split less mode. The temperature of injection was 270°C. Mass spectra in the electron impact mode (EI) were obtained at 70 eV and scan m/z range from 39 to 500 amu. The isolated peaks were identified by matching them with data from the library of mass spectra (National Institute of Standard and Technology, NIST). The analysis was performed using solid-phase micro-extraction-gas chromatography-mass spectrometry (SPME-GC-MS) methodology.

Statistical analysis:

Statistical analysis (Means ± SD) of three replicates for each experiment are statistically analyzed using one-way analysis of variance (ANOVA), $P \leq 0.05$ was used to indicate significance. Statistical software (Assist at Version 7.7, Brazil) was used for all statistical analyses [29].

2. Results and discussion

3.1. Chemical composition of raw materials and total calories:

Table (1) displays the proximate composition of soft wheat flour (SWF), orange peel powder (OPP), and tomato peel powder (TPP). The moisture content of the soft wheat flour was 11.65%, which exceeded the moisture content of 9.43% for the OPP and 6.09% for TPP. The levels of fat, protein, and fibre in TPP were greater than those in SWF or OPP. The ash content of OPP was 9.43%, which was higher than the ash content of TPP (4.58%) and SWF (0.62%). Nevertheless, the tomato peel flour had a decreased carbohydrate content compared to SWF and OPP. Ash is a measure of the mineral content in a food sample. The TPP had a little greater fat content of 8.30% compared to the OPP with 5.6% and the WF with 1.45%. The chemical composition results of the raw materials align with the findings of previous studies conducted by [30, 31].

Table (1): Gross Chemical composition of orange peels (OPP) and tomatoes pomace (TPP) by-product compared to soft wheat flour (SWF) on dry weight basis.

Samples	Chemical composition of flour samples (%)						Caloric Value (cal/100g)
	Moisture	Ash	Fiber	Protein	Lipids	CHO	
SWF	11.65 ± 0.25	0.62±0.10	0.71±0.09	10.32±0.11	1.45±0.14	86.90± 0.31	401.93
OPP	9.43±0.17	9.43±0.07	10.3±0.32	5.5±0.27	5.6±0.05	69.17±0.56	349.08
TPP	6.09±0.29	4. 58±0.01	28.0±0.37	24.3±0.25	8.3±0.03	34.82±0.85	311.18

3.2. Minerals Content of Used Materials:

Results presented in Table (2), show the mineral content of SWF (72% ext.), OPP, and TPP. OPP had high contented of Calcium (Ca), Potassium (K), Phosphorus (P), Sodium (Na), and Iron (Fe) compared with TPP and SWF. It was recorded 134, 163, 51, 230 and 7.4 mg/100g, respectively. Also, TPP contained higher amount of Magnesium (Mg) and Zinc (Zn) being 40.12, and 3.79, respectively compared to OPP which recorded 32.15and 3.50 mg/100g for Magnesium (Mg) and Zinc (Zn). SWF (72% ext.) had the mean lowest mineral content being 33.85, 29, 24,35.88, 2.75, and 2.40 mg/100g for Ca, K, Mg, Na, Fe, and Zn, respectively. Such results are in line with those obtained by **[32, 33].**

Table (2): Minerals content (mg/100g) of orange peels (OPP) and tomatoes pomace (TPP) by-producst compared to soft wheat flour (SWF).

Samples	Macro-elements					Micro-elements	
	Calcium (Ca)	Potassium (K)	Magnesium (Mg)	Phosphorus (P)	Sodium (Na)	Iron (Fe)	Zinc (Zn)
SWF	33.85±2.00	29.0±0.84	24.0±0.30	44.0 ±1.00	35.88±1.15	2.75±0.22	2.40±0.10
OPP	134±1.15	163±1.92	32.15±0.70	51±2.15	230±1.19	7.4±0.25	3.5±0.12
TPP	42.15±0.55	66±2.80	40.12±0.39	21.0±2.30	79.45±1.22	5.6±0.18	3.79±0.15

3.3. Functional properties of wheat flour, tomato pomace powder and orange peel powder:

The impact of dietary fibres on their activities in foods is mostly determined by their functional qualities **[34].** Table (3) presents the results of evaluating the bloating and water binding capacities of SWF, OPP, and TPP. Previous studies have reported that the swelling ability of SWF, OPP, and TPP was 3.94, 20.74, and 0.11 ml water/gm, respectively. In a study conducted by **Jamal [35]**, the swelling ability of orange peel powder was found to be 10.7 ml water/gm. **Figuerola *et al* [36]** reported an average bloating ability of 6.11 ml water/gm for oranges, 8.27 ml water/gm for apples, and 8.02 ml water/gm for grapes. **Ocen and Xu [37]** obtained a swelling ability of 11 ml water/gm for orange peel powder. In terms of water holding capacity, the SWF, OPP, and TPP had capacities of 3.3, 16.05, and 6.76 gm water/gm, respectively. Previous investigations by **Jamal [35]** on orange peel powder reported a water holding capacity of 5.65 gm water/gm. The water absorption capacity of orange peel powder was 6 gm per gramme.The values align with those obtained by **Sharoba *et al* [38],** who reported that the water holding capacity (WHC) of orange wastes and carrot pomace was 16.39 and 19.72 g water per gm. respectively. **Mis´kiewiczet *et al* [39]** demonstrated that the incorporation of lemon peel powder enhanced the capacity of dough ingredients to form a cohesive mixture with water, resulting in reduced water evaporation during baking. The water-binding capacity of orange peels is enhanced by the presence of soluble fibres and pectin substances, which possess hydrophilic properties. The moisturising effect of the fibres is attributed to their ability to bind water through their structure **[40]**. Therefore, the increased ability to absorb water and swell makes orange peels a potential ingredient for low-calorie dishes **[41]**. Table (3) displays the oil-binding capacity of SWF, OPP, and TPP, which exhibited no significant variation in this characteristic. The average oil binding capacities were 1.66 gm oil / gm, 1.65 mg oil / gm, and 1.46 gm oil / gm for SWF, OPP, and TPP, respectively. The capacity to adhere oil influences the amount of oil retained in food, with the hydrophobic component being primarily responsible for this characteristic. Previous research has shown that the oil binding capacity of orange peels is 1.6 gram of oil per gram of dry matter, which is consistent with the findings of **Figuerola *et al* [36].**

Table (3): Functional properties of orange peels (OPP) and tomatoes pomace (TPP) by-producst compared to soft wheat flour (SWF).

Samples	SWC (ml water/ gm dry fiber source	WHC (g water/g dry fiber source)	OHC(g oil/g Dry fiber source)
SWF	3.94±0.05	3.3±0.03	1.66±0.02
OPP	20.74 ±0.17	16.05 ±0.12	1.65 ±0.04
TPP	0.11 ±0.001	6.76 ±0.09	1.46±0.03

Where: OHC: Oli holding capacity; WHC: Water holding capacity; SWC: Swelling capacity

3.4. Total phenolic, flavonoids and antioxidant activity of SWF, TPP and OPP:

Phenolic and flavonoids are recognised as significant categories of nonessential dietary constituents that have been proposed to have positive effects on human health **[42, 43]**. The bioactive compound findings for the examined SWF, OPP, and TPP are presented in Table 4. The levels of total phenols, measured in mg of gallic acid equivalent per gm (mg GAE/g), and total flavonoids, measured in mg of catechin equivalent per gm (mg CAT/g), were determined in SWF, OPP, and TPP. The SWF had a total phenol content of 34.05 mg/g, a total flavonoid content of 25.30 mg CAT/g, and an antioxidant activity of 21.19%. In comparison, the OPP had a total phenol content of 312.29 mg/g, a total flavonoid content of 122.61 mg CAT/g, and an antioxidant activity of 65.20%. The TPP had a total phenol content of 516.52 mg/g, a total flavonoid content of 101.79 mg CAT/g, and an antioxidant activity of 83.57%. The Orlando orange peel yielded the highest amount of phenolic compounds, measuring 178.90 mg GAE/100 g. which had 169.54 mg GAE/100 g. These results are consistent with those reported by **Al-Juhaimi [44].**

Table (4): Total phenolic, total flavonoids and antioxidant activity of orange peels (OPP) and tomatoes pomace (TPP) by-product compared to soft wheat flour (SWF).

Samples	Total phenolic contents (mg GAE /g sample)	Total flavonoids content (QE µg / g sample)	DPPH radical scavenging (%)
SWF	34.05±0.05	25.30±0.02	21.19±0.03
OPP	312.286±9.4	122.609±13.2	65.203±1.8
TPP	516.520±11.8	101.786±11.5	83.574±3.5

Where: **GAE: Gallicacid;** QE: quercetin

3.5. Phenolic acids profiles:

The standard phenolic acids (Gallic, Protocatechuic, p-hydroxybenzoic, Gentisic, Cateachin, Chlorogenic, Caffeic, Syringic, Vanillic, Ferulic, Sinapic, Rutin, p-coumaric, Apigenin-7-glucoside, Rosmarinic, Cinnamic, Qurecetin, Apigenin, Kaempferoland Chrysin) were investigated in SWF, OPP and TPP are shown in Table 5.Gallic, Ferulic, Sinapic, Rosmarinic and Qurecetinwere the predominant phenolic acids in TPP with

a concentration of 42.03, 728.13, 159.35, 173.35 and 81.46 µg/g, respectively while, p-hydroxybenzoic, Cateachin, Caffeic and Apigenin acids were the predominant phenolic acids in OPPwith a concentration of 47.14, 45.96, 59.37 and 187.05 µg/g, respectively. Meanwhile, Gentisic, Rutin and Chrysin were not detected these results are in agreement with observed by **authors [45- 49].**

Table (5): Phenolic acids profiles (ug/g) of orange peels (OPP) and tomatoes pomace (TPP) by-product compared to soft wheat flour (SWF).

Compound	SWF	OPP	TPP
Gallic	15.22	26.09	42.03
Protocatechuic	ND	ND	6.06
p-hydroxybenzoic	1.79	47.14	ND
Cateachin	ND	45.96	ND
Chlorogenic	ND	8.05	10.75
Caffeic	ND	59.37	16.99
Syringic	1.88	ND	ND
Vanillic	1.82	3.84	31.54
Ferulic	30.21	ND	728.13
Sinapic	ND	34.62	159.35
p-coumaric	6.00	ND	9.83
Apigenin-7-glucoside	2.55	ND	18.16
Rosmarinic	2.22	6.94	173.35
Cinnamic	1.26	11.32	28.25
Qurecetin	ND	10.28	81.46
Apigenin	ND	187.05	7.09
Kaempferol	6.44	ND	4.05

3.6. Amino acids composition of raw materials:

The composition of amino acids in raw materials is an important factor in determining the nutritional value of food, particularly its protein content. This value is influenced by both the overall profile of amino acids and the specific quantities of essential amino acids present **[50].** The Table (6) provides the composition of amino acids in TPP, OPP, and SWF. The TPP comprises a majority of amino acids. The TPP formulation exhibits much higher concentrations of all specified amino acids as compared to OPP or SWF. Additionally, it demonstrates that TPP have a higher abundance of total essential amino acids in comparison to the OPP and SWF. Simultaneously, it also contains a significant amount of nonessential amino acids. Moreover, the amino acids TPP, glutamic acid, proline, and tyrosine exhibited the highest prevalence across proteins. The predominant essential amino acids found in the protein of seeds were Methionine (64.05 mg/gm), Valine (50.82 mg/gm), Threonine (46.97 mg/gm), and Isoleucine (33.71 mg/gm). The most prevalent essential amino acids in OPP were Threonine (92.13 mg/gm), Methionine (66.72 mg/gm), Lysine (64.50 mg/gm), and Valine (49.21 mg/gm). Cysteine and Aspartic acid exhibited the lowest levels among the amino acids in OPP.OPP is regarded as a valuable source of both necessary and nonessential amino acids. The findings of our study were consistent with the research conducted by **[51-54]**. This indicates that the proteins from tomato waste will significantly contribute to the provision of important amino acids in food products.

Table (6): Amino acids composition of orange peels (OPP) and tomatoes pomace (TPP) by-product compared to soft wheat flour (SWF).

Amino Acids	Results (Amounts mg/gm Protein)		
	SWF	OPP	TPP
Aspartic acid	10.65	17.17	32.64
Glutamic acid	36.4	135.03	103.62
Serine	5.7	24.41	36.88
Glycine	4.8	48.45	30.01
Histidine*	27	22.86	29.15
Arginine	4.6	32.18	33.72
Threonine*	3.4	92.13	46.97
Alanine	5.0	30.61	44.83
Proline	12.9	155.89	166.95
Tyrosine	4.5	137.59	186.34
Valine*	5.4	49.21	50.82
Methionine*	1.9	66.72	64.05
Cysteine	2.6	3.31	10.12
Isoleucine*	5.1	26.25	33.71
Leucine*	8.8	32.46	28.46
Phenylalanine	6.9	23.46	22.99
Lysine*	2.9	64.50	28.83
Total essential amino acids	61.4	377.41	304.98
Total non-essential	87.15	602.64	645.11
E / N	1 :1.41	1 : 1.59	1 : 2.11

Where: *****: Essential amino acids ; ND: not detected ; E/N: essential / non-essential ratio

3.7. Fatty acids composition of tomato seeds oil:

The composition of fatty acids in tomato seeds oil is an essential component of all fats and oils. The complexity of glycerides is primarily determined by the quantity and composition of fatty acids. The chemical properties of lipids are greatly influenced by the contents of their fatty acids **[55]**.The data in Table (7) indicates that the most prevalent fatty acid in TPP oil is linoleic acid, with a value of 47.94%.

This is followed by oleic acid and then palmitic acid in TPP oil. According to the Table, the TPP oil contained 26.38% saturated fatty acids and 73.62% unsaturated fatty acids. The substantial quantities of unsaturated fatty acids, particularly essential fatty acids, contribute to enhancing the nutritional properties of TPP oil. The results align with those previously documented by **authors [56, 57, and 30].**

Table (7): Fatty acid composition of TPP

Fatty acids	TPP
Methyl Palmitate (C16:0)	14.78
Methyl Stearate (C18:0)	3.99
Methyl Oleate (C18:1)	21.69
Methyl Linolate (C18:2)	47.94
Elcosinoic acid, methyl ester (C20:0)	11.6
Total Saturated fatty acid	26.38
Total Unsaturated fatty acids	73.62

Where: TPP: Tomato peel powder

3.8. Volatile compounds of TPP and OPP:

The volatile compounds of TPP and OPP. The GC-MS analysis was used to characterize the volatile oils extracted from tomato peels [Table 8]. A total of 24 components were detected, accounting for 99.65% of the total oils. The major chemicals in the TPP were D-Limonene (67.13%), Toluene (5.6%), Benzene (3.49%), β-Pinene (2.35%), Isomenthone (1.95%), p-Cymene (1.51%), and Dimethylsilanediol (1.44%). Nineteen components, as shown in [Table 9], were discovered, accounting for 99.65% of the total oils. The major chemicals found in the OPP essential oil were D-Limonene (76.24%), Linalool (4.84%), β-Myrcene (4.31%), Valencene (2.54%), Decanal (2.02%), Nerol (1.61%), and 1-Octanol (1.38%). **Authors [58- 61]** conducted studies on the same species in Egypt, Iran, Spain, Mexico, and the USA, and their findings were similar. The variations in the primary constituents of the essential oil can be ascribed to diverse cultivation conditions, geographical locations, seasonal fluctuations, and extraction techniques **[62].**

Table (8): Volatile compounds (expressed as area units (AU) x $10^8 g^{-1}$ of sample) of Tomato peel powder

Peak	Components	R_t	Area Sum %
1	Benzene	2.697	3.49
2	Dimethylbutadiyne	2.943	0.53
3	Dimethylsilanediol	3.71	1.44
4	Toluene	4.288	5.6
5	p-Xylene	7.075	2.3
6	Styrene	7.813	2.43
7	6-Methyl-5-heptene-2-one	11.778	0.78
8	β-Pinene	11.91	2.35
9	p-Cymene	13.358	1.51
10	D-Limonene	13.609	67.13
11	2-Propynylbenzene	14.199	0.37
12	Benzeneacetaldehyde	14.262	0.61
13	γ-Terpinene	14.931	0.67
14	Linalool	16.94	2.65
15	Nonanal	17.117	0.78
16	Methyl octanoate	18.101	0.51
17	(E)-Limonene oxide	18.639	0.53
18	Isomenthone	19.366	1.95
19	Estragole	21.471	1.08
20	Decanal	21.832	1.32
21	Pulegone	23.337	0.44
22	(-)-Carvone	23.543	0.45
23	Valencene	32.967	0.46
24	Palmitic acid	41.241	0.63

Table (9): Volatile compounds (expressed as area units (AU) x $10^8 g^{-1}$ of sample) of Orange peel powder

Peak	Components	RT	Area Sum %
1	β-Myrcene	11.921	4.31
2	Octanal	12.453	0.95
3	D-Limonene	13.844	76.24
4	1-Octanol	15.635	1.38
5	Linalool	16.985	4.84
6	Nonanal	17.128	0.53
7	Isomenthone	19.377	0.62
8	α-Terpineol	21.134	1.1
9	Decanal	21.843	2.02
10	Nerol	22.913	1.61
11	Copaene	28.87	0.42
12	β-Elemene	29.488	0.41
13	Dodecanal	30.094	0.41
14	β-Caryophyllene	30.443	0.58
15	β-Copaene	30.781	0.38
16	cis-β-Farnesene	31.754	0.34
17	Valencene	32.972	2.54
18	δ-Cadinene	33.917	0.95
19	2,6-Dimethyl-10-methylene-2,6,11-dodecatrienal	37.556	0.37

4. Conclusion

The objective of this study was to generate tomato pomace (TPP) and orange peel (OPP) powders as a food additive materials from the waste of food industry. From the obtained results it could be concluded that these by-products could used as a functional food additive to several bakery products.

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