EFFECT OF USING TOMATO PEELS AS A FAT REPLACER ON THE SENSORY, NUTRITIONAL AND PHYSICAL PROPERTIES OF BEEF BURGER AND SAUSAGES

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ABSTRACT

This study was proposed to investigate the effect of using tomato peels as a fat replacer on the quality of meat products. Chemical composition and minerals content of tomato peels were determined. Identification and quantification of amino acids, fatty acids and phenolic compounds of tomato peels were performed. Sensory attributes, physical properties and chemical composition of final meat products were also determined. The results revealed that tomato peels contain 7.55% crude protein, 7.25% ether extract, 45.64% crude fiber and 5.09% ash. The most predominant elements in tomato peels were potassium, magnesium, sodium and calcium followed by iron, manganese, zinc and copper. Tomato peels protein contains high levels of essential amino acids such as valine, phenylalanine, lysine, leucine and isoleucine. The fatty acids profile of tomato peels shows that palmatic and stearic were the predominant saturated fatty acids (33.18 and 30.19% respectively), while lenoleic (17.65%) was the major unsaturated fatty acid. It was identified and quantified 23 phenolic compounds in tomato peels with total content 114.34 mg/100g and the major phenolic compounds were e-vanillic acid, pyrogallol and chlorogenic acid which valued 24.78, 14.42 and 14.07mg/100g, respectively. The dried peels were added to sausages and burger in 5, 10 and 15% as replacement of fat. The results of sensory evaluation indicated that the meat products contained tomato peels until 15% substitution of fat were acceptable. Also, using tomato peels as a fat replacer decreased the fat content on the final meat products and increased protein, ash and fiber contents, consequently, the energy value decreased. The effect of using tomato peels up to 15% as a fat replacer on the physical properties of tested meat products was remarkable.

INTRODUCTION

Recently, more attention has been focused on the utilization of food processing by-products and wastes. Obviously, such utilization would contribute to maximizing available resources and result in the production of various foods. The problems of industrial waste are becoming harder to solve, and much effort will be needed to develop the nutritional and industrial potential of by-products and waste. Tomato *(Lycopersicon esculentum*), is one of the most important vegetable crops in Egypt and all over the world for both fresh consumption and processing. The annual production of tomato in Egypt is 6.3 million ton, 80% of this amount is processed. It generates about 603000 ton /year wastes **(El-Adawy *et al*., 1999).** The fact that the nutritional quality of foods has become an increasingly important factor in the consumer's buying decision and the recommendation by the U.S. Dietary Goals (1977) to obtain more protein from sources low in total fat, saturated fat and cholesterol **(Carlson, *et al*., 1981).** The processing of many fruit and vegetable products generate a large amount of waste. Unutilized wastes not only add to the disposal problem but also aggravate environmental pollution **(Kaur *et al.,* 2005).** Commercial processing of tomato produces a large amount of waste. Tomato paste manufacturing units generate 7-7.5% solid waste of raw material and 71-72% of this waste is pomace. The wet pomace contained 33% seed, 27% skin and 40% pulp **(Sogi and Bawa, 1998)**. Tomato processing waste could be used as essential raw materials in some food items. Wherein, tomato skin comprised a highly colored concentrate and it contains about 11% protein with lysine, valine and leuciene as the most predominant essential amino acids **(Al-Wandawi *et al*., 1985).** Since tomato peel is rich in lycopene, the direct addition of peel to food products could be a way to use this by-product. Adding tomato, tomato products or lycopene to meat could lead to products with health benefits. Few studies have been reported regarding the use of tomato products in meat products **(Calvo *et al*., 2004).** Tomato processing produces a huge bulk of wastes when these wastes unutilized, causes a great environmental pollution. Tomato peels are a valuable source for minerals and dietary fibers **(Arafa *et al.,* 2008).**

Fats impart very desirable mouth feel characteristics as well as physical properties to foods. They also impart highly desirable taste and other sensory attributes such as tenderness and juiciness **(Yackel and Cox, 1992).** Fats in foods serve three basic functions as sources of essential fatty acids, carry of fat soluble vitamins and energy sources (**Papadima and Bloukas, 1991).** Unfortunately, there is an apparent relationship between dietary fat and the development of cardiovascular disease and hypertension (**O'Neil, 1993)**. There is an advice from health organizations to reduce the amount of dietary fat to reduce the risks of chronic disease such as coronary heart disease, some types of cancer and obesity **(Haward *et al*., 2006).**

Finding the way to satisfy the desire for fatty tasting foods while reducing fat intake could be a valuable solution in this respect, and it could also go far towards solving the healthy problems related to the over consumption of fats. Fat replacers can help in both of these areas **(Napier, 1997).** A fat replacer is an ingredient that can be used to provide some or all of the functions of fat, yielding fewer calories than fat (**Schwenk and Guthrie, 1997)**. Carbohydrates-based fat replacers are most popular and can be fully digestible, partially digestible or non-digestible yielding 0-4 kcal/g (**Drewnowski, 1992)**.

Increased proportions of fiber in foods are known to reduce the risk of colon cancer, obesity, cardiovascular disease and several other disorders (**Anon, 2001).** Dietary fibers and pectin are considered as very excellent hypocholesterolemic agents in animals **(Hanczakowski *et al*., 2001).**

The aim of this study was to investigate the utilization possibility of tomato peels as a fat replacer by adding to some meat products and study their effect on the quality of final products.

MATERIALS AND METHODS

Beef meat and other ingredients used to prepare meat products (spices mixture, garlic, onion, sunflower oil and salt) were obtained from local market at Kafr El-Sheikh city, Egypt. Tomato processing wastes were obtained from El-Araby El- Aseel Company at Baltim city, Kafr El-Sheikh, Egypt. All chemicals and solvents used in this study were purchased from El- Gomhorea Company for Chemicals and Drugs, Tanta, Egypt.

Preparation of tomato peels

Tomato processing wastes were washed with tap water and dried at 60^0 C in a drying oven for 18 hours. The dried wastes were screened to separate the seeds from peels. The dried peels were ground into a fine powder, packed in polyethylene bags and stored in refrigerator at 5^0C until further analysis.

Analytical Methods

Gross chemical composition

Moisture, ether extract, ash, crude fiber and crude protein (N x 6.25) of samples were determined according to **A.O.A.C. (2005)**. All analyses were carried out in triplicates and the average was expressed**.** Total carbohydrates content was calculated by subtracting protein, ash and ether extract contents from the total mass of 100 as reported by **Tadrus (1989)**. Available carbohydrates were calculated by subtracting crude fiber content from total carbohydrates. Energy value (Kcal/100g of food) was calculated by sum of multiplying 4 available carbohydrates, 4 protein and 9 ether extract content (% on wet weight basis) as reported by **Liu *et al*. (1990).**

Determination of minerals content

Minerals content of tomato peels was determined after wet ashing by 6N HCl using different equipments. The atomic absorption spectrophotometer (Zeiss FMD3) was used to determine the magnesium (Mg), iron (Fe), manganese (Mn), Zinc (Zn), copper (Cu), Lead (Pb) and cadmium (Cd) according to the method of Chapman and Pratt (1978). The flame photometer was used for the determination of potassium (K), sodium (Na) and calcium (Ca) according to the method described by Pearson (1991). Phosphorus (P) was estimated photometrically according to the method in A.O.A.C. (2005).

Identification and quantification of amino acids

The amino acids composition was determined using amino acid analyzer (Beckman amino acid analyzer, Model 119CL) according to the method of **Duranti and Cerletti (1979)** in National Research Center, Cairo, Egypt.

Chemical score of amino acids

Chemical score of essential amino acids was calculated using the **FAO/WHO (1991)** reference pattern; following the equation of **Pellet and Young (1980)** as follows:

$$\text{Chemical score} = \frac{\text{Determined essential amino acid (g/100g protein) in sample}}{\text{Its recommended amount (g /100g protein) in FAO/WHO}} \times 100$$

The amino acid that shows the lowest value of chemical score among the essential amino acids is called limited amino acid.

Computed protein efficiency ratio (C-PER)

C-PER was estimated, on the basis of amino acid profile, according to the regression equation proposed by **Alsmeyer *et al*. (1974).**

C-PER = -0.468 + 0.454 (Leucine) - 0.105 (Tyrosine).

Computed biological value

Computed biological value of potato, tomato and orange peels protein was calculated according to its C-PER as reported by **Farag *et al.* (1996**) using the following equation:

Biological value (BV) = 49.9 + 10.53 C-PER

Where C-PER = computed protein efficiency ratio.

Identification and quantification of phenolic compounds using HPLC

Phenolic compounds were extracted from tomato peels using 95% methanol according to the method of **Rodriguez de Sotlillo *et al*., (1994)**. Phenolic compounds of tomato peels methanolic extract were identified using HPLC Hewllet Packared (series 1050). Retention time and peak area were used to calculate phenolic compound concentration by the data analysis of Hewllet Packared software according to the method of **Anderson and Pederson (1983).**

Determination of fatty acids composition

Fatty acids composition of tomato peels were carried out by gas liquid chromatography apparatus GC Model: Shimadzu – 4CM (PFE) in the central laboratory, Fac. of Agric., Alex. Univ. according to the procedure of **Radwan (1978).** Fatty acid was expressed as a percentage relative to the total fatty acids.

Technological methods

Preparation of sausage

Sausage was prepared from minced meat of beef according to **Chatong *et al.* (2007)** with some modifications. Fat was removed by knife to obtain red muscles. Mass of 300g red meat was mixed with 50g kidney fat, 3g spices mixture, 6g sodium chloride and 6g garlic. The aforementioned ingredients were used to prepare the control sample while 5, 10 and 15% of control fat content were replaced by dried tomato peels to prepare sausage supplemented with tomato peels as a fat replacer. The mixture was minced with 5g ice water using electro meat mincer (Japan Ek400 MG). Then electric chopper was used in filling sheep intestine with sausage mixture and formed into asymmetrical shape as Egyptian market. Sausage was cooked in boiling water for 30 min then fried with a little of oil at 170^{o}C in electro frying pan for 8 min (4 min per side).

Preparation of burger

Burger was prepared from beef meat according to **El-Akary (1986)** with some modifications. Fat was removed by knife to obtain red muscles. Mass of 300g red meat were mixed with 50g kidney fat, 50g bread sticks, 3g spices mixture(50% black pepper, 30% coriander, 5% cubeb, 5% clove, 5% cinnamon and 5% red pepper),6g sodium chloride and 3g dried onion. The aforementioned ingredients were used to prepare the control sample while 5, 10 and 15% of control fat content were replaced by dried tomato peels to prepare burger supplemented with tomato peels as a fat replacer. The mixture was minced with 30g ice water using electro meat mincer (Japan Ek400 MG). After mixing, the mixture was cut to small pieces (about 50g weight) and round by hand. The pieces were formed into patties using a Hollymatic machine (Model 200 U) with 10 cm diameter and 8 mm thickness. The burger patties were fried with a little oil at 170^{o}C for 10 min (5 min per side).

Sensory evaluation

Sensory evaluation of prepared burger and sausage was performed by ten trained panelists in Food Technology Department, Fac. of Agric., Kafrelsheikh Univ. using nine-point hedonic-scale ratings for color, taste, aroma, texture, tenderness and overall acceptability (**Watts *et al.*, 1989).**

Physical evaluation of meat products

Cooking loss and cooking yield

Cooking loss values were determined by calculating the difference of sample weight before and after cooking or frying using the following equation according to **Crehan *et al*. (2000)**.

$$\text{Cooking loss \%} = \frac{\text{Sample wt. before cooking - Sample wt. after cooking}}{\text{Sample wt. before cooking}} \times 100$$

Cooking yield % = 100 – Cooking loss %

Feder number

Feder number was determined in sausage and burger according to the procedure described by **Pearson (1976),** using the following equation:

$$\text{Feder number} = \frac{\text{Moisture content \%}}{\text{Organic nonfat content \%}}$$

Where: organic nonfat % = 100 – (% fat + % ash + % moisture)

Texture indices:

Protein water coefficient and protein water fat coefficient

Protein water coefficient (PWC) and protein water fat coefficient (PWFC) were determined by the method of **Tsoladze (1972) and** calculated as follows:

$$\text{PWC} = \frac{\text{Protein content \%}}{\text{Moisture content \%}}$$

$$\text{PWFC} = \frac{\text{Protein content \%}}{\text{Moisture content \% + fat content \%}}$$

Results and Discussions

Chemical composition of tomato peels

Proximate chemical composition

The proximate chemical composition of tomato peels is presented in Table (1). It could be observed that tomato peels contain moisture 9.59%,crude protein 7.55% and ether extract 7.25%.

Table (1): Proximate chemical composition (on dry weight basis) of tomato peels

Components %	**Tomato peels**
Moisture	**9.59**
Dry matter	**90.41**
Crude protein (N x 6.25)	**7.55**
Ether extract	**7.25**
Ash	**5.09**
Crude fiber	**45.64**
Total carbohydrates	**80.12**
Available carbohydrates	**34.48**

Data presented in the same Table reveal that tomato peels contain a high content of ash (5.09%) in addition they are good source of crude fiber which constituted 45.64% indicating that if these peels are used as a fat replacer,they will reduce the energy intake consequently, avoid the obesity. According to Thompson et al. (2004), total energy, total fat and saturated fat intakes were found to be significantly correlated with an increased body mass index. Del Valle et al., (2006) found that tomato pomace (a mixture of peels and seeds which represented around 4% of the whole fruit weight) contain 59.03% crude fibers, 25.73% total sugars, 19.27% crude protein, 7.55% pectin, 5.85% total fat and 3.92% minerals. The results of Abdel-Hady et al. (2013) showed that tomato peels contain a high amount of crude fiber (51.50%) and a middle amount of protein (9.31%). They also found that tomato peels contained 1.33% ether extract and 5.17% ash. Salem (2013) determined also the chemical composition of tomato peels powder on dry weight basis and found that it contains 11.72 % protein, 4.70% lipids and 3.71% ash. The variations between the obtained results and these previous reported may be attributed to the effect of the cultural practices and the differences of tomato cultivars or processing.

Minerals content of tomato peels

Minerals composition of tomato peels is presented in Table (2). The results indicated that phosphorus, potassium and magnesium were the major elements, which figure more than 80% of total minerals, followed by calcium then sodium in tomato peels. Tomato peels contain 3.15, 0.79 and 1.33mg/100g of manganese, iron and zinc, respectively but they are free of cadmium and lead.

Table (2): Minerals content (on dry weight basis) of tomato peels

	Elements										
	P	Na	Ca	Mg	K	Mn	Fe	Zn	Cu	Pb	Cd
Amount as mg/100 g	154.6	23.53	53.35	84.1	111.1	3.15	0.79	1.33	0.40	0.00	0.00
% of total minerals	35.76	5.44	12.34	19.45	25.70	0.73	0.18	0.31	0.09	0.00	0.00

These results are in agreement with those reported by **Al-Wandawi *et al.,* (1985)** who found that the major elements in tomato skins were potassium, magnesium, sodium and calcium, but the minor elements were iron, manganese, zinc and copper. **Shams El-Din & Abdel-Kader (1997)** found that the most predominant elements in tomato processing wastes were P, K, Mg, Na and Ca but the minor elements were Fe, Mn, Zn and Cu. Also, **Arafa, *et al.* (2008)** determined the minerals content of tomato peels and found that the P, K, Mg, Na and Ca are the major elements but the elements Fe, Mn, Zn and Cu are in fewer values. The obtained results indicate that the tomato peels when added to food products would improve their minerals content.

The amino acid composition of tomato peels

Protein quality is primarily assessed by comparing its amino acid composition with standard reference patterns, and the relative quantities of the various amino acids, in particular the essential amino acids, in the food could be used as reliable estimates of actual protein quality **(FAO/ WHO, 1991**). Data presented in Table (3) show the essential amino acids composition of tomato peels were higher than that the pattern recommended by the **FAO/ WHO (1991**). Results in the aforementioned Table indicated that the protein of tomato peels contained all essential amino acids, and met human requirements for adults which reported by **FAO/WHO (1991)**. Total essential amino acids of protein from tomato peels was 49.82% and this value is aproximatly equal that of whole egg (49.5%) and higher than that recommended by **FAO/WHO (1991)** (12.7%).

The results indicated also that phenylalanine (8.93%) followed by valine (6.78%) and lysine (6.28%) are the major essential amino acids but, cystine, methionine and histidine are the minor one. It is considered to mention that values of aromatic amino acids (phenylalanine + tyrosine), isoleucine, therionine and valine in tomato peels protein are higher than those of whole egg which reported by **FAO/ WHO (1985)** as shown in Table (3). Data presented in the same Table(3) clearly indicated that aspartic acid is the most abundant nonessential amino acids of tomato peels protein followed by glycine. The obtained results are particularly agreement with those of **Attia *et al.,* (2000),** who found that the major essential amino acids in tomato peels protein were leucine, lysine, phenylalanine and valine, but the minor essential amino acids were therionine and methionine. They found also that the major non-essential amino acids in tomato peels protein were aspartic, glutamic and serine but cystine was the limited essential amino acid. **Arafa *et al.* (2008)** determined the amino acids composition in tomato peels protein and found that the most predominant essential amino acids in peels were leucine, valine, lysine, phenylalanine and isoleucine, while methionine was the lowest amino acid. They also found that glutamic and aspartic were the most predominant nonessential amino acids. The results in Table (3) indicated that the tomato peels protein considers a good source for essential and nonessential amino acids but not for sulfur containing amino acids.

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Table (3): Amino acids composition (g/100g protein) of tomato peels protein

Amino Acids	Tomato peels	Whole egg	FAO/ WHO,1991
Essential Amino Acids (EAA)			
Histidine	1.98	2.2	1.6
Isoleucine	5.78	5.4	1.3
Leucine	5.69	8.6	1.9
Lysine	6.28	7.0	1.6
Methionine	1.49		
Cystine	1.98		
Methionine + Cystine	3.47	5.7	1.7
Phenylalanine	8.93		
Tyrosine	5.79		
Phenylalanine + Tyrosine	14.72	9.3	1.9
Threoinine	5.12	4.7	0.9
Valine	6.78.	6.6	1.3
Total EAA	**49.82**	**49.5**	**12.7**
Non essential amino acids (NEAA)			
Alanine	5.95		
Arginine	5.45		
Aspartic acid	10.74		
Glutamic acid	4.96		
Glycine	8.93		
Proline	5.29		
Serine	4.96		
Total NEAA	**46.28**		
EAA/NEAA	**1.08**		

In general, it could be concluded that tomato peels protein contains all of essential amino acids in favorable amounts and the total percentage is higher than that recommended pattern of **FAO/ WHO (1991).** Moreover, their protein contains all of nonessential amino acids in high amounts.

Chemical score of essential amino acids in tomato peels

The essential amino acid scores of tomato peels protein was calculated and the data were recorded in Table (4).

The data in Table (4) indicate that all essential amino acids of tomato peels protein are present in excessive chemical scores. The chemical scores of aromatic amino acids (phenylalanine + tyrosine), isoleucine, therionine and valine in tomato peels protein are higher than those of whole egg (as a reference protein). In contrast, chemical scores of leucine, lysine, sulfur amino acids and histidine are lower than those of whole egg. The results also show that histidine is the first limited amino acid and sulfur containing amino acids (methionine + cystine) are the second limited amino acid in tomato peels protein.

Table (4): Chemical score(cs) of essential amino acids of tomato peels

Amino acid	Tomato peels		Whole egg		FAO/ WHO 1991
	g/100g protein	CS	g/100g protein	CS	
Isoleucine	5.78	444.6	5.4	415.4	1.3
Leucine	5.69	299.5	8.6	452.6	1.9
Lysine	6.28	392.5	7.0	437.5	1.6
Methionine + Cystine	3.47	204.1	5.7	335.3	1.7
Phenylalanine + Tyrosine	14.72	774.7	9.3	489.5	1.9
Threoinine	5.12	568.9	4.7	522.2	0.9
Valine	6.78.	521.5	6.6	507.7	1.3
Histidine	1.98	123.8	2.2	137.5	1.6

Computed protein efficiency ratio and biological value of tomato peels

The data of computed protein efficiency ratio (C- PER) and computed biological value (C-BV) are given in Table (5) compared with casein as a reference protein.

Table (5): Computed protein efficiency ratio (C-PER) and biological value (BV) of tomato peels protein compared with casein

Samples	C-PER	C-BV
Tomato peels	1.51	65.80
Casein*	2.50	76.23

*FAO\WHO (1991).

From the data given in Table (5), the C-PER and C-BV of tomato peels were low compared with casein. These results can be related to the low amounts of leucine and tyrosine, the only two amino acids which were considered for the calculation of C-PER, and consequently, the C-BV, as well. Further more, it should also taking into consideration that the cholesterol- lowering affect of dietary proteins is correlated to their contents of some amino acids, especially arginine, lysine and methionine, which play an important role in the process of lipogenesis **(Metwalli, 2005).**

Fatty acids composition of tomato peels oil

Based on the data recorded in Table (6), 14 fatty acids were identified in tomato peels oil. These fatty acids are different in carbon chain length and in the number of unsaturated (double) bonds present. It could be noticed that there was a predominance of fatty acids containing a wide number of carbon atoms. The results reveal also that the most of fatty acids in tomato peels oil are saturated, which amounted 70.50%.

Table (6): Fatty acids profile (g/100g oil) of tomato peels oil

Carbon atoms	Fatty acid	Tomato peels oil
Saturated fatty acids		
8:0	Caprylic	0.13
13:0	Tridecylic	2.41
15:0	Pentadecylic	3.35
16: 0	Palmatic	33.18
18: 0	Stearic	30.19
23: 0	Tricosanoic	1.24
Total Saturated fatty acids		**70.50**
Unsaturated fatty acids		
15:1	Pentadecyloleic	3.13
16: 1	Palmitoleic	0.59
18: 1	Oleic	0.10
20: 1	Gadoleic	3.11
22: 1	Erucic	1.96
18: 2	Linoleic	17.65
20: 2	Eicosadienoic	2.45
22: 2	Docosadienoic	0.81
Total Unsaturated fatty acids		**29.50**

The results in the same Table show that palmatic and stearic were the predominant saturated fatty acids (33.18 and 30.19% respectively), while lenoleic (17.65%) was the major unsaturated fatty acid. Further more, it should also taking into consideration that tomato peels oil contained 1.96% erucic acid. **Shams El-Din and Abd El-Kader (1997)** determined the fatty acids composition of total tomato processing wastes lipids and they found that linoleic was the major fatty acid (56.94%), followed by oleic (22.3%) and palmatic (14.81%). Total saturated fatty acids were 21.37%, while total unsaturated fatty acids were 78.63%. **Arafa *et al.* (2012)** found that linoleic acid was the most abundant fatty acid in tomato peels oil, which valued 36.79% followed by palmatic and oleic.

Phenolic compounds composition of tomato peels

The results of phenolic compounds composition in methanolic extract of tomato peels (mg/100g dry sample) were recorded in Table (7).

Table (7): Phenolic compounds composition in methanolic extract of tomato peels

Phenolic compound	As mg/100g dry sample	% of total phenolic compounds
Galic	2.16	1.89
Pyrogallol	14.42	12.61
3-OH-Tyrosol	3.46	3.03
4-Amino-benzoic	2.97	2.60
Protocatechuic	7.25	6.34
Chlorogenic	14.07	12.30
Catechol	9.67	8.46
Catechein	7.63	6.67
Caffeine	2.08	1.82
P-Oh-benzoic	2.47	2.16
Caffeic	2.15	1.88
Vanillic	1.15	1.01
Ferulic	0.83	0.73
Iso-ferulic	4.34	3.80
e-Vanillic	24.78	21.67
Reversetrol	1.00	0.87
Ellagic	5.42	4.74
Alpha- coumaric	1.18	1.03
Benzoic	5.07	4.43
3,4,5-methoxy-cinnamic	1.12	0.98
Coumarin	0.24	0.21
p-coumaric	0.79	0.70
Cinnamic	0.09	0.08
Total (∑)	114.34	100

From the data in this Table, it could be observed that 23 phenolic compound were identified and quantified in tomato peels. The major phenolic compounds of tomato peels were e-vanillic acid, pyrogallol, chlorogenic acid and catethol which valued 24.78, 14.42, 14.07 and 9.67 mg/100g, respectively as shown in Table (7). But the minor phenolic compounds were cinnamic, coumarin, p-coumaric, and ferulic acid with values of 0.09, 0.24, 0.79 and 0.83 mg/100g, respectively. **George *et al*. (2004)** found that the free phenolic content (expressed as mg catechin/100g fresh weight) in tomato skin ranged from 10.4 to 40.0 mg/100g. **Toor & Savage (2005)** found that the total polyphenolic content (expressed as mg gallic acid equivalents/100g) of tomato skin was 29.1. **Cetkovic *et al*. (2012)** reported that phenolic acids (caffeic, chlorogenic, p-coumaric, ferulic and rosmarinic acid) and flavonols (quercetin and rutin) were identified in tomato processing wastes. **Abdel-Hady *et al.* (2013)** found only 9 phenolic compounds in tomato peels. They mentioned that tomato peels contained many another phenolic compounds, according to the obtained diagram, but unfortunately, were not identified because their standards were not available.

Effect of tomato peels on sensory properties of meat products

Sensory properties of any food product are the major part of important attributes that affect the consumer choice **(Salem, 2013).** Sensory properties of burger and sausages as affected by replacing fat with tomato peels at different levels (5, 10 and 15%) were evaluated and the results were listed in Table (8).

Table (8): Effect of tomato peels as a fat replacer at different levels on sensory properties of Burger and Sausage

Meat product	Tomato peels level	Sensory properties					
		Taste	Color	Odor	Texture	Tenderness	Overall acceptability
Burger	0%	8.00	8.31	8.00	7.36	7.18	7.73
	5%	7.36	7.27	7.18	7.09	7.09	7.20
	10%	7.09	7.18	7.18	7.00	6.72	7.04
	15%	6.55	6.55	6.91	6.72	6.82	6.71
Sausage	0%	7.78	7.22	7.89	7.44	7.33	7.53
	5%	8.11	8.44	7.89	7.89	7.11	8.07
	10%	7.44	7.33	7.33	6.78	6.72	7.24
	15%	7.44	7.11	7.33	7.11	7.33	7.29

From these results, it could be observed that there are very slight differences between control(0% tomato peel level) sample of burger and that contained 5 and 10% tomato peels as fat replacer for all sensory characteristics. While the scores of these characteristics for burger contained 15% tomato peels instead of fat were low compared with control sample, however they were in the acceptable limits (more than 6). Regarding sausage, it could be noticed that the sample contained 5% tomato peels as fat replacer gained scores for most sensory properties higher than those of control. Moreover, the other samples of sausage which contained higher levels of tomato peels have nearly similar scores of sensory evaluation as control.

As can be clearly seen from Table (8), addition of tomato peels as replacement of fat at 5, 10, and 15% did not have negative effect on the acceptability of burger and sausage. These results are in agreement with those obtained by **Salem (2013)** who reported that addition of tomato peels 3% did not have any negative effect on the acceptability of sausages rather it has partially improved the color of the product. **Calvo *et al*. (2007)** studied the effect of adding tomato peels at 6, 9 and 12g/kg of meat mixture on sensory properties of dry fermented sausages and reported that although the color influenced the preference, all samples showed good overall acceptability.

Effect of tomato peels on chemical composition of meat products

Chemical composition of burger and sausages prepared using tomato peels as fat replacers at different levels (5, 10 and 15%) was determined on wet and dry weight basis and the results were listed in Table (9).

Table (9): Effect of tomato peels as a fat replacer at different levels on chemical composition of burger and sausage

Meat product	Component%	Replacement level							
		On wet weight basis				On dry weight basis			
		0%	5%	10%	15%	0%	5%	10%	15%
Burger	Moisture	62.47	63.85	64.50	65.72	0.00	0.00	0.00	0.00
	Crude protein	15.57	15.16	15.09	14.78	41.50	41.94	42.50	43.13
	Ether extract	12.10	11.39	10.89	10.32	32.25	31.51	30.69	30.12
	Ash	1.51	1.52	1.61	1.63	4.05	4.20	4.53	4.76
	Crude fiber	1.13	1.50	1.74	1.99	3.00	4.15	4.89	5.79
	Total carbohydrates	8.33	8.08	7.90	7.64	22.20	22.35	22.28	21.96
	Available carbohydrates	7.20	6.58	6.16	5.65	19.20	18.20	17.39	16.17
	Kcal/100g	200.0	189.5	183.0	174.6				
Sausage	Moisture	46.50	48.67	51.30	54.20	0.00	0.00	0.00	0.00
	Crude protein	22.60	21.79	20.92	19.77	42.25	42.48	42.96	43.16
	Ether extract	18.70	16.65	15.52	13.85	34.98	32.44	31.86	30.23
	Ash	1.81	1.84	1.89	1.86	3.39	3.58	3.88	4.07
	Crude fiber	1.07	2.18	3.17	3.99	2.00	4.25	6.50	8.72
	Total carbohydrates	10.39	11.05	10.37	10.33	19.38	21.50	21.30	22.54
	Available carbohydrates	9.32	8.87	7.20	6.34	17.38	17.25	14.80	13.82
	Kcal/100g	296.0	272.5	252.2	229.1				

The results indicate that the moisture content was higher in samples containing tomato peels than that of control. The moisture content increased with increasing the replacement level of tomato peels. This result may be due to the high content of fiber in tomato peels may be able to hold more water during the cooking process. **Laban (2004)** found that the addition of pomegranate peels, as a fat replacer at 5, 10 and 15% to prepare low fat burger, resulted in retention of more moisture during cooking due to their ability to bind water.

Protein contents (on dry weight basis) of burger and sausages contained tomato peels were higher than those of control and they increased gradually with increasing the level of tomato peels replacement. The amount of protein in control sample of burger was 41.5% increased to 43.13% in burger prepared with 15% tomato peels as a fat replacer. **Garcia *et al.* (2002)** found that protein content increased with increasing the rate of fat replacers. Furthermore, ash content (on dry weight basis) increased from 4.05% in control samples of burger to 4.76% in that prepared with 15% tomato peels as a fat replacer, while for sausages, ash content increased from 3.39% to 4.07%. Also, the fiber content increased markedly with increasing the replacement level of tomato peels either for burger or sausages. These results attribute to the high content of ash and crude fiber in tomato peels. The obtained results are in harmony with those reported by **Laban (2004),** who found that moisture, protein, ash and fiber contents were considerable higher in beef burger formulated with pomegranate peels and lower in fat than in control. **Bessar (2008)** reported that the high level of fiber in burger can be useful in decreasing cholesterol level in human body.

The results in Table (9) show also that energy value in burger decreased from 200 (in control) to 174.6 Kcal/100g on wet weight basis in burger formulated using 15% tomato peels as a fat replacer with reduction rate about 8%. While in sausages the energy value decreased from 296 in control to 229.1 kcal/100g (on wet weight basis) in sample contained 15% tomato peels as a fat replacer with reduction rate about 23.3%. **Caceres *et al.* (2004)** found that energy values decreased from 279 Kcal/100g in the conventional control to 187 Kcal/100g in the reduced fat sausages with 12% added fiber (the reduction rate was 35%).

Effect of tomato peels on physical properties of meat products

Some physical properties of burger and sausages prepared using different levels of tomato peels as substitution of fat were measured and the data were listed in Table (10).

Table (10): Effect of tomato peels as a fat replacer at different levels on physical properties of Burger, and Sausage

Meat product	Tomato peels level	Physical properties				
		Cooking Loss	Cooking yield	FDR	P W C	P W F C
Burger	0%	30.78	69.22	2.61	0.25	0.21
	5%	25.69	74.31	2.75	0.24	0.20
	10%	22.84	77.16	2.80	0.23	0.20
	15%	20.48	79.52	2.94	0.23	0.19
Sausage	0%	23.25	76.75	1.41	0.49	0.35
	5%	21.47	78.53	1.48	0.45	0.33
	10%	19.73	80.27	1.64	0.41	0.31
	15%	17.74	82.26	1.80	0.36	0.29

From the results in this Table, it could be noticed that cooking loss of control was higher than that of samples prepared with tomato peels. Cooking loss of burger was higher than that of sausages. The loss during cooking decreased with increasing the level of tomato peels. Decrease in the cooking loss with increasing tomato peels level may be due to high fiber content of these peels which bounded more water. The results also indicate that use of tomato peels have a positive effect on cooking yield of meat products. This result is in agreement with that obtained by **Bessar (2008)** who found that the cooking loss in reduced fat burger decreased when the level of rich fiber materials (apple and orange peels) was increased.

Feder number, which is used for assessing the physical properties of meat products, was 2.61 and 1.41 for control samples of burger and sausages, respectively. Feder number of both burger and sausages increased gradually with increasing the replacement level of tomato peels. All values of feder number were kept under 4.0. According to **Pearson (1976),** the feder number in good quality product should not exceed 4.0. These increments in feder number may be due to the increase in water content as a result to increase the fiber content.

The values of protein water coefficient (PWC) and protein water fat coefficient (PWFC), which are considered as indices for tenderness of the prepared burger and sausages, were given inthe same Table (10). The results show that the values of PWC and PWFC of prepared meat products decreased gradually with the increasing of tomato peels level replaced of fat. These decrements relate to the increase occurred in moisture content. These results were in agreement with those published by **Metwalli (2005) and Bessar (2008).**

In general, it can say that the using of tomato peels with meat products as a fat replacer up to 15% lead to increasing protein, fiber, minerals and phenolic compounds but decreasing the fat and energy value without any negative effects on sensory or physical properties.

Moreover, the utilization of these wastes would help in reduction the environmental problems caused by them.

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الملخص العربي

تأثير إستخدام قشور الطماطم كبديل للدهن على الخواص الحسية والطبيعية والغذائية للبرجر والسجق

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أجريت هذه الدراسة بهدف معرفة تأثير إضافة القشور المتخلفة من تصنيع الطماطم بعد تجفيفها وطحنها علي الخواص الحسية والطبيعية والغذائية للبرجر البقري والسجق كبديل للدهون. تم تقدير التركيب الكيماوي ومحتوي المعادن للقشور. تم التعرف علي الأحماض الأمينية والأحماض الدهنية وكذلك تم التعرف علي المركبات الفينولية في هذه القشور. تم إضافة نسب مختلفة من مطحون القشور كبديل للدهن (5 و 10 و 15%) إلي البرجر والسجق وتم تقييم الناتج بعد طهيه من الناحية الحسية والطبيعية وكذلك تم تقدير التركيب الكيماوي وأيضا تم حساب السعرات الحرارية لكل 100 جرام من الناتج النهائي. وأوضحت النتائج ما يلي: قشور الطماطم غنية بالألياف والمعادن وخاصة الفوسفور والبوتاسيوم والكالسيوم والحديد. القشور تحتوي علي معظم الأحماض الأمينية الأساسية وغير الأساسية وبكميات تقترب من كمياتها في بروتين البيض وقد وجد أن بعض الأحماض مثل أيزوليوسين والفالين والثريونين والأحماض الأروماتية كانت كمياتها أعلي منها في البيض. تحليل الأحماض الدهنية أظهر أن الحمض السائد هو البالمتيك والإستيارك واللينوليك. تحتوي قشور الطماطم علي 23 نوع من الفينولات بإجمالي 114ملجم/100جم. عند إضافة مطحون القشور إلي السجق والبرجر حتي 15% كنسبة إستبدال من محتوي الدهن في العينات وتقييم الناتج حسيا أظهرت النتائج أن الخواص الحسية كلها لم تتأثر كثيرا وأخذت قيم قريبة من الكنترول وكلها كانت في مستوي جيد. كذلك الخواص الطبيعية للعينات المضاف إليها مطحون قشور الطماطم حتي نسبة إستبدال 15% من الدهن كانت في الحدود المقبولة وتكاد تكون مثل الكنترول. التركيب الكيميائي للمنتجات أوضح أن العينات المحتوية علي مطحون قشور الطماطم محتواها مرتفع من البروتين والألياف الخام والرماد ومنخفض في الدهن مقارنة بالكنترول. السعرات الحرارية للعينات المحتوية علي قشور الطماطم إنخفض بشكل

ملحوظ حتي وصل الإنخفاض إلي 8% في حالة البرجر و23% في حالة السجق المحتوية علي نسبة إستبدال 15% من قشور الطماطم وذلك مقارنة بالكنترول.

من هذه النتائج يمكن القول بأن إستخدام قشور الطماطم كبديل للدهن بنسب إستبدال حتي 15% مفيد جدا في تقليل الدهن والسعرات الحرارية وزيادة الألياف الخام والمعادن وهذا له تأثير صحي جيد دون التأثير علي الخواص الحسية والطبيعية للحوم المصنعة. في نفس الوقت تبين الدراسة أنه يمكن الإستفادة من هذه المخلفات لتقليل المشاكل البيئية التي قد تنتج من تراكمها.