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The Utilization of Yellow and Red Onion Peels and Their Extracts as Antioxidant and Antimicrobial in Preservation of Beef Burger during Storage

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Abstract Natural antioxidants have gained interest in recent years as a result of their ability to reduce auto oxidation of fats, oils and fat containing food products by replacing synthetic antioxidants. Yellow and red onion peels were chosen as a natural antioxidant source in our study. In addition, the storage stability, TBA, antimicrobial and organoleptic of beef burgers with yellow or red onion peels or extracts were compared to BHT under refrigerated storage at 4±1°C for 15 days. Also cooking measurements (cooking loss, cooking yield, shrinkage and moisture retention) were compared to BHT. The major components in red onion peels were quercetin 11290.09 µg/g and 1761.31 µg/g in yellow onion peels, according to the findings. The results showed that increasing the amount of onion peels enhanced total phenolic, total flavonoids, and antioxidant activities in burgers. Burgers made with onion peel extracts had the highest levels of total phenol and total flavonoids.The cooking yield and moisture retention of beef burgers using onion peels were both improved. The control burger had the most cooking loss, followed by the BHT prepared burger. As yellow or red onion peels and their extract were put to beef burgers, the pH of the beef was much lower when compared to the control. In the sensory acceptance test, there were no significant differences in color, odor, taste, appearance, and overall acceptability of beef burgers prepared with red and yellow onion peel powder and extracts at zero time, while slightly lower or similar judging scores in all organoleptic characteristics were observed in the tested beef burger samples and control sample during storage periods of two weeks. In addition, yellow or red onion peels, as well as their extract, may have antibacterial properties.

Keywords: *red onion peels powder, yellow onion peels, natural antioxidants, antimicrobial*

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1. Introduction

The onion is one of the most common and popular species of vegetables in the world. As production increases, the generation of waste from various portions of the onion, were raising the need for efficient ecological elemination and use of such waste products. On the other hand, onion waste products are a rich source of antioxidants with a variety of biological qualities, thus they might be used in the food and pharmaceutical industries, according to Fredotovi *et al*. [1]. The food sector in Egypt is likely one of, if not the largest, industrial operations. It plays a critical part in meeting the Egyptian people's food needs (about 100 millions in 2020).According to recent reports, food production businesses in wealthy countries, including Egypt, contribute 39 % of all food waste [2]. If not properly exploited, the massive amount of waste created by the food industry generates major environmental difficulties as well as economic losses [3]. The most popular vegetables and fruits in Egypt, such as potatoes, cauliflower, onion and mango, are key sources of food industry by-products. After tomatoes, the onion (*Allium cepa* L.) is the second most significant horticultural crop in the world, with an annual production of roughly 66 million tones. Onion production has increased by more than 25% in the last ten years [4].

According to Benitéz *et al.* [5] the principal onion waste include onion skins, two outer fleshy scales and roots created during industrial peeling as well as undersized deformed onions. Due to customer demand for natural chemicals to replace synthetic compounds as food ingredients, onion wastes that have been treated and stabilized could be beneficial in the food industry as functional ingredients to be added to processed foods. Consumers in the market would embrace compounds of intrinsically natural origin [6].

Furthermore, according to Nuutila *et al*. [7], onions are one of the principal sources of dietary polyphenols in

many countries. Certain sections of onion waste are high in flavonoids, the richest being onion skin, where quercetin and its glycosides are the most abundant antioxidant and radical scavenging compounds [8]. In a study of 28 vegetables and 9 fruits, onions had the greatest quercetin content [9]. Specific sulfur-containing compounds and flavonoids are related to a variety of pharmacological activities, including tumour and microbial cell growth suppression, cancer risk reduction, free radical scavenging, and cardiovascular disease prevention [10]. Due to the high level of quercetin in the red onion skin, quercetin possesses anti-inflammatory, antibacterial, antiviral, antiallergic, cardioprotective, vasodilatatory, and anticarcengenic activity, which has a positive impact on human health [11]. Lipid oxidation is a major source of meat product quality degradation [12], as it has negative impacts on thecolour, flavour, and texture of meat, making these dishes less appealing. Lipid oxidation can have a negativeimpact on the sensory qualities (colour, texture, and flavour) as well as the nutritional quality of meat and meat products [13,14]. Ethanol onion skin extracts, as a natural antioxidant source, have been shown to prevent meat lipid oxidation [15] as well as microbiological deterioration [16].

2. Materials and Methods

2.1. Materials

Red and yellow onion peels were obtained from the New Beni Suef company for Preservation, Dehydration and Industrialization of Vegetables, Beni Suef Elgadida City, Nile East, Beni Suef.

Ingredients of beef burgers: minced meat, onion, starch, salt, garlic, spices and sunflower oil were obtained from local market at Giza and used for manufacture of beef burger. Texturized soy was purchased from Food Technology Research Institute, Agricultural Research Center (ARD), Giza, Egypt.

Chemicals: The 2, 2-diphenyl-1-picrylhydrazyl (DPPH), thiobarbituric acid (TBA) and butylated hydroxy toluene (BHT) were obtained from Sigma-Aldrich Chemical Co. (St. Louis, MO, USA). Nutrient agar, Mac-Conkey agar, Mannitol salt agar and Salmonella agar media used for estimating the microbial growth were obtained from Biolife Italian Company dealer at Cairo.

2.2. Methods

Preparation of onion peels and their extracts

The onion peels were removed, cleaned, washed under running tap water, air-dried, and processed to powder in an electric grinder at a temperature of 25°C, then sieved (35 meshes) and stored at room temperature until use. The onion peels extract was prepared according to the method of Ifesan *et al*. [17]. Twenty grams of sample was soaked in 200 ml of hot water (40°C) in water bath for 24 hrs. The extract was filtrated through a Whatman filter paper 125 mm (No 1) at room temperature. The filtrate was evaporated under reduced pressure in a rotary evaporator at 45°C until the extracts became completely dry, and then was stored at and the extracts were stored at −18°C until usage.

Extraction yield

The extraction yield for hot water (40°C) was calculated by subtracting the dried weight of (plant material) yellow and red onion peels residue after extraction from the weight of the original plant material.

Manufacture of beef burgers

In the Experimental Kitchen of the Food Technology Research Institute (FTRI), Agricultural Research Center (ARC), eleven beef burger blends were processed. Texturized soy protein was rehydrated (by combining one part powdered soy protein with two parts tap water) before being added to the beef burger mixtures. 0 percent (control), BHT (200ppm), YOPP800 ppm (5.10g from yellow onion peels powder equivalent 800ppm extract), YOPP1000 ppm (6.40 g from yellow onion peels powder equivalent 1000 ppm extract), ROPP800 ppm (5.90 g from red onion peels equivalent 800ppm extract), ROPP1000 ppm (6.40 g from red onion peels powder equivalent 1000 ppm extract), ROPP1000 (7.40 g from red onion peels equivalent 1000ppm extract). EYOP (extract yellow onion peels) and EROP (extract red onion peels) added 800 ppm and 1000ppm individually. The ingredients of each blends burger were homogenized in Braun Cutter Machine (CombiMax 700, USA), then homogenized meat mixture and processed into burger of about 60 gm weight, 8 cm diameter and 1 cm in thickness.

Antioxidant activity

According to Thaipong *et al*. [18], the radical scavenging activity of onion peel powder, extract, and beef burger at zero time and end period storage were investigated using 2, 2-Diphenyl-1-picrylhydrazyl (DPPH). Each sample (500 µl) was added to a methanolic DPPH radical solution (1 ml) (final concentration of DPPH was 0.2 m M). The mixture was briskly agitated and allowed to rest for 30 minutes at room temperature. At 517 nm, the absorbance of the solution was determined spectrophotometrically. The percentage of DPPH decrease achieved by each extract was compared to BHT in this test. Scavenging activity was calculated as a percentage inhibition using the formula: (Control Absorbance Sample Absorbance)/Control Absorbance = percent Anti-radical activity.

Total phenolics

According to Singleton *et al*. [19], the phenolic component content of red and yellow onion peels was measured calorimetrically using the Folin–Ciocalteu reagent (as gallic acid/g extract).

Total flavonoids

Total flavonoids content was determined using aluminium chloride ($Alcl_3$) according to the method of Slimestad *et al*. [20]. The results were expressed as mg quercetin equivalents/g extract of yellow and red onion peels.

Identification of phenolic compounds and flavonoids in yellow and red onion peels

Phenolic concentrations of yellow and red onion peels were determined by HPLC like the method described Hossain *et al*. [21]. As follows: 1g of sample and 0.1g of extract were mixed with 20 ml methanol (99.90%) and centrifuged at 10000 rpm for 10 min ((HERMLE Z206A, Germany) and therefore the supernatant was filtered through a 0.2 µm Millipore then 1-3 ml was collected in vial for injection into HPLC Hewlett Packard (series 1050), using equipped with a variable wave length

detector (Agilant, Germany) 1100. Also the HPLC was equipped with auto sampler, Quaternary pump degasser and column compartment. Analyses were performed on a C18 reverse phase packed stainless-steel column (4×250 mm, i.d.), malti wavelength detector set at 330 nm and 280 nm for detection of flavonoids and phenolic compounds, degasser, column used for fractionation Zorbax OD.4.6x250nm and also the flow rate of mobile phase during run was 1 ml/min. The column temperature was maintained at 35°C. HPLC method started with linear gradient at a flow rate of 1.0 ml / min with mobile phase of water / acetic acid (98: 2 v/v, solvent A) and methanol / aceto nitril (50: 50, v/v, solvent B), starting with 5 % B and increasing B to levels of 30% at 25 min, 40% at 35 min, 52% at 40 min, 70% at 50 min, 100% at 55 min. The initial condition was re-established by 5 min wash in both solvents.

The percentages of meat beef burger ingredients are illustrated in Table 1.

Determination of physical characteristics of burger samples

Cooking characteristics

Moisture retention, shrinkage, cooking loss and cooking yield of the beef burger like blends were determined according to El-Magoli *et al*. [22]. The detail procedures are described below: Moisture retention (%) = (percent yield x % moisture in cooked beef burger like)/ 100.

Table 1. The percentage of ingredient in beef burger samples (g/100g)

Ingredients	Minced Meat	BHT	YOPP	EYOP	ROPP	EROP	Spices	Textured soya	Onion	Garlic	Starch	Salt
Control	68.00						1	17	6	1	5	2
BHT_{200ppm}	67.80	0.2					1	17	6	1	5	2
$YOPP_{800\ ppm}$	62.90	---	5.10	-----			1	17	6	1	5	2
$YOPP_{1000\ ppm}$	61.60	---	6.40				1	17	6	1	5	2
$EYOP_{800\ ppm}$	67.20			0.80			1	17	6	1	5	2
$EYOP_{1000\ ppm}$	67.00			1.00			1	17	6	1	5	2
$ROPP_{800\ ppm}$	62.10				5.90		1	17	6	1	5	2
$ROPP_{1000\ ppm}$	60.60				7.40		1	17	6	1	5	2
$EROPP_{800\ ppm}$	67.20					0.80	1	17	6	1	5	2
$EROPP_{1000\ ppm}$	67.00					1.00	1	17	6	1	5	2

YOPP = yellow onion peels powder, **EYOP**= extract yellow onion peels, **ROPP**= red onion peels powder and **EROP**= extract red onion peels.

$$\text{Shrinkage\%} = \frac{\left[\begin{array}{l}(\text{Raw thickness} - \text{Cooked thickness}) \\ +(\text{Raw diameter} - \text{Cooked diameter})\end{array}\right]}{\text{Raw thickness} + \text{Raw diameter}} \text{x}100$$

Cooking loss was calculated according to the following equation:

$$\text{Cooking loss\%} = \left[\frac{\left(\begin{array}{l}\text{weight of raw sample} \\ -\text{weight of cooked sample}\end{array}\right)}{\text{weight of raw sample}}\right] \times 100.$$

$$\text{Cooking yield\%} = (\text{Cooked weight x } 100) / \text{Raw weight.}$$

pH of beef burger samples

In a blender, a 10 g uncooked beef burger sample was homogenised for 1 minute in 90 ml distilled water. The pH values were determined using a Jenway pH metre (Jenway 3510; Jenway Ltd., Essex, UK) with a glass electrode at 25°C utilising A.O.A.C. [23] techniques.

Determination of thiobarbituric acid (TBA). The thiobarbituric acid (TBA) distillation process was used, as described by Tarladgis *et al*. [24]. TBA levels of processed beef burger-like blends were determined using a colorimetric technique at 538 nm with a digital spectrophotometer Spekol 11 No. 849101 (as mg malonaldehyde / kg sample).

Microbiological evaluation of different samples

The microbiological evaluation of yellow and red onion peels powder, their extracts and burger samples include; the determination of total plate count and the detection of coliform group, *Staphylococcus aureu* and *Salmonella* spp.

Sample preparation

5g of each tested samples was weighted under aseptic conditions and transferred into a sterile flask. A known volume of sterile water (45 ml) was added and shacked for 2-3 min, then different dilutions were made (1/10, $1/10^2$, $1/10^{3,}$ $1/10^4$, $1/10^5$and $1/10^6$).

Microbiological analysis

On nutrient agar medium, the total plate count (CFU/g sample) was determined. Plates were incubated for 48 hours at 37°C [25]. According to [26], *Staphylococcus aureus* was determined on Mannitol salt agar medium, and plates were incubated at 37°C for 48 hours. On Mac-Conkey agar, the coliform group was determined. Plates were incubated at 37°C for 48 hours, following the APHA technique [25]. Difco *Salmonella Shiguella* agar medium was used to detect *Salmonellaspp.* The plates were incubated for 48 hours at 37°C [26].

Organoleptic evaluation

Cooked beef burgers, as well as samples, controls, BHT, and tested peels and extracts (red and yellow onion), were organoleptically evaluated by 20 panellists from the Food Technology Research Institute (FTRI) at zero time and at the end of the storage period (15 days). Color, odor, texture, taste, tenderness, appearance, and overall acceptability of cooked samples were assessed by panellists using the approach established by AL-Mrazeeq *et al*. [27].

Statistical analysis

All assessment data were subjected to an analysis of variance (ANOVA) and Duncan's multiple range tests, both of which were performed using SAS statistical [28]. The results were presented as mean ± SE, with a significance level of 0.05.

3. Results and Discussion

Antioxidants can prevent lipid peroxidation by preventing chain inhibition by scavenging starting radicals, interrupting chain reactions, decomposing peroxides, lowering localized oxygen concentrations, and binding chain initiating catalysts such metal ions [29]. Total phenolic content and total flavonoids may be an indication that flavonoids are the most compounds answerable for the antioxidant activity in onions sections. Data in Table 2 revealed that the ROPP had significantly higher ($P < 0.05$) antioxidant activity and total polyphenol content than YOPP.

Additionally, the total phenols contents within red onion peels had a higher extract than yellow onions. Data in Table 2 showed that the extracts with the highest level of total phenols, flavonoid content, and antioxidant activity. The onion (Allium cepa L.) is one of the world's oldest cultivated vegetables, with a high content of dietary flavonoids. [20], Onion skin, according to Bedrnek *et al.* [31], could be a rich natural source of flavonoids, and their aqueous extracts (as an environmentally friendly solvent) could be employed as an antioxidant material for meat products. This demonstrates that red onion peels have a higher antioxidant content than yellow onion peels, which is in accordance with the findings of the many author [8,32,33]. The extraction yield % of yellow onions peels powder was higher than that of red onions peels powder, according to Table 2. Qualitative HPLC analysis of the main peaks of the red and yellow onion peels was supported the comparison of their retention times with reference standards. The following polyphenols were identified in red and yellow onion peels: gallic acid, chlorogenic acid, catechin, naringenin, propyl gallate, quercetin, and, cinnamic acid. The main compound in red onion peels was querectin (11290.09 µg/g) and therefore the lower one was propyl gallate (Table 3). However, querectin was identified because the largest phenolic compound as 1761.31 µg/gin yellow onions peels, but less than red onion peels. Propyl gallate and cinnamic acid were identified bigger values in red onion peels than yellow onion peels. These findings are almost like results obtained by Kim and Kim [34]. As a result, plants high in phenols and flavonoids could be a strong source of anti-oxidant potential. Numbers of recovered microorganisms are illustrated in Table 4. The obtained results indicated that the total count of bacteria in red and yellow onion peels powder were 3×10 and 5x10 CFU/g respectively, while the total count of their extracts was 1×10 and 2x10 CFU/g, respectively. according to data in Table 4 showed that the coliform group, *Salmonella*spp and *Staph. aureus* were no detected within the minced meatand the examined samples. The obtained results are in line with those reported by Mrema *et al.* [35] who revealed that meat shelf-life would depend upon many factors including some kinds of microorganisms initially present and their subsequent growth, additionally, among other issues; the storage temperatures could play a crucial role within the handling of the raw meat products [36].

Table 2. Total flavonoid and phenolic contents of onion peels and their extracts

Sample	Extraction yield (%)	Total phenolic contents (mg of gallic acid/g of extract)	Total flavonoids contents (mg of quercetin/g of extract)	DPPH radical scavenging activity (%)
YOPP	---	57.78±3.04^{d}	62.53±3.71^{d}	70.04±2.42^{b}
EYOP	15.67 ± 0.031^{a}	111.23±9.34^{b}	90.17±3.71^{b}	83.49±0.66^{a}
ROPP	--	96.89±11.37^{c}	76.37±3.87^{c}	72.06±2.095^{b}
EROP	13.40± 0.0125^{b}	291.4±17.95^{a}	128.64±5.26^{a}	85.34±0.25^{a}

ANOVA used to compare data (P = 0.05); data sharing the same letter in a column were not significantly different. **YOPP** = yellow onion peels powder, **EYOP**= extract yellow onion peels, **ROPP**= red onion peels powder and **EROP**= extract red onion peels.

Table 3. Polyphenolic and flavonoids fractions of yellow and red onion peels

Components	Conc. (µg/g yellow onion peels	Conc. (µg/g red onion peels
Polyphenolic		
Gallic acid	349.86	2614.96
Chlorogenic acid	77.96	513.03
Caffeine	60.94	105.98
Coffeic acid	56.05	125.30
Vanillin	18.70	65.31
Ferulic acid	50.02	122.80
Propyl Gallate	195.39	1004.78
Cinnamic acid	74.14	178.13
Flavonoids		
Rutin	0.00	1169.83
Coumaric acid	9.67	115.60
Naringenin	0.00	644.57
4`.7-DihydroxyisoFlavone	244.83	1055.68
Querectin	1761.31	11290.09

Table 4. Microbiological quality of raw material and their extracts

Sample	Total count (CFU/g sample)	E coli	Staph. Aureus	Salmonella spp
Minced meat	$6x10^{6}\pm0.015^{a}$	ND	ND	ND
PYOP	$5x10\pm0.125^{b}$	ND	ND	ND
EYOP	$2x10\pm0.015^{d}$	ND	ND	ND
PROP	$3x10\pm0.114^{c}$	ND	ND	ND
EROP	$1x10\pm0.015^{e}$	ND	ND	ND

ANOVA used to compare data (P = 0.05); data sharing the same letter in a column were not significantly different. **YOPP** = yellow onion peels powder, **EYOP**= extract yellow onion peels, **ROPP**= red onion peels powder and **EROP**= extract red onion peels.

Antioxidant activity (AA) of a food could be a useful index to predict oxidative stability [37]. Data on the antioxidant activity of beef burgers as suffering from addition natural extracts as antioxidants stored at zero time are illustrated in Table 5. Within the tested samples, a significant difference between the AA % like a results of adding the onion peels (extracts, powder and BHT) at zero time was observed. The ranking of antioxidant activity was BHT>$EROP_{1000ppm}$ > $EROP_{800ppm}$> $EYOP_{1000\ ppm}$> $ROPP_{1000ppm}$>$EYOP_{800ppm}$ > $ROPP_{800ppm}$> $YOPP_{1000ppm}$> $YOPP_{800ppm}$. AA% than other tested samples during storage periods, the information indicated that the marked antioxidant activity of $EROP_{1000ppm}$, $EROP_{800ppm}$, $EYOP_{1000\ ppm}$, $EYOP_{800ppm}$ exhibited a higher AA% than other tested samples during zero time. The phenolics may act during a similar fashion as reductions by donating electrons and reacting with free radicals to convert them to more stable products and terminate free radical chain reactions [38]. The phenolic derivatives compounds were the most antioxidant components and their total contents were directly proportional to their antioxidant activity [39]. The total phenol contents and flavonoids of the burger with onion peels during this study ranged from 59.04 to 302.4 mg GA/g and 199.3 to 185.00 mg QE/g respectively. Our results indicated that total phenolic, total flavonoids and DPPH increased of burgers by increasing of levels of onion peels. This may be addition of onion peels powder contains phenols and flavonoids. The highest values of total phenol and total flavonoids were in burgers with onion peels extracts. Burgers with red onion peels extracts were higher than that of burgers with yellow onion peels extracts. Onion has been reported together of the main sources of dietary flavonoids [10]. The brown skin of red onion was found to contain the most level of phenolics [31,40]. The quercetin is the major flavonoids in onion peels, by chelating of transition metal ions and inhabitation of oxidase acted as antioxidant [41]. Data on the antioxidant activity of beef burgers as suffering from addition onion peels as natural antioxidants stored at 4+1°C for 15 days were tabulated in Table 5. Within the tested samples, significant differences between the AA % like a results of adding the onion peels(extracts, powder and BHT) during storage for 15 days were observed. The order of antioxidant activity was BHT>$EROP_{1000ppm}$ > $EROP_{800ppm}$ > $EYOP_{1000ppm}$> $ROPP_{1000\ ppm}$ >$EYOP_{800\ ppm}$> $ROPP_{800\ ppm}$> $YOPP_{1000}$ ppm> $YOPP_{800ppm}$. The data indicated that the marked antioxidant activity of $EROP_{1000ppm}$, $EROP_{800ppm}$, $EYOP_{1000\ ppm}$, $EYOP_{800ppm}$ exhibited a higher AA% than other tested samples during storage. Concerning the thiobarbituric acid (TBA) value for prepared beef burger blends as an honest indicator for the quantity malonaldehyde which is the most predominant product of the secondary oxidation within the food lipids, hence it's considered a good chemical constant for quality assurance and for measuring the extent of the secondary oxidation of edible lipids during processing. As shown in Table 5, the results showed within the zero phase that there have been no significant changes in TBA values for a few samples, like control, BHT, $YOPP_{800ppm}$, $YOPP_{1000ppm}$, $ROPP_{800ppm}$ and $ROP_{1000ppm}$. However, there was a significant decrease in TBA values within the samples, $EYOP_{1000ppm}$, $EROP_{800ppm}$, $EROP_{1000ppm}$. After the storage period, there was a significant decrease in TBA values, and therefore the results showed a significant difference between the stored samples, and therefore the highest value in TBA was the control sample, and the least of them were samples containing red onion peels extract. These results are consistent with Martinez-Tome *et al*. [42] who reported that, usually antioxidants like butylatedhy droxytoluene (BHT) and butylaledhy droxyanisole (BHA), both powerful synthetic antioxidants, are used to reduce the rate of oxidation processes. Our results are in agreement with these reported by authors who reported that high effectively of onion peels ethanol extracts in regard to meat lipid oxidation, and also that red onion skin ethanol extracts showed better results than yellow onion skin extracts [8,15]. Onion is one of the major sources the main sources of dietary flavonoids which contains anthocyanins, that's answerable for the red or purple color observed in some varieties, and flavonols (quercetin) that will contribute to the assembly of yellow and brown compounds found in the skins of the many onions. Quercetin has demonstrated antioxidant and free radical scavenging power and its capability to safeguard against cardiovascular disease [31,43]. However, onion skins contain higher concentrations of quercetin aglycon than the flesh [44].

Cooking characteristics of beef burgers

As cooking measurements (moisture retention, shrinkage, cooking loss and cooking yield) which are considered one of the most important physical quality changes occur in beef burgers during cooking process due to protein denaturation and releasing of fat and water from beef burger [45]. Therefore, the impact of incorporating of yellow, red and their extracted (red, and yellow) onion peels powder were added alone at 800 and 1000 parts per million to the beef burger mixture. The measurements of moisture retention, shrinkage, cooking loss and cooking yield for beef burger samples as influenced by formulation with onion peels powder and onion peels extract are summarized in Table 6. Formulation of beef burger with replacement of meet with onion peels significantly

improved the cooking yield of samples as well as their moisture retention. The observed improvement was pronounced with increasing the added onion peels, as shown for the various formulated $YOPP_{1000ppm}$ and $ROPP_{1000ppm}$ burger samples. There was a significant decrease in the percentage of cooking loss between the tested burgers sample. The most cooking loss was observed for the control followed by BHT formulated burger which can be attributed to the surplus fat separation and water release during cooking. Furthermore, shrinkage property was not affected by the quantity and kind onion peels within the meat product. Cooking loss refers to the reduction weight of beef meat during the cooking process [46]. As shown, no significant differences were observed between the measurements of pH for burger samples at zero time and after refrigerated storage at 4°C ± 1 °C (Table 6).

Organoleptic evaluation

Organoleptic evaluation is the crucial point in judging the quality of food stuffs. Also, consumer may be a major factor for choosing a product and among the most characteristics relating to product quality are color, odor, taste and texture [47,48]. Cooked beef burger samples were organoleptic evaluated and compared with control burger and BHT (200 ppm) as shown in Table 7. Data showed that there were no significant differences observed among tested beef burger samples and control sample in color, odor, taste, appearance and total all acceptability at zero time. Also, the results showed that there have been significant differences among control and the samples that include red and yellow peels and their extracts (800 ppm and 1000 ppm) in texture and tenderness, but the samples that include 200 ppm BHT and control were significantly different ($P < 0.05$) as compared with the other tested samples. On the other hand, beef burgers were prepared with red and yellow onion peels and their extracts showed slightly lower or similar judging scores altogether sensory characteristics than control burger sample during storage periods for three weeks, with exception the color, odor, taste, appearance and tenderness of the control sample. With regard to the overall acceptability, the control sample was the least ($P < 0.05$) acceptable, while the opposite samples weren't significantly different as compared with control. Generally, the results of sensory tests for the cooked burger samples accepted as true with those observed in studies of Martinez *et al.* [49] and Estevez *et al.* [50] reported that the flavor and color are two critical quality criteria of meat products that affect consumer acceptance and shelf life of the products. The changes of color (as the pigments oxidize), flavor and aroma occur as results of the accumulation of secondary volatiles.

Table 5. Antioxidant, total phenolic and flavonoid contents in burger during storage period (15 day)

Samples	Antioxidant (%)		Total phenols as gallic acid (mg / g dry sample)		Total flavonoid as mg quercetin equivalents /g dry sample)		TBA (mg malonaldehyde / Kg sample)	
	Zero time	End storage	Zero time	End storage	Zero time	End storage	Zero time	End storage
Control	26.00±2.007^{i}	21.586±0.61^{f}	38.178±1.687^{i}	28.355±1.590^{e}	21.066±1.233^{i}	14.916±1.452^{h}	0.23±1.616 ^{a}	0.95±0.814 ^{a}
BHT	147.333±1.333^{a}	124.600±7.114^{a}	490.218±11.665^{a}	431.891±19.614^{a}	199.333±3.480^{a}	185.133±2.53^{a}	0.21±0.554 ^{a}	0.45±1.554^{d}
YOPP $_{800\ ppm}$	39.733±1.616^{h}	24.090±0.017^{ef}	59.066±6.35^{h}	31.325±3.459^{e}	43.966±2.826^{h}	35.540±1.52^{g}	0.22±1.524 ^{a}	0.65±0.664^{b}
YOPP $_{1000ppm}$	48.333±0.554^{g}	35.313±0.006^{d}	81.598±4.36^{g}	56.924±4.268^{e}	63.400±3.95^{g}	55.713±4.30^{f}	0.21±0.758^{a}	0.52±0.351^{c}
EYOP $_{800ppm}$	56.100±0.115^{e}	30.700±0.248^{de}	156.144±5.564^{e}	94.215±2.728^{d}	98.233±2.61^{e}	79.916±2.90^{e}	0.19±0.565^{b}	0.50±0.554^{c}
EYOP$_{1000\ ppm}$	73.233±0.033^{c}	48.836±0.056^{c}	188.822±3.240^{d}	143.250±12.470^{c}	119.00±2.309^{d}	92.146±2.413^{d}	0.18±2.154 ^{b}	0.45±1.554^{d}
ROPP $_{800\ ppm}$	51.800±0.60214^{f}	44.603±.501^{c}	125.251±4.059^{f}	92.442±3.955^{d}	78.733±2.699^{f}	64.363±2.75^{f}	0.21 ±0.654 ^{a}	0.42±0.474^{e}
ROPP $_{1000\ ppm}$	67.766±0.837^{d}	59.713±0.0796^{b}	145.886±2.056^{e}	110.252±2.884^{d}	92.433±3.743^{e}	77.99±1.44^{e}	0.20±1332 ^{a}	0.39±0.635^{f}
EROP $_{800\ ppm}$	75.533±0.633^{c}	64.060±0.230^{b}	232.692±8.614^{c}	166.659±5.937^{c}	138.666±10.47^{c}	103.450±3.52^{c}	0.18±1.554 ^{b}	0.38±0.554^{f}
EROP $_{1000\ ppm}$	85.300±1.78^{b}	66.630±0.770^{b}	302.454±7.915^{b}	240.287±18.960^{b}	185.00±5.507^{b}	125.066±4.79^{b}	0.16±0.984 ^{c}	0.36±0.926^{g}

ANOVA used to compare data (P = 0.05); data sharing the same letter in a column were not significantly different. **YOPP** = yellow onion peels powder, **EYOP**= extract yellow onion peels, **ROPP**= red onion peels powder and **EROP**= extract red onion peels.

Table 6. Physicochemical properties and pH value of produced beef burger samples

Item	% Moisture retention	% Shrinkage	% Cooking loss	% Cooking yield	pH at zero time	pH after storage
Control	48.09±0.281^{c}	16.40±0.154^{a}	19.54±0.265^{a}	80.46±0.454^{e}	6.19±0.145^{a}	6.41±0.256^{a}
BHT	45.26±0.251^{d}	15.70±0.466^{a}	17.65±0.325^{b}	82.35±0.254^{d}	6.22±0.236^{a}	6.42±0.145^{a}
YOPP$_{800ppm}$	51.07±0.281^{b}	13.90±0.354^{b}	14.41±0.179^{c}	85.59±0.464^{b}	6.09±0.489^{a}	6.53±0.356^{a}
YOPP$_{1000ppm}$	52.89±0.381^{a}	12.50±0.254^{b}	11.22±0.454^{d}	88.78±0.444^{a}	6.07±0.356^{a}	6.43±0.256^{a}
EYOP$_{800ppm}$	50.39±0.185^{b}	12.90±0.155^{b}	14.64±0.278^{c}	85.36±0.325^{b}	6.15±0.486^{a}	6.36±0.365^{a}
EYOP$_{1000ppm}$	50.89±0.432^{b}	12.20±0.454^{b}	14.26±0.4546^{c}	85.74±0.254^{b}	6.12±0.453^{a}	6.46±0.236^{a}
ROPP $_{800ppm}$	51.37±0.351^{b}	13.40±0.256^{b}	13.66±0.564^{c}	86.34±0.154^{b}	6.22±0.186^{a}	6.41±0.324^{a}
ROPP $_{1000ppm}$	52.49±0.281^{a}	12.40±0.145^{b}	10.75±0.254^{d}	89.25±0.326^{a}	6.18±0.154^{a}	6.53±0.425^{a}
EROP$_{800ppm}$	50.13±0.278^{b}	13.00±0.254^{b}	15.89±0.364^{c}	84.11±0.254^{c}	6.17±0.123^{a}	6.71±0.445^{a}
EROP$_{1000ppm}$	50.75±0.281^{b}	12.40±0.454^{b}	15.47±0.454^{c}	84.53±0.454^{c}	6.08±0.235^{a}	6.45±0.356^{a}

ANOVA used to compare data (P = 0.05); data sharing the same letter in a column were not significantly different. **YOPP** = yellow onion peels powder, **EYOP**= extract yellow onion peels, **ROPP**= red onion peels powder and **EROP**= extract red onion peels.

Table 7. Organoleptic properties of burger stored at 4±1°C at zero time and 15 day period storage

Samples	Color (10)	Odor (10)	Taste (10)	Texture(10)	Appearance(10)	Tenderness (10)	Over all acceptability(10)
Zero time							
Control	8.81±0.263^{ab}	8.72±0.272^{ab}	8.45±0.281^{a}	8.45±0.281^{b}	8.72±0.272^{a}	7.63±.0.243^{c}	8.03±0.309^{a}
BHT	8.81±0.203^{ab}	8.0±0.263^{b}	8.27±0.272^{a}	8.47±0.272^{b}	8.27±0.272^{a}	7.27±0.237^{c}	8.15±0.207^{a}
YOPP$_{800ppm}$	9.20 ±0.295^{a}	9.00±0.269^{a}	9.00±0.269^{a}	9.09±0.314^{a}	9.00±0.301^{a}	9.00±0.301^{a}	9.36±0.243^{a}
YOPP $_{1000ppm}$	8.54±0.247^{ab}	9.72±0.272^{a}	.63±0.278^{a}9	9.54±0.281^{a}	8.94±0.281^{a}	9.63±0.278a	8.81±0.263^{a}
EYOP$_{800ppm}$	8.63±0.387^{ab}	8.63±0.387^{ab}	9.04±0.412^{a}	8.81±0.377^{a}	8.81±0.400^{a}	8.90±0.314^{ab}	9.20±0.314^{a}
EYOP$_{1000ppm}$	8.85±0.363^{ab}	8.96±0.491^{ab}	9.36±0.432^{a}	8.83±0.472^{b}	8.54±0.412^{a}	8.63±0.432^{ab}	8.72±0.332^{a}
ROPP$_{800ppm}$	9.54±0.412^{a}	9.54±0.454^{a}	9.54±0.474^{a}	9.45±0.511^{a}	9.11±0.443^{a}	8.72±0.449^{ab}	8.72±0.428^{a}
ROPP$_{1000ppm}$	9.63±0.452^{a}	9.72±0.449^{a}	9.72±0.449^{a}	9.54±0.434^{a}	9.63±0.432^{a}	8.63±.0.452^{ab}	8.72±0.449^{a}
EROP$_{800ppm}$	9.09±0.250^{a}	8.90±0.284^{ab}	9.81±0.295^{a}	8.90±0.2502^{a}	8.81±0.295^{a}	9.10±0.250^{a}	8.90±0.314^{a}
EROP$_{1000ppm}$	9.00±0.269^{a}	8.90±0.314^{ab}	9.90±0.301^{a}	8.90±0.342^{a}	9.00±0.301^{a}	8.81±0.325^{ab}	9.00±0.301^{a}
End 15 day storage period							
Control	7.81±0.263^{b}	6.72±0.273^{b}	6.45±0.281^{c}	8.45±0.281^{a}	7.72±0.272^{b}	6.63±0.243^{b}	7.45±0.207^{b}
BHT	8.19±0.203^{a}	8.18±0.263^{a}	7.27±0.272^{b}	8.27±0.272^{a}	8.27±0.272^{a}	8.27±0.237^{a}	8.45±0.207^{a}
YOPP$_{800ppm}$	8.18±0.290^{a}	8.22±0.269^{a}	9.00±0.268^{a}	9.19±0.314^{a}	9.00±0.301^{a}	9.00±0.301^{a}	9.36±0.243^{a}
YOPP$_{1000ppm}$	8.54±0.247^{a}	8.72±0.272^{a}	9.63±0.278^{a}	8.54±0.281^{a}	8.54±0.281^{a}	8.63±0.278^{a}	8.81±0.263^{a}
EYOP$_{800ppm}$	8.63±0.387^{a}	8.63±0.387^{a}	8.54±0.412^{a}	8.61±0.377^{a}	8.41±0.410^{a}	8.90±0.314^{a}	9.09±0.314^{a}
EYOP$_{1000ppm}$	8.36±0.363^{a}	8.36±0.491^{a}	8.36±0.432^{a}	8.63±0.472^{a}	8.54±0.412^{a}	8.63±0.432^{a}	8.72±0.332^{a}
ROPP$_{800ppm}$	8.54±0.412^{a}	8.54±0.454^{a}	9.54±0.474^{a}	8.15±0.511^{a}	8.81±0.443^{a}	8.72±0.449^{a}	8.72±0.428^{a}
ROPP$_{1000ppm}$	8.63±0.452^{a}	8.72±0.449^{a}	9.72±0.449^{a}	8.24±0.434^{a}	8.63±0.432^{a}	8.63±0.452^{a}	8.72±0.449^{a}
EROP$_{800ppm}$	9.09±0.250^{a}	8.90±0.284^{a}	8.31±0.295^{a}	8.30±0.250^{a}	8.81±0.295^{a}	9.09±0.250^{a}	8.90±0.314^{a}
EROP$_{1000ppm}$	9.00±0.269^{a}	8.90±0.314^{a}	8.50±0.301^{a}	8.50±0.342^{a}	9.00±0.301^{a}	8.81±0.325^{a}	9.00±0.301^{a}

ANOVA used to compare data (P = 0.05); data sharing the same letter in a column were not significantly different. **YOPP** = yellow onion peels powder, **EYOP**= extract yellow onion peels, **ROPP**= red onion peels powder and **EROP**= extract red onion peels.

Table 8. Microbiological count of cooked burger samples at zero time and storage

Sample	**Zero time**			
	Total bacterial counts (CFU /g sample)	Coliform group	Staph. aureus	Salmonellaspp
Control	8.9 x10 ±4.64^{a}	ND	ND	ND
BHT	6.15x10^{2}±5.58 ^{b}	ND	ND	ND
YOPP$_{800ppm}$	6.7x10±3.82^{b}	ND	ND	ND
YOPP$_{1000ppm}$	8.7x10±3.82a	ND	ND	ND
EYOP$_{800ppm}$	7.6x10±7.81^{a}	ND	ND	ND
EYOP$_{1000ppm}$	3.7x10±3.49c^{d}	ND	ND	ND
ROPP$_{800ppm}$	4.0x10. ±2.89^{c}	ND	ND	ND
ROPP$_{1000ppm}$	3.2x10±4.4^{d}	ND	ND	ND
EROP$_{800ppm}$	3.0x10±1.74d	ND	ND	ND
EROP$_{1000ppm}$	2.1x10±6.01^{e}	ND	ND	ND
End 15 day storage period				
Control	2.18x10^{2}±6.71^{c}	ND	ND	ND
BHT	1.80x10^{2}±1.55^{d}	ND	ND	ND
YOPP$_{800ppm}$	1.50x10^{2}±2.87^{d}	ND	ND	ND
YOPP$_{1000ppm}$	5.3x10±8.82^{a}	ND	ND	ND
EYOP$_{800ppm}$	2.6x10±7.26^{c}	ND	ND	ND
EYOP$_{1000ppm}$	1.6x10±4.41^{d}	ND	ND	ND
ROPP$_{800ppm}$	1.16x10^{2}±8.82^{d}	ND	ND	ND
ROPP$_{1000ppm}$	4.0.x10±12.17^{b}	ND	ND	ND
EROP$_{800ppm}$	1.1x10±3.79^{d}	ND	ND	ND
EROP$_{1000ppm}$	ND	ND	ND	ND

ANOVA used to compare data (P = 0.05); data sharing the same letter in a column were not significantly different. **YOPP** = yellow onion peels powder, **EYOP**= extract yellow onion peels, **ROPP**= red onion peels powder and **EROP**= extract red onion peels.

Microbiology evaluation of burger samples

Burgers are one of the most widely consumed and accepted meat products. According to Moon *et al*. [51], the quality of this product degrades during storage due to lipid oxidation and microbial growth. Table 8 showed that adding yellow and red onion peel powder and extracts to different beef burger samples altered the microbiological quality criteria at the beginning and end of the refrigerated storage period (15 day). Also, it's clear that the counts of total bacterial for beef burger samples significantly decreased ($P < 0.05$) with increasing the extracts level in burger formulations. These results provide evidence for the presence of antimicrobial phenolic compounds in yellow and red onion peels powder. These compounds can degrade the cell wall, disrupt the cytoplasmic membrane, damage membrane proteins and interfere with membrane-integrated enzymes, which can eventually lead to cell death [52]. Results presented in Table 8 showed that addition of yellow or red onion peels powder and their extract partially decreased the initial microbial count and slowed down the growth during the storage period in parallel to increasing the concentration. Generally, the microbiological quality of meat products as purchased by the consumer relies on a number of factors, such as the quality of the raw materials, other ingredients or processing operations to the products as extraneous contaminants, sanitation during processing and packaging. Control sample showed slightly higher counts of all the tested microorganisms after extending storage time up to two weeks than those of other samples treated with onion peels powder or extract. It also showed that the coliform bacteria group, *Salmonellas pp* and *Staphylococcus aureus* were no detected for at zero time and 15 day of all samples. These findings are in accordance with those of other studies, which noted the absence of *Salmonella* growth at refrigeration temperatures (7 to 8°C) in beef [53]. Extracts of onion peels are high in glucosidic forms of phenols, mainly quercetin 340-diglucoside and quercetin 40 -monoglucoside, which also tested for antimicrobial activity. There are few studies on flavonoid glycosides, mainly flavonol 3-O-glycosides, which showed strong antibacterial activity against gram-positive bacteria and low activity against gram-negative bacteria as founded by Xiao [54]. The aforementioned results were agreed with Egyptian Organization for Standardization and Quality.

In conclusion, According to the findings of this study, food industry by-products can be good sources of significant bioactive compounds and antioxidants subsequently extending their potential uses as natural antioxidants in nutritional and therapeutic applications. The inclusion of onion peels and extract (such as red and yellow) in beef burger compositions as a good source of antioxidant components improved the oxidative stability and nutritional value as well as microbiological quality of produced beef burgers. Also, EYOP extract was more active and effective than EROP. This might be due to the strong antioxidant and antimicrobial properties of EYOP. Finally, this study is economic practicable and successful to utilize onion peels in manufactured of products.

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