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Research Article
Quality Characteristics of Beef Burger as Influenced by Different Levels of Orange Peel Powder

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Abstract

Background and Objective: Citrus peel is considered a rich source of phenolic compounds providing excellent alternative of synthetic antioxidants. Therefore, applications of citrus by-products as natural antioxidant have a promising future vision with regarding its use as bioactive compounds in meat products. The main objective of this study was to process beef burger with orange peel powder as natural source of antioxidants in beef burger. **Methodology:** The beef burger was processed with the addition of different concentrations (2.5, 5.0, 7.5 and 10%) of orange peel powder beside control sample. The prepared burgers were evaluated for quality attributes including: Chemical composition, physical characteristics (pH value, color and water holding capacity), cooking properties (cooking yield, cooking loss and shrinkage), total phenolic content, thiobarbituric acid reactants (TBA), Total Volatile Basic Nitrogen (TVBN) and sensory evaluation. One way analysis of variance (ANOVA) using SAS. **Results:** Addition of orange peel powder caused significant decrease ($p<0.05$) in pH values while, color parameters of burger showed significant increment ($p<0.05$) in both of the lightness (L*) and yellowness (b*) values on contrary, the redness (a*) was significantly decreased ($p<0.05$). On the other side, cooking properties were improved with the addition of orange peel powder when compared to control samples in which, cooking loss and shrinkage were significantly decreased ($p<0.05$) after cooking. Results indicated that increasing orange peel levels resulted in increasing the total phenol content of all samples dramatically. Lipid oxidation was retarded significantly ($p<0.05$) by the addition of orange peel in which increasing additives concentrations led to decreased thiobarbituric acid reactant TBA values (from 0.269 mg kg^{-1} with 2.5% additives and decreased to 0.163 mg kg^{-1} with 10%) compared to the control (0.303 mg kg^{-1}). While, total volatile basic nitrogen TVBN values were significantly decreased ($p<0.05$) by increasing orange peel concentration in burger samples. The sensory properties and overall acceptability were improved by using 5% of orange peel which was accepted and exhibited the maximum score of sensory properties compared to control. **Conclusion:** It could be concluded that 5% orange peels powder additives turn burger over to become a functional meat product. This study showed a promissing results with regarding the use of orange peel as strong natural antioxidants in meat products.

Key words: Orange peel, burger, quality characteristics, total phenolics, antioxidant, sensory evaluation

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Meat products represent the main source of protein in our diet daily for a broad base of consumers, especially young people and children who eat processed meat products as a fast food mainly in their diet[1].

The fundamental problem that threatens meat products are microbial spoilage and fat rancidity that lead to the use of synthetic preservatives like, nitrates and nitrites, which have carcinogenic effect on the human body, threatening his health and his life taking it to these foods[2].

Oxidative processes of meat lead to the degradation of lipids and proteins which, in turn, contribute to the deterioration in flavour, texture and colour of displayed meat products[2].

On the other side, the meat products manufactured, especially burgers containing a high proportion of fat, which qualifies them to be the main cause of chronic diseases such as obesity, atherosclerosis and heart disease[3].

The foregoing is clear about us the importance of the use of natural additives to processed meats, which acts to protect it from corruption and rancidity to give the highly nutritious value beside the preventive role played by these bioactive substances in the prevention of chronic diseases such as cancer, cardiovascular diseases, diabetes in some cases, assist in treatment where it prevents mutations result protection of DNA from oxidation and also protect proteins and lipid molecules of the cell[4-6].

Residues resulting from the fruit juices and concentrates factories and jam processing reconsidered the most important cheap and easy sources of bioactive compounds for its production from natural sources. Citrus waste is contributing a large part of the remnants of food processing fruit[7].

Citrus peel could be utilized as a rich source of bioactive compounds like phenolic compounds, vitamin C and β-carotene[8,9] in addition to its high content of minerals, fiber and lignin[7]. Obtain data from previous study[7] referred to the high content and sheep source of citrus peel bioactive compounds. Until now, there were very scarce information and studies on by-products and their applications of meat, which is presenting an important area for research[7].

Many studies were conducted on material add active vital in vegetables, fruits, legumes into meat products manufactured in order to save it from rancidity and microbial corruption and thereby increasing the useful shelf life[10].

Therefore, the main objective of the present study was to evaluate properties of beef burger prepared for different concentrations (2.5, 5.0, 7.5 and 10.0%) of orange peel powder as a natural source of bioactive compounds as antioxidants and their effectiveness in preserving beef burger.

MATERIALS AND METHODS

Materials

Plant material: The wastes obtained of orange *C. valencia* were purchased from local market and prepared for dried using microwave then milled to pass through 100 mesh screen sieve according to Mahmoud *et al.*[7].

Materials used in processing the burger: Beef meat, salt and white paper were purchased from the local marker, Cairo, Egypt.

Chemicals and reagents: All used chemicals and reagents were (Sigma, Aldrich and Fluka) purchased from Sigma, Aldrich and Fluka Chemical Co. (St. Ouis, Mo, 63103 USA). All other chemicals and reagents used were of analytical grade. The used water was distilled using water distillation apparatus (D 4000).

Preparation of the burger: Preparing beef burger was carried out according to Aleson-Carbonell *et al.*[11]. The constituents of the burger (beef meat, ice water 18%, salt 1.5% and white paper 0.2%) for each 100 g meat were mixed well, then mixed with the dried orange peel at four levels (2.5, 5.0, 7.5 and 10.0%) in addition to control. Each treatment mixed separately for 5 min at medium speed, using a cutter to obtain homogeneous mixture. This mixture was shaped using a commercial burger maker into disc pieces of 50 g and diameter of 9 cm and a thickness of 1 cm to obtain burger. Plastic packaging film was used to help maintaining the shape of the burger prior to freezing and stored at -18°C.

Chemical composition: All parameters were tested for triplicate. Moisture, ash, protein and fat contents were determined by AOAC[12] method. Moisture (39.1.03), ash (39.1.09), protein (39.1.15) and fat (39.1.09).

Physicochemical analysis of burger

Determination of pH: The measurement of pH was carried out on 10 g of sample homogenized in distilled water (1:10 sample/water). The pH value of the sample was measured using a pH meter[13].

Water Holding Capacity (WHC): Water Holding Capacity (WHC) was measured using the method of El-Seesy[14] as

follows: Minced beef burger sample 0.3 g was placed on an ashless filter paper Whatman, No. 41 and placed between 2 glass plates and pressed for 10 min by 1 kg weight, two zones were found on the filter paper, their surface areas were measured by a planimeter. The outer zone resulted from the water separated from the pressed tissues thus indicating the water holding capacity.

Color measurements: Color was evaluated using a colorimeter (Mod-CR-200, Minolta Camera Co., Osaka, Japan) with illuminate D_{65}, 2° observer, Diffuse/O mode, 8 mm aperture of the instrument for illumination and 8 mm for measurement. The colorimeter was standardized with a white tile (L*D98.14, a*D-0.23 and b*D1.89). Color was described by coordinates: Lightness (L*), redness (a*, red-green) and yellowness (b*, yellow-blue). Color difference (ΔE*) was calculated from a, b and L parameters Nine replicate measurements were taken for each sample, following the guidelines for color measurements of the American Meat Science Association[15].

Determination of total phenolic compounds: The Folin-Ciocalteu assay, adapted from Ramful *et al.*[16] was used for the determination of total phenolics present in the citrus fruit extracts. To 0.25 mL of diluted extract, 3.5 mL of distilled water was added followed by 0.25 mL of Folin-Ciocalteu reagent (Merck). A blank was prepared using 0.25 mL of 80% methanol instead of plant extract. After 3 min, 1 mL of 20% sodium carbonate was added. Tube contents were vortexed before being incubated for 40 min in a water-bath set at 40°C. The absorbance of the blue coloration formed was read at 685 nm against the blank standard. Total phenolics were calculated with respect to gallic acid standard curve (concentration range: 0-12 μg mL^{-1}). Results are expressed in mg of gallic acid 100 g^{-1} of plant material.

Lipid oxidation (Thiobarbituric acid reactive substances (TBARS)): The TBARS of samples were determined by spectrophotomer method[17]. Two grams of homogenized sample were taken and TBARS were extracted twice with 10 mL of 0.4 M perchloric acid. Extracts were collected and made up to 25 mL with perchloric acid and centrifuged for 5 min at 1790 g. After centrifugation, 1 mL of supernatant was pipette into glass stoppered test tube. The TBA reagent (5 m) was added and mixture was heated in a boiling water bath for 35 min. After cooling the absorbance of sample was read against the appropriate blank at 538 nm. A standard curve was prepared using 1, 1, 3, 3-tetraethoxy-propane (TEP).

Determination of Total Volatile Basic Nitrogen (TVBN): A sample (10 g) was minced and washed into distillation flask with 100 mL distilled water; then 2 g magnesium oxide and an antifoaming agent were added. The mixture was distilled using the micro kjeldahl distillation apparatus. Distillate was collected for 25 min into 25 mL 4% boric acid and five drops of Tashiro indicator. The solution was titrated using (0.1 M) HCl to calculated the total volatile basic nitrogen in the sample in terms of mg VBN/100 g sample[18].

Cooking properties: Burger samples were grilled in microwaves for about 5 min. After cooking, they were cooled to 21°C for 1 h before weighting.

Cooking properties were made by the method described by Aleson-Carbonell *et al.*[11]. To estimate cooking yield, cooking loss and shrinkage were calculated from the following equations:

$$\text{Cooking yield (\%)} = \frac{\text{Cooking weight}}{\text{Raw weight}} \times 100 \quad (1)$$

$$\text{Cooking loss (\%)} = \frac{\text{Raw weight} - \text{Cooking weight}}{\text{Raw weight}} \times 100 \quad (2)$$

$$\text{Shrinkage (\%)} = \frac{\text{Raw diameter} - \text{Cooking diameter}}{\text{Raw diameter}} \times 100 \quad (3)$$

Sensory evaluation: Burgers were assessed for a number of sensory characteristics by ten members of the Department of Food Technology in sensory for evaluation and availability. Panelists were instructed to evaluate colour, texture, taste, flovour, odour and overall- acceptability using 10 point scale for grading the quality of samples[19].

Statistical analyses: The data obtained from study and sensory evaluation was statistically subjected to one way analysis of variance ANOVA (SAS) and means separation by Snedecor and Cochran[20]. The Least Significant Difference (LSD) value was used to determine significant differences between means and to separate means at $p \leq 0.05$ using SPSS package version 15.0.

RESULTS AND DISCUSSION

Chemical composition of formulated beef burger: Data in Table 1 represent moisture, protein, fat and ash content of burger with orange peel additives at different concentrations. The analysis of variance betweentreatments indicated that there were significant differences ($p<0.05$) among all

Table 1: Chemical composition (%) of beef burger formulated with different concentrations of orange peel powders

Treatments	Moisture (%)	Ash (%)	Protein (%)	Fat (%)
Control	77.24±2.0[a]	2.91±0.66	13.13± 0.24[b]	11.36±0.02[a]
2.5%	72.99±1.05[b]	2.40±0.02	13.25± 0.48[ab]	9.50±0.02[b]
5.0%	70.94±2.0[b]	2.30±0.02	13.97±0.54[a]	8.95±0.07[c]
7.5%	70.71±2.0[b]	2.29±0.02	11.40± 0.02[c]	6.60±0.03[d]
10.0%	70.35±3.0[b]	2.24±0.02	11.64±0.58[c]	5.82±0.02[e]
L.S.D at 5%	2.82	0.02	0.78	0.03

All values are means of triplicate determinations ±Standard Deviation (SD), Means within column with different letters are significantly different at p<0.05

Table 2: Physico-chemical properties of beef burger formulated with different concentrations of orange peel powders

			Color			
Treatments	pH value	WHC (cm^2)	L*	a*	b*	ΔE*
Control	6.66±0.02[a]	3.80±0.02[a]	40.49±2.0[b]	12.22±0.02[a]	11.92±0.02[e]	54.99±0.13[d]
2.5%	6.54±0.02[b]	3.78±0.02[b]	41.36±3.0[a]	10.47±0.03[e]	14.26±0.02[d]	54.34±0.02[e]
5.0%	6.48±0.02[c]	3.73±0.02[c]	40.16±2.0[c]	11.14±0.12[d]	18.06±0.51[c]	56.72±0.55[c]
7.5%	6.42±0.02[d]	3.65±0.02[d]	39.50±1.77[d]	11.45±0.02[c]	21.23±0.16[a]	58.56±0.02[b]
10.0%	6.22±0.02[e]	3.40±0.02[e]	38.17±2.0[e]	11.83±0.02[b]	20.78±0.02[b]	59.53±1.55[a]
L.S.D at 5%	0.02	0.02	1.08	0.11	0.44	1.12

All values are means of triplicate determinations ±Standard Deviation(SD), Means within column with different letters are significantly different at p<0.05, L*: Lightness, a*: Redness, b*: Yellowness, WHC: Water holding capacity

treatments. Moisture content decreased significantly with the addition of orange peel (p<0.05) compared with control. Maximum moisture content was observed in treatment control while, treatment 10% showed minimum moisture content. Ash content did not change when orange peel was added with different concentrations. There was no significant difference in ash content observed within treatments while, maximum level was in control, while the minimum ash content showed at treatment 10%. Protein content was increased significantly (p<0.05) after treatment 5.0% orange peel additives followed by treatment 2.5% compared with control. The highest protein content may be due to the decrement in moisture content. While treatment 7.5% showed minimum protein content compared with control (Table 1). This may be due to the low protein contents of orange peel powder, while, increasing percentage of orange peel, decreasing protein content in burger. The presence of orange peel (for any concentration) did not modify (p>0.05) the fat. Reversed trend was found by Aleson-Carbonell[11] whereas, protein content was not modified by the addition of citrus peel in beef burger but the fat content decreased.

Physicochemical properties of formulated beef burger

pH value: Measuring of pH value is important due to its influence on many characteristics, including shelf-life, color, water holding capacity and texture of meat and meat products[21].

Data in Table 2 show the decrease of pH value in burger samples of orange peel additives (p<0.05) at any concentration, pH ranged from 6.22-6.54 compared to control samples in raw burger.

Kim and Song[22] reported that citrus peel additives had decreased the pH values of food due to the effects of organic acids such as ascorbic acid, citric acid and tartaric acid. These results were in agreement with Aleson-Carbonell[11] and Lee *et al.*[23].

Water Holding Capacity (WHC): The water holding capacity (WHC) of meat is defined as the affinity with meat to retain its own or added water during processing and considered as one of the important measurements of quality attributes to determining the possibility of using this meat in manufacturing of meat product. It is responsible for the eating quality, juiciness, tenderness, cooking loss and thawing drip of meat[24]. This property is affected by two main reasons, the muscle protein and the level of pH value. Moreover, tenderness directly affects on WHC of meat protein[14]. The water holding capacity WHC of different beef burger treatments was determined by filter press methods and data are shown in Table 2.

Table 2 shows that the WHC values of the beef burger which were significantly differing (p<0.05) affected by the orange peel powder additives. These results showed that there was an improvement in WHC with increasing concentrations of orange peel powder for all treatment study. Water holding capacity of beef burger decreased from 3.80 cm^2 at control sample of 3.78, 3.73, 3.65 and 3.40 cm^2 of formulated burger with concentrations of orange peels at 2.5, 5, 7.5 and 10%, respectively. With the fact that, the best water holding capacity the lowest percentage value, orange peel powder had high ability to

Table 3: Cooking properties of beef burger formulated with different concentrations of orange peel powders

Treatments	Cooking yield (%)	Cooking loss (%)	Shrinkage (%)
Control	46.53±2.0^{b}	55.57±3.0^{a}	32.22±3.0^{a}
2.5%	53.81±3.0^{a}	46.19±2.0^{b}	31.11±2.0^{b}
5.0%	54.93±2.0^{a}	45.07±3.02^{b}	31.11±1.02^{b}
7.5%	55.57±1.02^{a}	44.43±2.0^{b}	28.89±2.0^{c}
10.0%	57.61±3.0^{a}	42.39±3.0^{b}	27.78±3.0^{d}
L.S.D at 5%	4.23	4.60	3.77

All values are means of triplicate determinations ±Standard Deviation(SD), Means within column with different letters are significantly different at p<0.05

retain water whereas, increasing peel percentage decreasing WHC values which reflect increasing the ability of meat protein to holding water.

Color measurements of formulated beef burger: There is no doubt that color of meat and meat products is the most important indicator of freshness. Natural antioxidant has been reported to prolong color stability of meat products with retarding lipid oxidation directly and keeping out of deformation meat metmyoglobin into oximyoglobin[25].

Table 2 shows that hunter color parameters of burger with orange peel additives at different concentrations. There was significant (p<0.05) increasing trend of lightness (L*) whereas, lightness value observed in concentration of 2.5% when compared with control samples, while it was decreased with increasing percentage of orange peel concentration 5, 7.5 and 10%. Lightness in food is related with many factors, including the concentration and type of pigments present[26]. On the other hand, addition of orange peel in burger samples led to significantly lower (p<0.05) the redness (a*) in concentration 2.5% when compared with control samples. That trend of decrement in a* values may be due to interference with the lipid oxidation in the myoglobin oxidation[27]. While comparing the samples-containing different ratios of orange peel additives, it found that the more orange peels ratio the greater the red color in which increased from 11.14-11.45 then 11.83 in 5, 7.5 and 10%, respectively. That behaviors may be due to orange peel additives did not contained any myoglobin led to reduce the proportion of red pigment in samples, while they were the greater the roll over ratio of the proportion of the red color was evidence that those additions halted oxidation of myoglobin pigment operations and its transformation into oxymioglobin with brown color.

In the case of yellowness, results showed that increasing orange peel levels resulting in increased (p<0.05) yellowness (b*) were the values ranged from (14.26, 18.06, 21.23 and 20.78) at concentrations 2.5, 5.0, 7.5 and 10%, respectively when compared with control samples. These results indicated that the yellowness of food was increased with increasing additives of orange peel powder as a source of carotenoids pigments due to the yellow and orange color of citrus powder[28]. High E* (color difference) was recorded for orange peel powder concentration at 10 and 7.5% were 59.53 and 58.56, respectively.

Cooking properties of formulated beef burger: Cooking properties like cooking loss, cooking yield and shrinkage are the most important attributes of meat products quality[14].

Table 3 shows that the cooking properties of beef burger with different concentrations of orange peel. Cooking yields of all orange peel concentrations added to burger were significantly higher (p<0.05) than control samples. The increments represented additional improvements in cooking yield of burger with 10% orange peel followed by samples with 7.5% orange peel. It is obvious that these yield value are related to fat and water retention. The improvement in cooking performance due to orange peel addition appears to be related with their fat and water holding capacity[29], due to their soluble components, mainly pectin, which may constitute up to 25% of the tissue[30].

Rocha-Garza and Zayas[31] reported that, in meat products, quality attributes such as texture, structural binding and yield are determined by the ability of the protein matrix to retain water and bind fat in this regard, carbohydrates and fiber have been successful in improving cooking yield, reducing formulas cost and enhancing texture.

Table 3 shows that orange peel at 10% were particularly effective (p<0.05) reducing the cooking loss comparing to control burger sample followed by concentration of 7.5%. This improvement in cooking loss was happened by the addition of orange peel which is able to bind water and fat, consequently[32].

Surface shrinkage is important in maintaining quality standard of burger by releasing of fat and water as a result of protein denaturation[33].

Table 3 shows that surface shrinkage of all cooked samples were significantly (p<0.05) decreased in 10% orange peel comparing to control samples followed by 7.5% orange peel additives. The results were in agreement with those of

Bessar[34], who reported that, increasing the concentration of orange and apple peels leading to increase the in shrinkage. Also, Hygreeva *et al*.[10] reported that lemon albedo had the ability of improving cooking performance due to by increasing fat and water holding capacity.

Total phenolic content of formulated beef burger: Polyphenols are exhibiting strong antioxidant activity because plant polyphenols donate hydrogen atoms to end fat rancidity by terminate the reaction of radical chain with converting free radicals into more stable molecules. Therefore they known to possess good antioxidant activities[35].

The addition of orange peel caused significant increase ($p<0.05$) in total phenol content of samples (Table 4). The results indicated that contents of total phenolics in beef burger fortified with orange peel powder were significantly higher ($p<0.05$) than the control. Total phenol content was found in the range 2.15-31. 90 mg/100 g sample. The results showed that, there was a dramatically relationship between additives of orange peel and phenolic content of burger whereas, increasing orange peel levels leading to increase total phenol content. The highest total phenol content was obtained in burger additives 10% and the lowest total phenol content with control sample.

Thiobarbituric acid reactive substances (TBARS) of formulated beef burger: Lipid oxidation is used to be determined by TBA test in meat and meat products[36]. Data shown in Table 5 shows TBA values of burgers depending on the concentration of orange peel. The analysis of variance for the TBARS data indicated that concentrations of orange peel additives were significantly affected ($p<0.05$) on TBA values whereas, increasing orange peel levels resulting in decreasing($p<0.05$) TBA values compared to the control sample. Data indicated that orange peel incorporated into beef burger was expressed antioxidant activities and emphasis the lipid peroxidation suppression of orange peel additives. The lowest TBA value was obtained in burger with 10% orange peel and the highest values with 2.5% orange peel compared to control samples. This result indicated that lipid oxidation was effectively suppressed by orange peel powder compared to the control by retarded lipid oxidation during and immediately after formulation of burger.

Hygreeva *et al*.[10] found that lemon albedo was very effective in retarded lipid oxidation. Also, Wang *et al*.[37] had reported that citrus by-products have a strong antioxidant activity which was associated with its bioactive compounds (ascorbic acid, polyphenols and carotenes).

Table 4: Total phenols (mg/100 g sample) of beef burger formulated with different concentrations of orange peel powders

Treatments	Total phenols (mg/100 g sample)
Control	2.15 ± 0.21^{e}
2.5%	15.39 ± 0.42^{d}
5.0%	17.99 ± 0.27^{c}
7.5%	26.64 ± 0.16^{b}
10.0%	31.90 ± 0.24^{a}
L.S.D at 5%	0.50

All values are means of triplicate determinations ±Standard Deviation (SD), Means within column with different letters are significantly different at $p<0.05$

Table 5: TBA values and TVBN of beef burger formulated with different concentrations of orange peel powders

Treatments	TBA values (mg kg^{-1})	TVBN (mg/100)
Control	0.303 ± 0.02^{a}	0.052 ± 0.02^{a}
2.5%	0.269 ± 0.02^{b}	0.041 ± 0.02^{b}
5.0%	0.212 ± 0.02^{b}	0.022 ± 0.01^{c}
7.5%	0.202 ± 0.02^{b}	0.019 ± 0.01^{d}
10.0%	0.163 ± 0.03^{b}	0.013 ± 0.01^{e}
L.S.D at 5%	0.02	0.02

All values are means of triplicate determinations ±Standard Deviation(SD), Means within column with different letters are significantly different at $p<0.05$

Total Volatile Basic Nitrogen (TVBN) of burger: Data in Table 5 shows the TVBN values of beef burger which indicated that there was a significant difference ($p<0.05$) among samples with different concentrations of orange peel additives. It is clear that these additives (for any concentration) have decreased the total volatile basic nitrogen with significant level ($p<0.05$) as compared to the control sample. Table 5 shows that TVBN values of raw burgers were depended on the concentration of orange peel additives. The lowest TVBN were obtained in burger with 10% orange peel additives while, the highest values were in 2.5% orange peel additive that compared to the control samples. This indicated the effectiveness of orange peel for inhibiting many types of microorganisms which caused protein hydrolysis, this may be due to the high content of phenolic and flavonoids compounds which expressed inhibition activity of microbes.

Correlation between either TBA or TVBN and total phenolic compounds: There were high reversed significant ($p<0.05$) correlation between total phenol content and both of TBA and TVBN on the other side. That correlation were (-0.919) between the total phenolic content and the TBA, which indicated that total phenolic substances are responsible for lipid oxidation retardation of burger samples, not only by decreasing thiobarbituric acid reactant substances (TBA) formation but also, by reacting with that molecules and decreasing its level in burger samples. On the other hand, the correlation between total phenolic compounds and TVBN compounds were (-0.915) which indicated that phenolic

Table 6: Sensory evaluation of beef burger formulated with different concentrations of orange peel powders

Treatments	Color	Taste	Odour	Flavour	Texture	Overall acceptability
Control	10.00±0.01^{a}	10.00±0.01^{a}	10.00±0.01^{a}	10.00±0.01^{a}	10.00±0.01^{a}	10.00±0.01^{a}
2.5%	6.83±0.16^{c}	7.17±0.47^{b}	7.00±0.09^{bc}	6.67±0.52^{c}	7.67±0.52^{b}	6.67±0.52^{c}
5.0%	8.00±0.63^{b}	8.17±0.98^{b}	7.50±0.67^{b}	7.92±0.92^{b}	8.33±0.03^{bc}	7.83±0.75^{b}
7.5%	5.67±0.82^{d}	6.00±0.89^{c}	5.83±0.75^{cd}	5.67±0.03^{d}	7.00±0.53^{c}	6.00±0.89^{c}
10.0%	5.42±0.80^{e}	4.92±0.49^{c}	5.25±0.42^{d}	5.00±0.63^{d}	6.17±0.75^{d}	5.17±0.75^{d}
L.S.Dat5%	0.48	1.09	1.19	0.85	0.73	0.79

All values are means of triplicate determinations ±Standard Deviation(SD), Means within column with different letters are significantly different at $p<0.05$

compounds were responsible for the retardation of total volatile basic nitrogen generating from protein degradation consecutively, inhibition of microbial growth in burger samples.

Sensory evaluation: Table 6 shows that the results of the sensory evaluation for burger samples prepared with different concentrations of orange peel. Data indicated that there were significant differences ($p<0.05$) for color, taste, odor, flavor, texture and overall acceptability between burger samples with orange peel additives and the control. There were decreased in sensory attributes parameters like color, taste, odor, flavor and texture by increasing orange peel powder concentration. Burger containing orange peel at 5.0% additive was well accepted and exhibited the maximum score of sensory properties compared to control. While, in the case of 10% additive, the mean scores were lower which indicated that samples were unacceptable compared to the 2.5 and 7.5%. Table 6 shows that the acceptability of burger containing 5% orange peel powder had higher total scores followed by 2.5%. These results indicate that the orange peel powder could be added amount up to 10% in formula of burger with adversely affecting sensory characteristics of burger. Generally, the preference for the burger by panelists was associated with the low level bitterness. The main reason for why control burger sample have received the highest score was its less bitter taste than other burger samples. The astringent taste and bitterness encountered in burger were caused by the alkaloids, tannins and saponins in the orange fruit peel[38]. Therefore, 5% orange peel powder supplemented burger could be recommended to be produced as burger with good quality acceptable sensory quality attributes at the same time of being good source for bioactive compounds for food possessing.

CONCLUSION

Using citrus by-product (orange peel) as natural antioxidant had high efficiency of lipid oxidation retardation. The addition of orange peel to beef burgers represented an improvement in their quality characterizations including; inhibition of lipid oxidation and retarded the degradation of meat pigments. On the other side, it helped to delay the onset of rancid flavors and maintained the color of burger beside the improvement in sensory properties. Addition of 5% orange peel powder could be recommended for improving their nutritional quality and enrich the burger with bioactive compounds to become a functional meat product.

SIGNIFICANCE STATEMENTS

This study proved that the addition of orange peel to beef burgers can be beneficial for improving their nutritional quality. Moreover, it enriched the burger with bioactive compounds, thus it became a functional meat product. This study will help the researchers to uncover the critical areas of using citrus by-product (orange peel) as natural antioxidant with high efficiency of lipid oxidation retardation in burger that many researchers were not able to explore. Thus a new theory on production of functional meat products may be achieved.

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