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Chemical Composition of Onion Peel (*Allium cepa*) and its Ability to Serve as a Preservative in Cooked Beef

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Beatrice O. T. Ifesan *

**Department of Food Science and Technology, Federal University of Technology Akure, Nigeria.*

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ABSTRACT

Onion peel is regarded as waste in the food industry and if not properly discarded may cause environmental pollution. Onion peel was subjected to proximate analysis and the extract from the peel was examined for total flavonoid, phenol content, ability to scavenge 2,2-diphenyl-1-picrylhydrazyl (DPPH) free radicals and total antioxidant activity. The result of the proximate composition revealed that onion peel contains very high content of carbohydrate (88.56%) and low protein (0.88%). Onion peel extract yielded 98.52 µg QUE ml^{-1} total flavonoid, 664.30 µg ml^{-1} GAE total phenol, total antioxidant property (1338.15 µg ml^{-1}) and scavenged DPPH radical 27.76 µg ml^{-1}. During 9-day storage at 4ºC onion, peel extract was able to delay lipid oxidation in cooked meat compared to the control. In addition, the extract could act as a bacteriostatic agent in meat against *Bacillus cereus* which was the most sensitive to the extract, followed by *E. coli, S. aureus, Proteus vulgaris* and *B. subtilis.*

INTRODUCTION

Onions (*Allium cepa*) possess strong characteristic aromas and flavors, which have made them important ingredients in food (Ly et al. 2005). It has been shown that bioactive compounds are present in every part of onion bulb (Benitez et al. 2011). Onion is a potent cardiovascular and anticancer agent, with hypocholesterolemic, antioxidant, antiasthmatic, and antithrombotic activity (Moreno et al. 2006). Onion is one of the major sources of dietary flavonoids which contains anthocyanins, that is responsible for the red or purple color observed in some varieties, and flavonols (quercetin) that may contribute to the production of yellow and brown compounds found in the skins of many onions. Quercetin has demonstrated antioxidant and free radical scavenging power and its capability to protect against cardiovascular disease (Bonaccorsi et al. 2008, Benítez et al. 2011). However, onion skins contain higher concentrations of quercetin aglycon than the flesh (Downes et al. 2009).

It has been reported that quercetin and quercetin 4'-O-glucopyranoside are the major flavonoids in red onion peel (Fossen et al. 1998). Quercetin, a bioflavonoid extracted from red onion peel, showed marked inhibitory activity against phosphodiesterase 5A (Lines and Ono 2006). During food processing, the two outer fleshy scales and roots of onion bulb are removed together with the peel and regarded as waste. Since the food industry produces a large amount of onion waste which may constitute the nuisance to the environment if not properly discharged, it is, therefore, necessary to investigate the antioxidant and antimicrobial properties of onion peel and its application in the food system.

MATERIALS AND METHODS

Collection and preparation of sample

Onion bulbs were purchased from local market in Ile-Ife, Osun State, Nigeria. The bulbs were sorted and the peels were manually removed, dried in the oven at 40ºC and milled into powder using attrition mill. It was then packaged, labeled, sealed and stored at room temperature for further analyses. All the chemicals used were of analytical grade.

Determination of proximate composition of onion peel

This was carried out using the method of Association of Official Analytical Chemists (AOAC 2005).

Preparation of ethanolic extract from onion peel

The onion peel ethanolic extract was prepared in the laboratory following the method of Ifesan et al. (2014). Twenty grams of sample was soaked in 200 ml of 80% ethanol for 24 h. The extract was filtered through a Whatman filter paper 125 mm (No 1) under vacuum at room temperature. The filtrate was evaporated under reduced pressure in a rotary evaporator at 45°C until the extracts became completely dry. After evaporation, the extract was stored at and the extracts were stored at −20ºC until use.

Determination of Total phenol from onion peel extract

Total phenol of sample was carried out following the method of Singleton et al. (1999). About 0.1 ml aliquot of the extract was prepared and mixed with Folin-Ciocalteu's phenol reagent and 20% sodium carbonate. The mixtures were kept at room temperature for 90 min before measuring their absorbance at 760 nm. For the blank, distilled water was added to replace the standard solution. The total phenolic content in the extract was calculated from the calibration curve and determined as gallic acid equivalent.

Determination of Total flavonoid content of onion peel extract

About 0.2 ml of the extract was added to 0.3 ml of 5% $NaNO_3$. After 5 min, 0.6 ml of 10% $AlCl_3$ was added and after 6 min, 2 ml of 1M NaOH was added to the mixture followed by the addition of 2.1 ml of distilled water. Absorbance was read at 510 nm against the reagent blank and flavonoid content was expressed as mg rutin equivalent (Edeoga et al. 2005).

Determination of DPPH radical scavenging of onion peel extract

The free radical scavenging ability of the extract against DPPH (1,1-diphenyl-2-picrylhydrazyl) free radical was evaluated as described by Hutadilok-Towatana et al. (2006). One milliliter of the extract was mixed with 1 ml of 0.4 mM methanolic solution containing DPPH solution, the mixture was left in the dark for 30 min and the absorbance was taken at 516 nm in the JENWAY UV–visible spectrophotometer. Control with 1% ethanol and without the extract was also set up under the same condition for the experiment.

Determination of total antioxidant capacity of onion peel extract

Determination of total antioxidant capacity was carried out using the method of Prieto et al. (1999). An aliquot of 0.1 ml of sample solution was combined in an Eppendorf tube with 1 ml of reagent solution (0.6 M sulphuric, 28 mM sodium phosphate, and 4 mM ammonium molybdate). The tubes were capped and incubated in a thermal block at 95ºC for 90 min. After the samples had cooled to room temperature, the absorbance of the aqueous solution of each was measured at 695 nm against a blank.

Preparation of meat samples

The fresh lean beef was bought from an abattoir in Akure, Ondo State, Nigeria. It was transported to the laboratory immediately within 30 min of purchase. The meat was washed with sterile water and then manually and aseptically minced to pieces. Ten grams of meat was put into sterile test tubes containing 10 ml of onion peel extract at various concentrations of 2.7 mg, 5.4 mg, and 10.8 mg. The various treatments were thoroughly mixed with the sterile spatula for uniform distribution of the added extract. The control was without extract (10% ethanol). Each portion was cooked in the microwave until the internal temperature reached 80 °C and was held for 2 min after which they were allowed to cool down at room temperature. They were then divided and packaged separately into plastic bags, sealed and stored at 4 ºC for chemical and microbiological analyses during storage (Ifesan et al. 2009).

Determination of thiobarbituric acid-reactive substances (TBARS)

Modified TBARS of meat samples treated with onion peel extract was carried out following the method described by Sallam et al. (2004). One gram of sample was mixed with 4 ml of TBA reagent (0.375% thiobarbituric acid, 15% trichloroacetic acid, and 0.25 N HCI) in screw cap test tubes. The mixture was heated in boiling water for 10 min and then cooled under running tap water. The mixture was centrifuged (Hitachi, Tokyo, Japan) at 3600 g for 20 min. The supernatant was removed and absorbance was read at 532 nm using a UV-160 spectrophotometer. TBARS were calculated from the standard curve of malonaldehyde and expressed as mg malonaldehyde per kg sample.

Bacterial strain and preparation of inoculum

Typed cultures of *Staphylococcus aureus* (NCIB 8588), *Escherichia coli* (NCIB 86), *Bacillus subtilis* (3610), *Bacillus cereus* (NCIB 6349), and *Proteus vulgaris* (NCIB 67) used for this study were supplied by the Pharmaceutical Microbiology Laboratory of the Obafemi Awolowo University Ile Ife, Osun State, Nigeria. The strains were subcultured in overnight buffered peptone water and incubated at 37 ^{0}C for 6 h. The inocula were finally adjusted to 10^{8}cfu ml^{-1} using the McFarland standard. About 0.2 ml of the overnight broth culture of bacteria matched with the Mcfarland standard solution was added to the already cooled mixture of beef and extract while the control was without extract but with 10% ethanol. Meat cooked with extract and inoculated with bacterial cultures to obtain approximately 10^{6} cfu g^{-1} were kept at 4 $^{\circ}$C for 9 days and examined on the first day and every 3 days for viable counts of bacteria. About 0.1 ml of the mixture was spread on a surface of dried nutrient agar plates in duplicate and plates were incubated at 37 $^{\circ}$C for 24 h, after which the number of organisms found on each plate was counted following the method of American Public Health Association (1984).

RESULTS AND DISCUSSION

Proximate composition of onion peel

Table 1 shows the results of the proximate composition of onion peel. It was observed that onion peel possessed the high content of carbohydrate (88.56%) and very low protein (0.88%), ash (0.39%) and crude fiber (0.15%). Previous findings revealed that onion peel had a protein content higher than that of garlic peel (0.57%) while carbohydrate (93.26%) and ash (0.49%) content were higher in garlic peel (Ifesan et al. 2014).

Table 1. Proximate composition of onion peel

Characteristics (%)	Onion peel
Ash	0.39 + 0.01
Carbohydrate	88.56 + 0.04
Crude fibre	0.15 + 0.01
Fat	0.04 + 0.01
Moisture content	9.98 + 0.01
Protein	0.88 + 0.03

Total flavonoid and phenol from onion peel extract

Total flavonoid and phenol content of onion peel ethanolic extract are shown in Table 2. There were increases in yield with an increase in the concentration of extract used for total flavonoid and phenol at 500 µg/ml (98.52 µg QUE ml^{-1}:644.30 µg ml^{-1} GAE) and for 1000 µg/ml (177.33 µg QUE ml^{-1}:714.33 µg ml^{-1} GAE). Benitez et al. (2011) reported total flavonoid of 19.50 mg QE g^{-1}DW and phenol (19.70 mg GAE g^{-1}DW) from outer scales of onion. Onion has been reported as one of the major sources of dietary flavonoids (Ly et al. 2005). The brown skin of red onion was found to contain the highest level of phenolics (Prakash et al. 2007; Benitez et al. 2011). Flavonoids are known to reduce the risk of heart disease, inhibit the initiation, promotion, and progression of tumors (Okwu 2004). Phenolic compounds with strong antioxidant properties are prominent components of aromatic plants such as onion and garlic that are engaged in cooking to enhance the sensory quality of foods (Tang and Cronin 2007).

Table 2. Total flavonoid and phenol content of onion peel extracts

Extract (µg ml^{-1})	Total flavonoid (µg QUE ml^{-1})	Total phenol (µg ml^{-1} GAE)
500	98.52 ± 5.45	664.30 ± 0.00
1000	177.33 ± 1.56	714.33 ± 66.09

Total antioxidant and free radical scavenging of onion peel extract

Table 3 shows the total antioxidant activity of 1338.15 µg ml^{-1} and DPPH radical scavenging (27.76 µg ml^{-1}) of onion peel extract. Total antioxidant activity of 105.10 µmoles Fe^{2+} g^{-1} DW was reported from outer scales of onion (Benitez et al. 2011). The high correlations between ferric reducing values, total phenolic content and total flavonoids may be an indication that flavonoids are the main compounds responsible for the antioxidant activity in onions sections (Santas et al. 2008, Benitez et al. 2011). In addition, brown skin, the top and bottom sections of onion showed better antioxidant capacity than inner fleshy leaves (Benitez et al. 2011). The flavonoid, quercetin, an antioxidant found in onions has been shown to eliminate free radicals in the body, inhibits low-density lipoprotein oxidation and helps to circumvent the harmful effects of heavy metal ions (Abuga 2014).

Table 3. DPPH scavenging and total antioxidant assays of onion peel extract

Activities (0.1 mg ml^{-1})	Onion peel extract
DPPH radical scavenging	27.76 + 0.91 µg ml^{-1}
Total antioxidant assay	1338.15+28.70 µg ml^{-1}

Effect of onion peel extract on thiobarbituric acid-reactive substances (TBARS)

The ability of onion peel extract to delay oxidation is shown in Table 4. The least extract concentration used (2.7 mg) demonstrated antioxidant activity (3.43 mg MDA kg^{-1}-7.85 mg MDA kg^{-1}) which was significantly higher than that of control (6.91 mg MDA kg^{-1}-11.23 mg MDA kg^{-1}) during the 9 days storage period. Addition of 0.5% onion exhibited some antioxidant effect on irradiated meat (Yang et al. 2011). Previously, it was reported that garlic peel extract was able to delay oxidation in cooked beef samples (Ifesan et al. 2014). Garlic

and onion are two major spices commonly used in cookery to complement and enhance the flavor of meat products (Tang and Cronin 2007). It may be explained that garlic and onion possess strong antioxidant properties due to the presence of high phenolic and sulfur compounds present in them.

Table 4. Thiobarbituric acid-reactive substances (mg MDA kg^{-1}) values of beef cooked with crude extract from onion peels during storage at 4 ^{0}C

Days	Control	2.7 mg	5.4 mg	10.8 mg
0	6.91± 0.03^{d}	3.43±0.16^{c}	2.59±0.17^{b}	1.90±0.03^{a}
3	8.79±0.03^{d}	6.17±0.04^{c}	4.04±0.18^{b}	3.01±0.04^{a}
6	9.51±0.08^{d}	6.81±0.08^{c}	3.66±0.07^{b}	2.60±0.12^{a}
9	11.23±0.07^{d}	7.85±0.09^{c}	3.60±0.26^{b}	1.85±0.13^{a}

Values are means + SD from triplicate determinations. Different superscripts in the same row are significantly different ($P < 0.05$)

Antibacterial activity of onion peel extract in cooked meat

Table 5 revealed that onion peel extract could act as a bacteriostatic agent in meat. *Bacillus cereus* was the most sensitive to the extract, followed by *E.coli, S. aureus, Proteus vulgaris* and *B. subtilis.* The result further showed that activity of the extract increased with increase in concentration. Similar observations were made when *Eleutherine americana* crude extract was used as the antibacterial agent in cooked pork and garlic peel extract in cooked beef (Ifesan et. al. 2009, Ifesan et. al. 2014). Report from the chemical characterization of onion demonstrated that sulfur compounds, some proteins and phenolic compounds present in them may be responsible for the antimicrobial activity exhibited (Griffiths et. al. 2002, Rose et. al. 2005).

Table 5. Antibacterial activity of onion peel crude extract against some foodborne pathogens inoculated into cooked beef and stored for 9 days at 4ºC.

Bacteria	**Log bacterial count (cfu g^{-1})**			
	Control	2.7 mg	5.4 mg	10.8 mg
S.aureus	221.0+3.43	8.0±0.71	24.0±0.00	10.0±0.00
E.coli	142.0+12.00	33.0±0.71	14.0+5.66	10.0±6.36
B.subtilis	217.0+9.13	200.0±2.83	127.0±10.61	18.0±2.83
B. cereus	229.0+22.04	101.0±1.41	19.0±3.54	9.0±1.41
Proteus vulgaris	84.0+6.21	26.0±0.00	36.0±0.00	12.0±0.00

CONCLUSION

The food industry produces a large amount of onion waste and there is need to search for possible ways of their utilization. This research has found that onion peel has a high content of carbohydrate, flavonoid, and phenol. It further revealed that onion peel ethanolic extract could delay oxidation in cooked beef as well as the inhibited growth of some pathogenic bacteria. It may be suggested that after proper cleaning, onion peel may be included in food processing instead of discarding it. Also, further studies should be done to investigate the capability of onion peel to serve as a functional ingredient in food formulations.

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