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Physicochemical and Biological Evaluations of Packaged Chips and Meat balls Produced from Broiler Chicken Fed Diets Supplemented with Onion Wastes for Sustainability

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Abstract The study investigated the antimicrobial properties of onion waste on the microbial spoilage of stored chicken chips and meat balls produced from broiler chicken fed diets supplemented with onion wastes and the repellency of processed chicken chips and meat balls against housefly. One hundred and fifty, day old Arbo acres broiler chicks were procured from a reputable source and reared according to standard experimental procedures. Experimental diets were made up of treatment 1 (control diets, basal only), treatment 2- basal diet + 25 mg/kg onion waste, treatment 3- basal diet + 50mg/kg onion waste, treatment 4 - basal diet + 75mg/kg onion waste and treatment 5- basal diet + 100mg/kg onion waste. Cook yield, cook loss, microbial load count, gram reaction test and housefly repellency bioassay of chips and meat balls were evaluated. The results of microbial load decrease as the level of inclusion of onion wastes increases which showed that onion wastes had antimicrobial properties. The cooking yield percentage of chicken chip which ranged from 49.70 to 58.70 had the highest cooking yield observed in treatment 2 while the lowest was in treatment 3. The percentage of cooking loss in meat balls ranged from 8.80 (treatment 5) to 20.00 (treatment 3). The percentage repellency in chip was higher in female as it ranged from 70.00 to 100.00 than in male housefly which ranged from 53.33 to 93.33. The percentage repellency of housefly in chip was higher (90.00 - 100.00) in female than in male housefly which ranged from 66.67 to 100.00. This trend was observed in meat ball, as percentage repelleny in female housefly was comparatively higher (76.67 - 100) than the male (70.00 - 100) along treatments. The study concluded that the chips and meat balls produced from chicken broiler fed diets supplemented with onion wastes had an improved shelf life with paper bags.

Keywords: *chips, meat balls, housefly, biological, packaged*

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1. Introduction

Meat is a perishable product, which deteriorates if it is left uncovered and unprocessed in the ambient temperature. Meat can only be stored effectively for future use through proper processing, packaging and storage. However, processing of meat in Nigeria is still developing, urbanization and changing life style demand ready to eat and convenient meat products. Meat is an excellent environment for microbial growth due to its chemical composition and biological properties. Mesophilic, thermophilic and psychrotrophic bacteria are different types of microorganisms which can cause spoilage of meat and infections in humans and animals. Thus, inhibition of microbial growth through the use of dietary fibre and phenolic compounds, good processing, packaging and storage practices are essential factors to make ready to eat meat and meat products available. The high levels of phenolic compounds in onion wastes that are thrown away could be used as a source of fructans and sulphurous compounds. Fructans are prebiotics which stimulate the growth and activity of bacteria in the colon and sulphurous compounds reduce the accumulation of platelets, improve blood flow and cardiovascular health in general. They also have a positive effect on antioxidant and anti-inflammatory systems in mammals.

In line with the growing demand for onion bulbs, production of onion waste has risen over recent years. More than 500,000 tonnes of onion waste which includes the dry brown skin, the outer layers, roots and stalks, as

well as onions that are not big enough to be of commercial use, or onions that are damaged are generated in the European Union each year, above all in Spain, Holland and the United Kingdom, where it has become an environmental problem [1]. Most Nigerian onion bulb markets and warehouses share the same environmental problem resulting from onion wastes. One solution to this problem of environmental pollution caused by onion wastes could be to use onion wastes as feed for animals, because this vegetable is rich in compounds such as phenolic compounds (quercetin) and other flavonoids (plant metabolites with medicinal properties) and dietary fibre (principally the non-soluble type) that provide health benefits for human [2] and livestocks.

On the other hand, housefly, *Musca domestica*, an important veterinary and medical pest that spoils food, causes irritation, and acts as a vector for many pathogenic organisms of medical and veterinary importance or may cause annoyance to humans and agronomic livestock, resulting in considerable economic loss in livestock business [3]. The flies are known for high intake of food and constantly deposit feces, which make these flies carrier of pathogenic bacteria, such as *Escherichia coli*, *Staphylococcus aureus*, *Shigella* sp, *Vibrio cholerae*, and *Salmonella* sp and varieties of eggs of parasitic worm [4]. Many insecticides such as organochlorines and organophosphates have been used for housefly control [5]. However, the use of these chemicals in the control of houseflies in food products has no application as sprays or additives. Food and food products should be formulated to repel insect especially, housefly, a dangerous carrier of pathogens. Many secondary metabolites found in plant essential oils have been demonstrated to be good repellent to a variety of insect species [6].

The objective of this present study is to evaluate the potential use of onion wastes in feeding animals, their antimicrobial, physicochemical properties on meat products produced from broiler chicken fed supplemented onion wastes and also to determine the repellency status of this meat products to houseflies.

2. Materials and Methods

2.1. Experimental Site

The research study was conducted at the poultry section of the Teaching and Research farm, Faculty of Agricultural Science, Ekiti State University, Ado – Ekiti.

2.2. Site Preparation

The site was properly cleaned, washed and fumigated adequately with formaldehyde in water solution to eliminate disease causing microorganisms that may be present in the site. The experimental housing unit was partitioned into fifteen (15) separate pens of equal sizes of about 90 cm x 80 cm, using wooden planks and wire nets.

2.3. Procurement and Management of the Experimental Birds

One hundred and fifty, day old Arbo acres broiler chicks were procured from a reputable source. The pen was properly covered with polythene bags, dry wood shaving up to 5 cm deep spread on the floor and pre-heated before the arrival of the chicks to raise the temperature of the brooding environment so as to keep the chicks warm. All necessary medications were administered throughout the experimental phase. At the onset of four weeks of age, one hundred and fifty birds were randomly allocated to five dietary treatments of three replicates. The replicate consisted of ten chicks per-treatment. Portable water provided *ad-libitum*.

2.4. Experimental Feed Composition

The basal diet (Table 2) was formulated according to the nutrient requirements (NRC 1994) for broilers. Experimental diets were treatment 1 (control diets, basal only), treatment 2- basal diet + 25 mg/kg onion waste, treatment 3- basal diet + 50mg/kg onion waste, treatment 4 - basal diet + 75mg/kg onion waste and treatment 5- basal diet + 100mgk/g onion waste.

2.5. Slaughtering Procedure of Broiler Chickens

At the end of 28-day feeding trial, three birds with body weight similar to average from each treatment were selected for meat ball processing. Selected birds were stunned, sticked, plucked, eviscerated and separated into prime cuts, of which left breast muscle was used for the production of meat balls.

2.6. Preparation of Chicken Meat Ball and Chicken Chip Samples

500g of breast muscle each was obtained from the experiment birds chopped into 1.0g and blended with a blender. A mixture of ingredients (salts, thyme, nut meg, curry, chilli pepper, corn flower) was added to grounded muscle and rolled into same size and weight. The raw meat balls were deep fried in unsaturated sun flower oil at 105°C to the internal temperature of 75°C and 72°C for meat balls and chips respectively, drained and dried with kitchen towels. Fried meat balls were weighed, divided into two portions for physico-chemical and microbial analysis.

Table 1. Experimental feed composition (g/100g)

Ingredients	Starter (1d-4th week)	Finisher (5th - 8th week)
Maize	40.0	45.0
Soybean meal	25.0	10.0
Brewer's dried grain	15.25	25.25
Palm kernel cake	15.0	17.0
Palm oil	2.0	5.0
Bone meal	1.0	1.0
DCP	1.0	1.0
Salt	0.25	0.25
Premix	0.25	0.25
Methionine	0.15	0.15
Lysine	0.10	0.10
Total	100	100
Calculated:		
Crude protein (%)	22.08	18.66
Metabolizable energy (kcal/kg)	2930	3119.79

2.7. Determination of Cooking Loss

The difference in weight of samples before and after cooking were recorded as total cooking loss and it was expressed as a percentage of weight before cooking [7]. The percentage of cooking loss was calculated using the following equation.

$$Cooking\ loss\ (\%) = \left[(W1 - W2)/W1\right]\ x\ 100$$

Where:
W1 = weight of sample before frying;
W2 = weight of sample after frying.

2.8. Evaluation of Cook Yield of Chips and Meatballs

Cook yield was evaluated by the procedure of Singh and Deshpande [8]. Meat was cooked by deep frying in sun flower oil at 105°C to the internal temperature of 72°C and the cooked chips and meatballs were allowed to cool down exposed to ambient air at room temperature. The pH of the cooked meat was measured after meat had cooled down to room temperature, and weight was also taken. The per cent cook yield was calculated as follows:

$$\%\ Cook\ Yield = \frac{Cooked\ weight}{Weight\ before\ cooking} x100.$$

2.9. Packaging of Meat Balls and Chips

Aluminium Laminated film (20µm), White Paper (80g), Brown Paper (80g), Pink Slip (15µm), Green Slip (20µm) and Blue Cup (25µm) were the packaging materials used to store the meat balls and chips for microbial load assessment after 7 and 14 days storage. Thirty grammes (30g) of meat balls and chips were weighed out into each of the packaging materials (12cm x 8cm) in triplicate along with the control [9]. The packaged samples were stored under laboratory conditions (25±3°C and 50-70% RH).

2.10. Total Viable Counts

A portion of each processed chicken chips (10 g) was macerated using mortar and pestle. Each macerated sample (1 g) was added into test tubes containing sterile distilled water (9 ml) and was thoroughly mixed to serve as stock. Four fold serial dilutions (10^{-1} to 10^{-4}) of the stock were done using 1 ml stock homogenate and 9 ml sterile distilled water in order to obtain discrete colonies [10]. The media (Nutrient Agar) used was prepared from commercially dehydrated products and reconstituted according to the manufacturer's directives, sterilized by autoclaving at 121°C for 15 minutes and was cooled to 45-59°C. 1.0 mL each of the serially diluted chicken meat chip and meat ball samples was dropped at the centre of a Petri dish followed by pouring of the nutrient agar using the pour plate method as described by Begum *et al.*, (1986) [11]. It was allowed to solidify for some minutes and then incubated upside down at 37°C for 24 hours. The colonies that emerged were counted using digital colony counter (Gallenkamp Colony Counter 5A044) and calculation for the colony forming units was expressed as log cfu/ml using the formula as described by Muhammad et al. [12].

2.11. Negative and Positive Gram Test

MacConkey agar medium was used to classify on the basis of gram negative and positive bacteria present in meat product samples. Key components of the MacConkey medium include bile salts, crystal violet dye, lactose, and neutral red (pH indicator). Crystal violet dye and bile salts inhibits the growth of gram-positive bacteria. Only gram-negative species form colonies on MAC agar. 49.53 grams of dehydrated medium was suspended in 1000Ml of distilled water. This was heated to boiling to dissolve the medium completely and sterilized by autoclaving at 121°C for 15 minutes. This was cooled to 45°C - 50°C. Well mixed MacConkey agar medium was poured into sterile Petri plates. The surface of the medium was allowed dry before inoculation with microbe source and incubated at 35-37°C for 24hours.

2.12. Rearing of Musca Domestica

Houseflies were reared in a 5L plastic bowl covered with muslin cloths and maintained at 28 ± 2°C, 65 ± 5 % relative humidity (RH) in a growth chamber. During rearing, flies were fed on a mixture of groundnut oil cake and wheat bran at a ratio of 1: 3. Eggs were transferred to another box containing the same diet. Hatched larvae were transferred individually to cylindrical vials (28 x 12 mm) containing a semi-synthetic diet (constituents: wheat bran 16 cups (3.75L), bakers fast rising yeast 3 tbls (15mL), Nonfat Dry Milk 1 cup (240mL), groundnut cake 1 cup (240mL), deionized water 12.5 cups (3L), evaporated milk 30 mL), this diet was maintained until larvae reached the adult stage to avoid contamination. Cages (100X100X100cm), covered with mosquito net were used to house the experiment in the laboratory. This was done according to the modified method of Ramamurthy *et al.*, [3].

2.13. Extraction of Garlic and Repellency Assay

Seventy five grams (75 g) of peeled garlic clove were pulverized and soaked in 750 ml of ethanol (99.8%) in the flask for 6 hours, stirring intermittently with a sterile glass rod, then, filtered through Whatman No.4 filter paper. The solvents were removed in a water bath at 79°C for ethanol to obtain a semi solid extract. 50 mL each of 1 %, 2 % 3 %, 4 %, and 5 % of ethanolic extracts of garlic powder extract were uniformly applied to the outer surface of the chips meat balls with the aid of an artist brush. Treated samples were air dried for 1 h. Effect of chicken chip and meat ball treated with different concentrations of garlic extracts on the repellency of *Musca domestica* L. (Diptera: Muscidae) was investigated.

2.14. Contact Repellency Assay

Houseflies were introduced, anesthetically into the opening end of the vertical tube leading to the horizontal tube of the T- shaped repellometer, which consisted of a

10 x 3 cm (vertical tube) and 13 x 3 (horizontal tube) cm section of PVC pipe respectively. The horizontal pipe was perforated 2 cm at both end of the tube. Filter paper was used to line the inner surfaces of the 2 cm perforated section end of the horizontal tube. For each trial, samples were placed on the on filter paper inserted at the two ends of the pipe, one end for the control sample while the other end was for the treated sample. 5g of chips and meat ball samples fried with sunflower oil were put in one end of the tube while another 5g of oven dried chips and meat ball samples were put in the other end as control. The second experiment evaluated the chips and meat ball treated with garlic extract and oven dried and the untreated as control. A lamp with a 35W incandescent bulb was placed 20 cm from the opening of the two ends of the pipe to provide a visual stimulus for the houseflies. Each fly was introduced into the central opening end of the pipe. Each fly had 10 cm of unbiased travel space before it could decide to have its tarsi in contact with samples. Three replicates, each consisting of 10 male and 10 female houseflies, were run for the chips and meat ball samples. All the bioassays were conducted under laboratory conditions (25±3°C and 50-70% RH). The number of flies present on control (Nc) and treated ends (Nt) was recorded after 1minutes. Percentage repellency (PR) values were computed as follows:

$$PR = \frac{Nc - Nt}{Nc + Nt} X100.$$

2.15. Statistical Analysis

All data were obtained in triplicates and subjected to analysis of variance (ANOVA). Means were separated using Tukey pairwise of Minitab 16.0 statistical package.

3. Results and Discussion

The highest (51.00) percentage cooking loss and the lowest (34.30) in chicken chips were observed in treatment 2 and 5 respectively. The cooking yield percentage of chicken chip which ranged from 49.70 to 58.70 had the highest cooking yield observed in treatment 2 while the lowest was in treatment 3. The results of cooking loss and cooking yield were significantly ($p<0.05$) different across treatments (Table 2).

Table 2. Physico-chemical properties of chips produced from Broiler chicken fed diets supplemented with graded level of onion wastes

Treatments	Parameters	
	Cooking loss %	Cooking yield %
T_1 (Control)	43.0±1.00^{c}	52.7±0.58^{d}
T_2(5mg/kg OW)	51.0±5.29^{a}	58.7±5.77^{a}
T_3 (50mg/kg OW)	45.7±0.58^{b}	49.7±4.93^{e}
T_4 (75mg/kg OW)	39.7±2.08^{d}	53.0±1.73^{c}
T_5(100mg/kg OW)	34.3±2.08^{e}	53.3±3.06^{b}

Mean ± standard deviation, a, b, c,d,e- means with different superscripts on same coloum are significantly different (P<0.05); OW- Onion wastes; T_1 = Treatment 1 (control diet); T_2 = Ttreatment 2 (25mg/kg) onion waste; T_3= Treatment 3 (50mg/kg onion waste); T_4= Ttreatment 4(750mg/kg onion waste); T_5= Ttreatment 5 (100mg/kg onion waste)

Similarly, the cooking loss observed in meat balls was comparatively low as against chicken chips. The percentage of cooking loss in meat balls ranged from 8.80 (treatment 5) to 20.00 (treatment 3). However, cooking yield of meat balls was between 84.00 (treatment 3) and 95.17 (treatment 5). The results of cooking loss and yield of meat balls were significantly ($p<0.05$) different (Table 3).

Table 3. Physico-chemical properties of meat balls produced from Broiler chicken fed diets supplemented with graded level of onion wastes

Treatment	Parameters	
	Cooking loss %	Cooking yield %
T_1 (Control)	19.8±00^{b}	84.1±0.12^{d}
T_2 (5mg/kg OW)	18.8±0.00^{c}	85.1±0.12^{c}
T_3 (50mg/kg OW)	20.0±0.00^{a}	84.0±0.00^{e}
T_4 (75mg/kg OW)	12.0±0.00^{d}	92.0±0.00^{b}
T_5 (100mg/kg OW)	8.80±0.00^{e}	95.17±0.06^{a}

Mean ± standard deviation, a, b, c,d,e- means with different superscripts on same coloum are significantly different (P<0.05); OW- Onion wastes; T_1 = Treatment 1 (control diet); T_2 = Ttreatment 2 (25mg/kg) onion waste; T_3= Treatment 3 (50mg/kg onion waste); T_4= Ttreatment 4 (750mg/kg onion waste); T_5= Ttreatment 5 (100mg/kg onion waste)

The results of the microbial load of chicken chips produced from broiler fed with onion waste and stored in different packaging materials; Aluminium Laminated film (20µm), White Paper bag (80g), Brown Paper Bag (80g), LDP Pink Slip (15µm), LDP Green Slip (20µm) and LDP Blue Cup (25µm) are as shown in Table 4. The total viable count of microflora in the analyzed samples showed a downward trend from treatment 1 to treatment 5 for day seven and fourteen investigated in this study. The highest proliferation of microbes in chicken chips, was recorded in Aluminium Laminated film (20µm) as it ranged from 0.52 to 6.05 $\log^{-4}$cfu/ml while the least values were enumerated with brown paper bag (80g) which had 0.04 to 0.33 $\log^{-4}$/ml. Microbial load of the stored chicken chips was significantly ($p<0.05$) different across treatments and packaging materials.

Table 5 shows the microbial load enumerated from the packaged meat ball produced from broiler chickens fed with onion waste supplemented diet. Brown Paper Bag (80g) and White Paper Bag (80g) had highest inhibitory effect on microbial growth as microbial growth enumerated ranged from 0.07 to 0.39 as against the control which had 0.47 $\log^{-4}$ cfu/ml at day 7 of storage and 0.09 to 0.41 $\log^{-4}$ cfu/ml as against the control which had 0.49 $\log^{-4}$ cfu/ml at day 14 of storage for meat balls. The range of microbial load enumerated from day 7 to 14 in Aluminium Laminated film (20µm) (3.42 - 9.05 $\log^{-4}$ cfu/ml), LDP Pink Slip (15µm) (3.60 - 7.54 $\log^{-4}$ cfu/ml), LDP Green Slip (20µm) (3.58 - 6.23 $\log^{-4}$ cfu/ml) and LDP Blue Cup (25µm) (3.64 - 814 $\log^{-4}$ cfu/ml) was significantly ($p<0.05$) higher than those enumerated in paper bags. The microbial load across treatments showed downward decease with increase in the level of inclusion of onion waste fed the chicken. Total viable count across packaging materials and treatments was significantly ($p<0.05$) different.

The results of gram test of chicken chips revealed that white paper bag, brown paper bag, blue cup LDP and control packs Aluminium Laminated film inhibit the

growth of gram positive bacteria. Similarly, the results of gram test of packaged meat ball produced from broiler chickens fed onion wastes showed that Aluminium Laminated film, pink slip LDP and green slip LDP halt the growth of gram negative bacteria and allowed the growth of gram positive bacteria except in the control pack of Aluminium Laminated film (Table 6 & Table 7). The differentials in the number of microbes enumerated in the packaging materials is possibly due to the presence of moisture in the meat products and variations in the permeability to moisture and gaseous exchange in and out of the packaging materials [9]. The modified atmosphere provided by Aluminium Laminated film (20µm), LDP Pink Slip (15µm), LDP Green Slip (20µm) and LDP Blue Cup (25µm) likely enhanced microbial growth while that of Brown Paper Bag (80g) and White Paper Bag (80g) inhibited microbial proliferations. Aluminium seems not to posses antibacterial activity. Microbial load of all the chips and meat balls samples (Table 4 & Table 5) fell within satisfactory level with reference to standard microbial load specification [13]. The results of the microbial load for both chips and meat balls samples were lower than values (2.9 - 9.8 × 10^6) reported of street vended suya meat product [14]. The stability of the meat products in this study might also be attributed to the presence of flanoids such as quercetin and catechin which exert strongest antimicrobial and antioxidant potential that retard meat oxidation [15,16,17,18,19].

Table 4. Microbial Load of packaged chips produced from Broiler chickens fed with onion wastes supplemented diets

Microbial Load/ Packaging Materials	Storage days/ Microbial load Storage days/ Microbial load (log^{-4} CFU/ml)									
	7 day					14 day				
	TI	T2	T3	T4	T5	T1	T2	T3	T4	T5
AL film (20µm)	6.05±0.71^{a}	5.33±0.71^{b}	4.23±0.71^{c}	2.58±0.71^{d}	0.52±0.71^{e}	8.05±0.71^{a}	7.33±0.71^{a}	4.63±0.71^{b}	2.88±0.71^{c}	0.62±0.71^{d}
White Paper (80g)	0.59±0.71^{a}	0.39±0.71^{b}	0.33±0.00^{c}	0.28±0.00^{c}	0.09±0.71^{d}	0.59±0.71^{a}	0.49±1.41^{b}	0.37±0.71^{b}	0.34±0.71^{b}	0.11±0.00^{c}
Brown Paper (80g)	0.33±0.00^{a}	0.25±0.71^{b}	0.20±0.71^{c}	0.09±0.00^{c}	0.04±0.00^{d}	0.37±0.71^{a}	0.29±0.71^{b}	0.24±0.00^{c}	0.12±0.71^{c}	0.06±0.71^{d}
LDP Pink Slip (15µm)	4.21±2.12^{a}	3.00±7.07^{b}	4.44±2.12^{a}	2.06±1.41^{bc}	0.60±4.24^{d}	4.54±2.12^{a}	4.431.41±^{a}	4.68±0.71^{a}	2.16±1.14^{b}	0.70±1.14^{c}
LDP Green Slip (20µm)	3.13±2.12^{a}	3.11±2.83^{ab}	2.27±3.54^{b}	0.71±2.12^{c}	0.58±1.41^{d}	3.23±1.14^{a}	3.19±2.14^{a}	2.33±1.41^{b}	0.79±2.12^{c}	0.66±1.41^{c}
LDP Blue Cup (25µm)	5.06±0.71^{a}	4.31±2.12^{b}	3.90±2.12^{c}	0.90±0.71^{d}	0.64±0.91^{d}	5.14±0.71^{a}	4.39±2.14^{b}	3.98±1.41^{c}	0.98±0.71^{d}	0.72±0.71^{d}

Mean ± standard deviation, a, b, c,d,e- means with different superscripts on same row are significantly different (P<0.05); OW- Onion wastes; AL- Aluminum laminated; T_1 .Treatment 1 (control diet); T_2.treatment 2 (25mg/kg) onion waste; T_3- treatment 3 (50mg/kg onion waste); T_4.treatment 4(750mg/kg onion waste); T_5 .treatment 5 (100mg/kg onion waste).

Table 5. Microbial Load of packaged meat balls produced from Broiler chickens fed with onion wastes supplemented diets.

Microbial Load/ Packaging Materials (HDP)	Storage days/ Microbial load (log^{-4} CFU/ml)									
	7 day					14 day				
	TI	T2	T3	T4	T5	T1	T2	T3	T4	T5
AL film (20µm)	8.05±0.71^{a}	7.33±0.71^{b}	6.23±0.71^{c}	4.58±0.71^{d}	3.42±0.71^{e}	9.05±0.71^{a}	8.33±0.71^{b}	6.63±0.71^{c}	4.88±0.71^{d}	3.52±0.71^{e}
White Paper (80g)	0.74±0.71^{a}	0.54±0.71^{b}	0.48±0.00^{c}	0.43±0.00^{d}	0.33±0.71^{e}	0.74±0.71^{a}	0.54±1.41^{b}	0.51±0.71^{b}	0.48±0.71^{c}	0.35±0.00^{d}
Brown Paper (80g)	0.47±0.00^{a}	0.39±0.71^{b}	0.33±0.71^{b}	0.31±0.00^{c}	0.07±0.00^{d}	0.49±0.71^{a}	0.41±0.71^{b}	0.35±0.00^{c}	0.42±0.71^{c}	0.09±0.71^{d}
LDP Pink Slip (15µm)	7.21±2.12^{a}	6.00±7.07^{b}	5.44±2.12^{a}	5.06±1.41^{bc}	3.60±4.24^{d}	7.54±2.12^{a}	7.431.41±^{a}	6.68±0.71^{a}	5.16±1.14^{b}	3.7±1.14^{c}
LDP Green Slip (20µm)	6.13±2.12^{a}	6.11±2.83^{ab}	5.27±3.54^{b}	3.71±2.12^{c}	3.58±1.41^{d}	6.23±1.14^{a}	6.19±2.14^{a}	5.33±1.41^{b}	3.79±2.12^{c}	3.66±1.41^{c}
LDP Blue Cup (25µm)	8.06±0.71^{a}	7.31±2.12^{b}	6.90±2.12^{c}	3.90±0.71^{d}	3.64±0.91^{d}	8.14±0.71^{a}	7.39±2.14^{b}	6.98±1.41^{c}	3.98±0.71^{d}	3.72±0.71^{d}

Mean ± standard deviation, a, b, c,d,e- means with different superscripts on same row are significantly different (P<0.05); OW- Onion wastes; AL- Aluminum laminated; T_1 .Treatment 1 (control diet); T_2.treatment 2 (25mg/kg) onion waste; T_3- treatment 3 (50mg/kg onion waste); T_4.treatment 4(750mg/kg onion waste); T_5 .treatment 5 (100mg/kg onion waste).

Table 6. Gram Staining Reaction of packaged chicken chips produced from Broiler chickens fed onion wastes diets

Microbial Load/ Packaging Materials	Storage days/ Gram Reaction									
	7					14				
	TI	T2	T3	T4	T5	T1	T2	T3	T4	T5
AL film (20µm)	-ve	+ve	+ve	+ve	+ve	-ve	+ve	+ve	+ve	+ve
White Paper- 80g	-ve	+ve	+ve	+ve	+ve	-ve	+ve	+ve	+ve	+ve
Brown Paper- 80g	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve
Pink Slip LDP (15µm)	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve
Green Slip LDP (20µm)	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve
Blue Cup LDP (25µm)	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve

AL- Aluminum laminated, tve, Positive; -ve, Negative; T_1 .Treatment 1 (control diet); T_2.treatment 2 (25mg/kg) onion waste; T_3- treatment 3 (50mg/kg onion waste); T_4.treatment 4(750mg/kg onion waste); T_5 .treatment 5 (100mg/kg onion waste)

Table 7. Gram Test of packaged chicken meat balls produced from Broiler chickens fed onion wastes diets

Microbial Load/ Packaging Materials	Storage days/ Gram Reaction									
	7					14				
	TI	T2	T3	T4	T5	T1	T2	T3	T4	T5
AL film (20µm)	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve
White Paper- 80g	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve
Brown Paper- 80g	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve
Pink Slip LDP (15µm)	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve
Green Slip LDP (20µm)	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve
Blue Cup LDP (25µm)	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve

AL- Aluminum laminated, tve, Positive; -ve, Negative; T_1 .Treatment 1 (control diet); T_2.treatment 2 (25mg/kg) onion waste; T_3. treatment 3 (50mg/kg onion waste); T_4.treatment 4(750mg/kg onion waste); T_5 .treatment 5 (100mg/kg onion waste).

Table 8. Effect of frying of chicken chips and meat balls with sunflower oil and graded level of onion waste on *Musca domestica* L. (Diptera: Muscidae) repellency bioassay

Treatment	Chips		Meat ball	
	Male Housefly	Female Housefly	Male Housefly	Female Housefly
1	53.33 ± 5.77^{a}	70.00 ± 10.00^{a}	60.00 ± 10.00^{a}	80.00 ± 0.00^{a}
2	60.00 ± 0.00^{b}	83.33 ± 5.77^{b}	70.00 ± 10.00^{b}	83.33 ± 5.77^{b}
3	76.67 ± 5.77^{c}	83.33 ± 5.77^{b}	93.33 ± 5.77^{c}	90.00 ± 0.00^{c}
4	83.33 ± 5.77^{d}	83.33 ± 5.77^{b}	93.33 ± 5.77^{c}	93.33 ± 5.77^{d}
5	93.33 ± 5.77^{e}	100.00 ± 0.00^{c}	93.33 ± 5.77^{c}	100.00 ± 0.00^{e}

Mean ± standard deviation, a, b, c, d, e- means with different superscripts on same coloum are significantly different (P<0.05).

Table 9. Effect of chicken chip and meat ball treated with different concentrations of garlic extracts on the repellency of *Musca domestica* L. (Diptera: Muscidae)

Concentration (g ml-1)	Chips (%)		Meat ball (%)	
	Male Housefly	Female Housefly	Male Housefly	Female Housefly
1%	66.67 ± 5.77^{a}	90.00 ± 0.00^{a}	70.00 ± 10.00^{a}	76.67 ± 5.77^{a}
2%	80.00 ± 0.00^{b}	90.00 ± 0.00^{a}	80.00 ± 0.00^{b}	80.00 ± 10.00^{b}
3%	100.00 ± 0.00^{c}	100.00 ± 0.00^{b}	100.00 ± 0.00^{c}	100.00 ± 0.00^{c}
4%	100.00 ± 0.00^{c}	100.00 ± 0.00^{b}	100.00 ± 0.00^{c}	100.00 ± 0.00^{c}
5%	100.00 ± 0.00^{c}	100.00 ± 0.00^{b}	100.00 ± 0.00^{c}	100.00 ± 0.00^{c}

Mean ± standard deviation, a, b, c,d,e- means with different superscripts on same coloum are significantly different (P<0.05).

Table 8 showed the results of the repellency effects of sunflower oil and graded level of onion waste inclusion in chips and meat ball on housefly. The percentage repellency in chip was higher in female as it ranged from 70.00 to 100.00 than in male housefly which ranged from 53.33 to 93.33. Similar trend was observed in meat ball, percentage repelleny in female housefly ranged from 80.00 to 100 while male housefly ranged from 60.00 to 93.33. The results of the repellency effects of chicken chip and meat ball treated with different concentrations of garlic extracts on the repellency of housefly is as shown in Table 9. The percentage repellency of housefly in chip was higher (90.00 - 100.00) in female than in male housefly which ranged from 66.67 to 100.00. This trend was observed in meat ball, as percentage repelleny in female housefly was comparatively higher (76.67 - 100) than the male (70.00 - 100) along treatments. The repellency of sunflower oils could be due to the presence of monoterpene and sesquiterpene compounds [20], as derivatives of the terpenes a and b-pinene have been shown to repel *Aedes albopictus* mosquitoes [21]. Garlic extracts have been widely reported to be repellent to a number of invertebrate pests [22]. The repellency observed with garlic extracts in this study might be due to the presence of diallyl disulphide and trisulphide compounds [23].

4. Conclusion

The study revealed that the chips and meat balls produced from Broiler chicken fed diets supplemented with graded level of onion wastes had an increase in cook yield, reduction in cook loss, minimal microbial growth and a good repellency percentage to houseflies and therefore concluded that the several tonnes of onion waste which includes the dry brown skin, the outer layers, roots and stalks, as well as onions that are not big enough to be of commercial use, or damaged onions which are being generated all over the world can be put into a productive use as functional feeds for livestock to solve the problem of environmental pollution posed by onion wastes.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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