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Effects of Silver Nano-Particles on Nutritional Qualities, Sensory Attributes and Microbial Quality of Chicken

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Abstract
This study assessed the effects of silver nanoparticles on the nutritional qualities, sensory attributes and microbial quality of chicken. A stock solution of silver nanoparticles was bought from Sigma Aldrich and a broiler chicken was obtained from the local market and sacrificed, the Broiler was cut into dimensions of 3×3 cm thick using a sharp stainless steel knife. The broiler was divided into four Groups and placed in a petri dish labelled A, B, C and D. Each of the four samples was subdivided into three portions to represent a replicate. The pure silver nanoparticles solution produced was measured into 10, 15, and 20 ml and made up to 100 ml by adding sterile distilled water to achieve 10, 15, and 20% concentrations respectively. The samples in Group A were kept in a laboratory cabinet without any treatment. Samples in Group B were immersed in 10% for 24, 72 and 120 hours. Samples in Group C were immersed in 15% silver nanoparticles for 24, 72 and 120 hours while Group E was immersed in 20% silver nanoparticles for 24, 72 and 120 hours. The highest number of microorganisms was recorded among Group A and the lowest number are recorded among Group D. The mean of the texture, odour and colour was revealed and Group A and Group B recorded the highest mean. The Chemical composition of the Broiler chicken meat showed that the highest crude protein is recorded in the control group with 62.45% and the least is in group D with 58.98%. Also control had the highest fat content with 24.31% and group D recorded the least with 21.09%. The study recommends that extensive research about the application of nano-silver in preservation and its effect on human health should be investigated.

Keywords: Silver, Nano-particles, Chicken, preservation

Introduction

With consumers demanding higher quality poultry products at affordable prices and growing competition, the meat production sector has witnessed an exceptional change in not only the ingredients but also the processing system (Weiss *et al*., 2010). The demand for sustainable storage of poultry products and emphasis on human health and wellness has further led to the growth of innovation in the poultry industry (Young *et al*., 2013). Thus, expectations have risen regarding the use of ingredients, and additives with improved functionality to enhance the shelf life of foods (Olmedilla-Alonso *et al*., 2013). Hence, bioactive materials providing health benefits are increasingly added to foods to treat or prevent the growth of microorganisms (IFIC, 2006). However, there are impediments in the production, storage and distribution of foods with incorporated bioactive components. Owing to the range of traditional meat products, the impediments are likely far bigger in the poultry industry. A significant challenge is the low bioavailability of bioactive components when included in meat products, mainly due to relatively elevated levels of proteins, fats, and minerals. Nanotechnology can be referred to as an area of science and technology focused on the manufacture of nano-sized materials (less than 100 nm in diameter at least one dimension) that possess unique and novel properties, although a globally accepted definition does not exist (Lövenstam *et al*., 2010; Gruère, 2012). It also refers to the production, characterization, and manipulation of such materials (Weiss *et al*., 2006). The major differences between nanomaterials and bulk materials are the changes in physicochemical (e.g., porosity), optical, mechanical and catalytic properties. Other differences are also observed in the strength, absorption, function, weight, and stabilization of materials (Cockburn *et al*., 2012). All of these properties make nanotechnology very promising and have led to the development of many innovations in the area of food packaging (Sozer and Kokini, 2009; Rhim *et al*., 2013). However, when this generic technology is applied to foods, the changed properties of the nanomaterials may also affect the behaviour and properties of the foods (Cockburn *et al*., 2012). The benefits of nano-technology include; enhanced stability and absorption of the bioactive compounds, along with improved antimicrobial effects against pathogens in the food storage that may be resistant to chemical antimicrobials (Duncan, 2011; Cockburn *et al*., 2012). Nanotechnology is projected to impact the food industry mainly through the creation of nano-sized materials with novel properties, the development of novel processing methods, products and improvements in food safety and biosecurity. Nevertheless, due to the novel properties exhibited by nanoparticles, significant beneficial changes are expected to be enabled in the production, packaging and preservation of many food products, including meat products (Weiss *et al*., 2006; Duncan, 2011; Gruère, 2012). Nanometals (Au, Ag, Ti), especially nanometric silver particles, have aroused great hope in the food industry. The antimicrobial properties of silver combined with nanomaterial properties have given rise to a new generation of preservative agents. According to the studies by Li *et al*. (2003) silver nanoparticles sized above 30 nm showed antimicrobial activity towards Gram-negative and Gram-positive bacteria as well as prevented the development of harmful microorganisms on the tested surfaces. Currently, an increase in bacteria-resistant organisms and other microorganisms to convert the preservative agent requires novel solutions in this field. The prevention of harmful microflora growth is the focus of the health service, as well as the agriculture and food industries. Therefore this study is undertaken to determine the effects of silver nano-particles on the nutritional qualities, sensory attributes and microbial quality of chicken. Consequently, modifications have been attempted in the preservation of poultry products, but these have often led to unfavourable effects, such as poor organoleptic quality, lowered capacity to retain water and poor resistance to the growth of microbes (Weiss *et al*., 2010). Therefore, the poultry industry needs to implement and support an innovation agenda to address such challenges and ultimately improve the quality experienced by consumers (Troy and Kerry, 2010). Thus, nanotechnology is one such process-based innovation that could have a significant impact on the food industry (Linton and Walsh, 2008).

METHODOLOGY

Sample Collection

A live Broiler chicken was purchased and sacrificed. The drumstick was removed and was used for the research. A stock solution of silver nano-particle was gotten from Sigma Aldrich.

Sample preparation and treatment

The Broiler thigh was cut into dimensions of 3×3 cm thick using a sharp stainless steel knife. The sample was divided into four groups and placed in a petri dish labelled A, B, C and D. Each of the four samples was subdivided into three portions to represent a replicate. The pure silver nanoparticle solution produced was measured into 10, 15, and 20 ml and made up to 100 ml by adding sterile distilled water to achieve 10, 15, and 20% concentrations respectively. The samples in group A were kept in a laboratory cabinet without any treatment. Samples in group B were immersed in 10% for 24, 72 and 120 hours. Samples in Group C were immersed in 15% silver nano-particles for 24, 72 and 120 hours while Group E were immersed in 20% silver nano-particles for 24, 72 and 120 hours. All the treated samples were joined with the untreated sample in the laboratory cabinet for storage.

Isolation and Enumeration of Bacteria

Isolation and enumeration of bacteria in the samples are carried out according to Fawole and Oso, (2007).

Sensory Characteristics

The sensory characteristics of the samples were determined. The texture was determined by feeling the samples between fingers to determine whether it is hard, soft or slippery, colour change was determined by comparing the samples colour after treatment and storage with the sample original colour before treatment and storage while the change in odour was determined by bringing the sample close to the nostrils to smell to determine whether it is pleasant, slightly pleasant, moderately bad, bad or very offensive. The changes are judged on 9 point hedonic scale.

Determination of Chemical composition

The protein, ash, and crude fat contents of the meat samples were evaluated using the standard AOAC (2005) procedure.

Data Analysis

Data obtained was analysed using SPSS (Version 20.0) statistical package. Data were subjected to descriptive statistics in form of tables.

Results and Discussion

The effects of silver nano-particles on microorganisms is showed in Table 1, in which four (4) microorganism was isolated. The microoganisms are *Salmonella enteritidis*, *Staphylococcus aureus, Campylobacter jejuni* and *Escherichia coli*. Highest number of microorganism were recorded among group A and lowest number are recorded among group D. The mean of the texture, odour and colour was revealed in Table 2, 3 and 4. In which Group A and B recorded the highest mean and Group D recorded the lowest value across the study period. The Chemical composition of the Broilers' chicken meat is revealed in Table 5, the highest crude protein is recorded in the control group with 62.45% and the least is in group C with 58.59%. According to the results of these findings, five microorganism was enumerated and their activities was high in the untreated than the nano-silver treated groups. According to the FAO (2012), the maximum acceptable value of total microbial count for meat was 5.106 cfu/g, this study indicated that bacterial count in nano-silver treated groups was under this level at 24 hours. These findings demonstrated the inhibitory effect of nano-silver particles on microbial growth, particularly at 20% concentration. The inhibitory effect of nanosilver on microbial growth has been previously discussed. Cho (2004) investigated the antimicrobial activity of Ag-NPs. He suggested that Ag-NPs, but not platinum and gold nanoparticles, have antimicrobial activity. Rai (2001) described Ag-NPs as a new generation of nanomaterials that are capable to inhibit microbial growth. Also, the finding of this study is in accordance with previous research which includes; Ahari *et al.* (2013), study the effect of nano-silver on the shelf life of Iranian saffronusingnano-coatings SNP 103.3 and reported that 5% nanosilver, *i.e.* 4000 ppm, can reduce the microbial load by up to 98% (Ahari *et al*., 2013). Fernández *et al*. (2010), also investigated the efficacy of cellulosic pads containing silver nanoparticles in controlling the microbial flora (mesophilic aerobic psychotropic bacteria, mould and yeast) of packages containing a food model (Fernández *et al*., 2010). These pads increased the lag phase and reduced microbial load by about 3 cycles compared to the control group. The results of this study are consistent with our regarding its effect on microbial load. Incoronato *et al*. (2011) studied the effect of an antimicrobial packaging system containing nano-silver on cheese quality and reported that while this packaging significantly increased shelf life of cheese, it had no undesirable effect on main germs, functional dairy and sensory characteristics of the product (Incoronato *et al*., 2011). Mahdi *et al*. (2012) investigated the effect of using nano-silver packaging in meat packing and reported that nano-silver reduced the microbial load and increased the shelf life about 2-7 days. The sensory characteristics of untreated groups are sticky, tacky and slimy as compared to silver nano-particles treated chicken. The colour of poultry carcasses and poultry meat products is important sensory characteristic on which consumers often base product selection and judge quality. Broiler skin colour and broiler meat colour are influenced by numerous live production, handling, and processing factors (Obidoa *et al*., 2010). Pinking (pinkness or pink tinge) of white meat in cooked poultry products is one of the quality defects that the poultry industry is faced with. With this defect, white poultry meat displays areas that retain a pink colour even after the meat has been heated to an internal temperature exceeding 71.1°C. The protein and fat content reduced as the concentrations of the silver nanoparticles increased. Limited reduction in protein and fat contents was observed from the sample treated with 15 and 20% concentrations of silver nanoparticles. The decrease in the protein contents can be attributed to the changes in the protein structures due to the disruption of chemical bonds and secondary interactions with other constituents (Alizadeh, 2009). Olusanya (2008) reported that fats play a protective role in the body system and some important fatty acids such as omega-3-fatty acid, etc., that are derived from fats played significant roles in the proper functioning of body system (Obidoa *et al*., 2010).

Conclusion

The result of the study showed that the qualities of chicken were positively affected by silver nanoparticle treatment. The silver concentration of 20%, at 24 hours and 72 hours immersion could be said to be the optimum condition for the nanoparticle treatment in terms of quality parameters considered. Although the ability of silver nanoparticles to migrate from the packaging material into the food and its effect on human health is controversial, the possible introduction of silver into the chicken samples was not investigated in this study. Hence, extensive research about application of nano-silver in preservation and its effect on human health is recommended. There is thus a current need to study the relationships between particle characteristics, polymer type, food pH/polarity and environmental conditions relevant to food storage and packaging (*e.g.,* temperature, pressure, humidity, light exposure, storage time).

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Table 1: Effect of Silver Nano-particle against Microorganisms Load of Broiler Chicken

Period of Preservation	Microorganisms count (cfu/mL)x 10^3							
	Control (A)		10% Silver Nano-silver Particles (B)		15% Silver Nano-silver Particles (C)		20% Silver Nano-silver Particles (D)	
	Organism	No	Organism	No	Organism	No	Organism	No
24 hour	A C D	18 TNTC 11	B D	2 9	A B D	9 1 2	A	1
72 hours	A B C D	TNTC TNTC TNTC TNTC	A B D	17 31 47	A B D	14 21 29	A C D	9 6 13
120 hours	A B C D	TNTC TNTC TNTC TNTC	A B C D	49 TNTC 33 TNTC	A B D	38 TNTC TNTC	A C D	21 27 59

Key; TNTC- Too Numerous to be counted
A- Salmonella enteritidis B – Staphylococcus aureus
C- Campylobacter jejuni D- Escherichia coli

Table 2: Change in Texture of Silver nano-particle treated Broilers Chicken

Period of Preservation	Control	10%	15%	25%
24 hours	7.08	6.10	5.95	4.02
72 hours	8.06	7.03	6.32	5.22
120 hours	9.00	8.02	7.54	6.76

Table 3: Effect of Silver Nano-particles on Broilers Chicken Odour

Period of Storage	Control	10%	15%	20%
24 hours	8.10	7.05	7.03	6.13
72 hours	9.00	8.01	7.84	6.45
120 hours	9.00	8.45	8.00	7.07

Table 4: Effects of Silver nano particles on Broilers Chicken Colour

Period of Storage	Control	10%	15%	20%
24 hours	6.31	4.2	3.88	3.22
72 hours	8.13	7.97	6.90	6.00
120 hours	9.00	8.98	8.95	8.93

Table 5: Chemical Composition of Silver Nano-particle Treated Broiler Chicken sample During Storage

Period of Storage	Control	10%	15%	20%
Crude Protein (%)	62.45	61.78	59.76	58.98
Ash content (%)	13.24	14.58	18.11	19.93
Fat content (%)	24.31	23.64	22.13	21.09