

Evaluation of dynamics and prevalence of microbial flora of soaked dry meats (Kundi and Ponmo) in Nigeria

*Kehinde, O. O.,²Makinde, G. E. O.,²Agbato, O.,¹Adebowale, O. O.,¹Awoyomi, O. J. and²Fasanmi, O. G.

¹Department of Veterinary Public Health and Preventive Medicine,
Federal University of Agriculture, Abeokuta

²Federal Colleges of Animal Health and Production Technology,
Moor Plantation, Ibadan,



*Corresponding author: gbengakehinde210@yahoo.com

Abstract

The manner in which dry meat is prepared in under developed countries is highly unhygienic. Preserved meats (kundi and ponmo) were obtained from three food markets in Ibadan and were properly labelled. Samples cut into 50 grams were taken to the laboratory and soaked for 0, 6, 12, 18 and 24 hours. Water used for soaking and homogenised meat samples were cultured for *Salmonella*, *Campylobacter*, *E. coli*, total bacterial count (TBC), total coliform count (TCC). Data were subjected to analysis of variance (ANOVA). Comparison of microbial loads for all the parameters measured due to effects of soaking had no significant ($p > 0.05$) differences on kundi and ponmo, and the water for soaking. There was a significant increase of microbial load for kundi water from 0.94×10^3 cfu/g at 0hr to 4.93×10^3 cfu/g at 24hr for total bacterial count (TBC) at $p < 0.05$. The highest bacterial prevalence was the isolates from *Escherichia coli* in water for soaking Kundi, while the highest fungal prevalence was isolates from *Aspergillus niger* in water for soaking ponmo. The microbial load was lesser for ponmo than kundi and the soaking of the dried meat in water over a period of time reduced the microbial load in the preserved meat with the lowest microbial count found after 24 hours. It is recommended that consumers of dried meat should endeavour to soak this meat for a minimum of 24 hours before they are utilized.

Keywords: Microbial flora, food markets, bacterial prevalence

Evaluation de la dynamique et de la prévalence de la flore microbienne des viandes sèches trempées (Kundi et Ponmo) au Nigeria



Résumé

La manière dont la viande sèche est préparée dans les pays sous-développés est très peu hygiénique. Les viandes conservées (kundi et ponmo) provenaient de trois marchés alimentaires d'Ibadan et étaient correctement étiquetées. Des échantillons coupés en 50 grammes ont été amenés au laboratoire et trempés pendant 0, 6, 12, 18 et 24 heures. L'eau utilisée pour le trempage et les échantillons de viande homogénéisée ont été cultivés pour *Salmonella*, *Campylobacter*, *E. coli*, le nombre total de bactéries (NTB), le nombre total de coliformes (NTC). Les données ont été soumises à une analyse de variance (ANOVA). La comparaison des charges microbiennes pour tous les paramètres mesurés en raison des effets du trempage n'a révélé aucune différence significative ($p > 0,05$) sur le kundi et le ponmo, et sur l'eau de trempage. Il y a eu une augmentation significative de la charge microbienne pour l'eau de kundi de $0,94 \times 10^3$ cfu/g à 0 h à $4,93 \times 10^3$ cfu/g à 24 h pour le nombre total de bactéries (NTB) à $p < 0,05$. La prévalence bactérienne la plus élevée était les isolats d'*Escherichia coli* dans l'eau pour faire tremper Kundi, tandis que la prévalence fongique la plus élevée était les isolats d'*Aspergillus niger* dans l'eau pour faire tremper le

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ponmo. La charge microbienne était moindre pour le ponmo que pour le kundi et le trempage de la viande séchée dans l'eau sur une période de temps a réduit la charge microbienne dans la viande conservée avec le plus faible nombre de microbes trouvés après 24 heures. Il est recommandé aux consommateurs de viande séchée de s'efforcer faire tremper cette viande pendant au moins 24 heures avant de l'utiliser.

Mots clés : Flore microbienne, marchés alimentaires, prévalence bactérienne

Introduction

Meat and other animal products contribute to diets due to their high nutritional qualities by supplying high quality protein, vitamins and minerals (Olusola and Omojola, 2010; Adeyeye, 2016). However, these high nutritional qualities make meat perishable and ideal for growth of spoilage microbes. Hence, various methods are employed to preserve meat products (Akhtar and Pandey, 2015; Adeyeye, 2016). Worldwide, meat can be preserved by freezing, refrigerating and thermal processing though some traditional meat processed products are still popular especially in developing countries experiencing insufficient electric power supply. To preserve and add value to fresh meat, several food processing techniques such as boiling, frying, drying, and grilling are employed (Akhtar and Pandey, 2015; Adeyeye, 2016). Commonly preserved dried meats in Nigeria include Banda, Tinko or Kundi and Kilishi (Alonge, 1999; Vilar *et al.*, 2000; Okaka *et al.*, 2006; Adeyeye, 2016). Another common one is the processed raw hide (Ponmo), which is a by-product obtained from slaughter animal for leather production. Ponmo is obtained from the tenderization of hides of cattle in hot water followed by scrapping with sharp object like blade or singeing and sun drying (Okiel *et al.*, 2009). Ponmo and kundi are palatable, used as major delicacy and important food ingredient in the preparation of several stews in various cultures especially at several public outings, despite their less nutritional value (FAO, 2003; Obiri-Danso *et al.*, 2008).

Traditionally dried meat microbiology involves a natural development of wild fermentation in which microbial successions occur, uniform salting over the entire surface is most critical to inhibit pathogens and spoilage organisms (Okaka *et al.*, 2006). However, meat and meat products offer a highly favourable environment for the growth of pathogenic microbes such as *Salmonella* spp., *Campylobacter* spp., verotoxigenic *Escherichia coli* and *Listeria monocytogenes*, which will cause greatest risk of meat borne infections (Saucier, 2000; Ostry and Reprich, 2001; Fasanmi *et al.*, 2017). Dried food including meat products have been increasingly reported to be involved in outbreaks and recalls due to the presence of food-borne pathogens (Bourdoux *et al.*, 2016). Food-borne bacterial pathogen contamination may have been introduced at primary production (especially antibiotic resistant pathogens due to on-farm injudicious use of antibiotics), during and post-harvest levels - handling, processing, storage and transportation. The unregulated intake of antibiotics in food-producing animals has been associated with the development of antimicrobial-resistant bacteria; which can be transmitted from animals to humans either via direct contact, or consumption when such pathogens are passed down the food chain and the environment (FAO, 2014). Antibiotic use plays a major role in the emergence of antimicrobial resistance. Huge antibiotics use occurs in agricultural settings, especially in livestock production and slaughter animals, where little attention is focused (Landers *et al.*, 2012). Ensuring

the safety of meat and meat products calls for control of foodborne pathogens at all points of the food processing chain; from the farm, inspection before and after slaughtering, to the handling, processing, preservation and storage of meat and the products until the time it is consumed (FAO, 2014). Therefore, this study was aimed to determine the microbial load dynamics of soaked dried meats over a space of time and the antibiotic resistance of the isolated bacteria.

Materials and methods

Materials

Incubator, colony counter, Kundi and Ponmo tissues, microscopes, culture media, cotton wool, refrigerator, wire loop, distilled water

Sample collection

Dry meat tissues (kundi and ponmo) were bought from three food markets (Bodija, Oje and Molete) located in Ibadan, Oyo State, Nigeria. The kundi and ponmo samples were put in an air-tight polythene bags separately and taken to the Microbiology laboratory of the Institute of Agricultural Research and Training (I.A.R.&T.), Moor Plantation, Ibadan.

Preparation of samples for microbial counts

At the laboratory, thirty samples of 20g each of kundi and ponmo tissues weighed in a Kern 572-33 weighing scale (Kern and SohnGmbh, Germany) were soaked in labelled sample bottles with 50 mL distilled water, all the materials used for sample collection were sterile. These samples were prepared for microbiological studies within 24 hours of collection, and soaked in water and analysed for 0hr, 6hr, 12hr, 18hr and 24hr duration of soaking. The samples (water samples for the respective periods) were analyzed for the presence of bacterial and Total Fungal Count (TFC). The same procedure was followed for the soaked tissues, ground using mortar and pestle and

mixed with normal saline solution to make 10 millilitre and diluted serially into ten test tubes. One millilitre of inoculum was taken from the test tube using sterile pipette and poured into each sterile petri dish. Then 20 millilitre of sterile nutrient agar was poured into each sterile petri dish, distributed and mixed evenly throughout. All samples inoculated in the nutrient agar (Oxoid, USA) were incubated in an incubator (M e m m e r t i n c u b a t o r , BechickingSchwabach, Germany) at 37°C for 24 hours in order to get the viable bacterial count (*Salmonella*, *Shigella*, *Escherichia coli*), Total bacterial count (TBC), Total Coliform Count (TCC) and Total Fungal Count (TFC).

Interpretation of microbial growth

Petri dishes containing 30 - 300 colonies on nutrient agar plate were selected. These were counted using colony counter (Stuart Bibby Scientific, UK), enumerated and expressed in CFU/g/ml of meat and water samples from every soaked tissue.

Isolation of pathogenic bacteria from dry meat tissue and water

The pure colonies were obtained according to the method described by Clinical and laboratory standards institutes (CLSI (2005)). One nutrient agar plate, Mac-Conkey agar plate, *Salmonella-Shigella* agar plate and Eosin methylene Blue Agar plates (Oxoid ,USA) for each were streaked using a wire loop with inoculum got from the prepared meat samples and incubated in an incubator (M e m m e r t i n c u b a t o r , BechickingSchwabach,Germany) at 37°C for 24hours. The isolates obtained were observed for morphological and cultural characteristics in each of the cultured media for all the samples and biochemical tests.

Identification of isolate

The identification of the isolates *Salmonella* spp., *Shigella* spp. and *Escherichia coli*, was done following the procedure described by WHO (2003) and

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Cheeseborough (2006) as follows:

Morphological and cultural characteristics

Incubated nutrient agar plates were examined for yellow and amber growth. Isolates were examined microscopically (Olympus Microscope, Zeiss 080600 Zeiss, Germany) using Gram staining procedure for Gram- positive Cocci in clusters. These suggested the presence of *Staphylococcus* species. The incubated EMB Agar plates (Oxoid, USA) were examined for characteristic dark centred greenish and translucent amber growth which suggest the presence of *Escherichia coli*, and translucent, amber colour or colourless growth which suggest the presence of *Salmonella* or *Shigella* species. The isolates were examined microscopically (Olympus Microscope, Zeiss 080600 Zeiss, Germany) using Gram-staining procedure for gram-negative straight short rods which suggested the presence of *Escherichia coli* and Gram-negative long rods which suggest the presence of *Salmonella* and *Shigella* species. The growth on Mac-Conkey plates (Oxoid, USA) were examined for pink colonies for *Escherichia coli* which is a lactose fermenter and amber colonies for *Salmonella* or *Shigella* species. The incubated Salmonella Shigella Agar plates (Oxoid, USA) were examined for colourless colony with black centred growth which suggest the presence of *Salmonella* species (hydrogen sulphite producing bacteria), pink growth which suggests the presence of *Escherichia coli* (lactose fermenter) and colourless colony which suggests the presence of *Shigella* species (non-lactose fermenter and non-hydrogen sulphite producing bacteria).

Biochemical characteristics

The biochemical activities were carried out according to the method described by Cheeseborough (2006) and Oyeleke and Manga (2008).

Catalase production test

A wire loop (sterile) was used to take a speck of growth from each plate of 24 hours growth and a suspension was made with sterile distilled water on a clean microscope slide. Few drops of hydrogen peroxide were added using a pipette. Positive result showed the evolution of gas bubbles (effervescence) while negative result produced no bubbles.

Motility test

The isolates were cultured in peptone water for 24 hours before the motility test was carried out. A drop of the suspension was placed on a glass slide and covered with a cover slip. The whole preparation was sealed using a petroleum jelly to prevent it from drying. The preparation was observed microscopically (Olympus Microscope, Zeiss 080600 Zeiss, and Germany) for motile organisms using the X10 and X40 objectives.

Coagulase test

A small speck of growth from different plates were picked with a sterile loop and dropped on glass-slides. Few drops of plasma were applied on the inoculum and a smear was made and slides were rocked for 2 minutes. Positive result produced clumps while negative results produced no clumps.

Oxidase test

Oxidase test strips were used, by inserting it into a 24-hour broth culture of isolates and withdrawing and kept for 5 minutes for colour change. For Positive result, colour change from yellow to dark purple while negative result produced no colour change. Other biochemical tests carried out were citrate test, indole test, urease test, starch hydrolysis test, methyl- red test etc.

All identification tests were carried out according to validated standard operation procedures of Isenberg (2004) and Murray (1999).

Isolation of pathogenic fungi from dry meat tissues and water for soaking

The tissue and water samples were placed

on Sabouraud-glucose agar (SGA) supplemented with chloramphenicol for fungi. Petri dishes were incubated at 37°C for 48 - 72 h while the cultures were observed daily under a stereoscopic microscope for presence of fungal mycelia.

Data analysis

All data were subjected to analysis of variance (ANOVA) and Duncan multiple range test was used for post-hoc comparison of means found to be statistically significant ($p < 0.05$). Furthermore, Pearson's correlation coefficient analysis was carried out to determine the correlation between bacterial load and the soaking time for dried meat.

Results

Table 1 shows the comparison of microbial loads due to the effects of soaking of preserved meats (kundi and ponmo). The variables measured for the different tissues and the water used for the soaking include total bacterial count, total coliform count. The TBC was the same for the kundi tissue, kundi water and ponmo water, while the TCC is the same for KDT and KDW. However, the TBC and TCC for KDT is

greater than PT at $p < 0.05$. The *Escherichia coli* and *Salmonella spp.* count did not show any significant difference ($p > 0.05$) among the tissues and their respective waters. *Shigella* count was highest in the kundi tissue and lowest in ponmo water at $p < 0.05$. However, the total fungal count (TFC) is highest in ponmo tissue which is higher than the kundi tissue and water except for ponmo water, the least amount of TFC was observed in ponmo water at $p < 0.05$.

Effects of the soaking duration of kundi meat on the microbial loads in water

There was a corresponding increase in the microbial load with duration of soaking of the preserved tissue (kundi). It increases significantly from 0.94×10^5 cfu/g at 0hr to 4.10×10^5 cfu/g at 24hr for total bacterial count(TBC) at $p < 0.05$. Similar trend was observed for TCC, *E.coli*, *Salmonella spp.* and *Shigella spp* and also TFC; all at $p < 0.05$ (Table 2). The correlation between microbial load and duration of soaking is presented in Table 3. There is a direct correlation between the time of soaking and the microbial counts in the water used for soaking. As the time of soaking increases, there is a corresponding increase in the microbial load in the water.

Table 1: Comparison of microbial loads due to the effects of soaking preserved meats (kundi and ponmo)

Variables (x 10 ⁵ cfu/g)	KDT	KDW	PT	PW	±SEM
TBC	4.29 ^a	4.10 ^{ab}	2.75 ^b	3.05 ^{ab}	0.40
TCC	2.37 ^a	2.19 ^a	1.41 ^b	1.27 ^b	0.28
<i>E. coli</i>	1.36	1.11	0.86	0.89	0.19
<i>Salmonella spp.</i>	0.70	0.86	0.65	0.60	0.11
<i>Shigella spp.</i>	0.57 ^a	0.40 ^b	0.35 ^b	0.22 ^c	0.11
TFC	0.81 ^b	0.77 ^b	0.95 ^a	0.44 ^c	0.13

*^{abc}mean values on the same row with different superscripts are significantly different ($p < 0.05$)
 KDT –Kundi Tissue, KDW –Kundi Water, PT –Ponmo Tissue, PW –Ponmo Water, TBC – Total Bacterial Count, TCC – Total Coliform Count, TFC – Total fungal Count

Table 2: Effects of the duration of soaking of kundi tissue on microbial loads in water

Variables (x 10 ⁵ cfu/g/ml)	Duration of soaking					±SEM
	0hr	6hr	12hr	18hr	24hr	
TBC	0.94 ^c	3.29 ^b	3.39 ^b	3.70 ^{ab}	4.10 ^a	0.33
TCC	0.51 ^d	1.40 ^c	1.81 ^b	2.00 ^{ab}	2.19 ^a	0.74
<i>E. coli</i>	0.30 ^c	0.68 ^b	0.80 ^b	1.08 ^a	1.11 ^a	0.08
<i>Salmonella spp.</i>	0.14 ^c	0.26 ^{bc}	0.42 ^b	0.58 ^{ab}	0.86 ^a	0.05
<i>Shigella spp.</i>	0.05 ^c	0.21 ^b	0.22 ^{ab}	0.38 ^a	0.40 ^a	0.02
TFC	0.10 ^c	0.31 ^b	0.40 ^b	0.69 ^{ab}	0.77 ^a	0.05

*^{abc}mean values on the same row with different superscripts are significantly different ($p < 0.05$)

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Table 3: Pearson’s correlation between microbial loads and duration of soaking

	Time	TBC	TCC	<i>E. coli</i>	<i>Salmonella sp.</i>	<i>Shigella sp.</i>	TFC
Time	1.00						
TBC	0.80	1.00					
TCC	0.83	0.93	1.00				
<i>E. coli</i>	0.98	0.87	0.94	1.00			
<i>Salmonella sp.</i>	0.95	0.85	0.89	0.92	1.00		
<i>Shigella sp.</i>	0.83	0.82	0.92	0.92	0.83	1.00	
TFC	0.87	0.75	0.82	0.84	0.89	0.85	1.00

The highest bacterial prevalence was in isolates from *Escherichia coli* and this was seen in Kundi water, and the least prevalence was seen in different isolates for the different bacteria in tissues and water

(Fig.1a). The highest fungal prevalence was in isolates from *Aspergillus niger* and this was seen in ponmo water, while the least prevalence was seen in different isolates for the different fungi in tissues and water (Fig.1b).

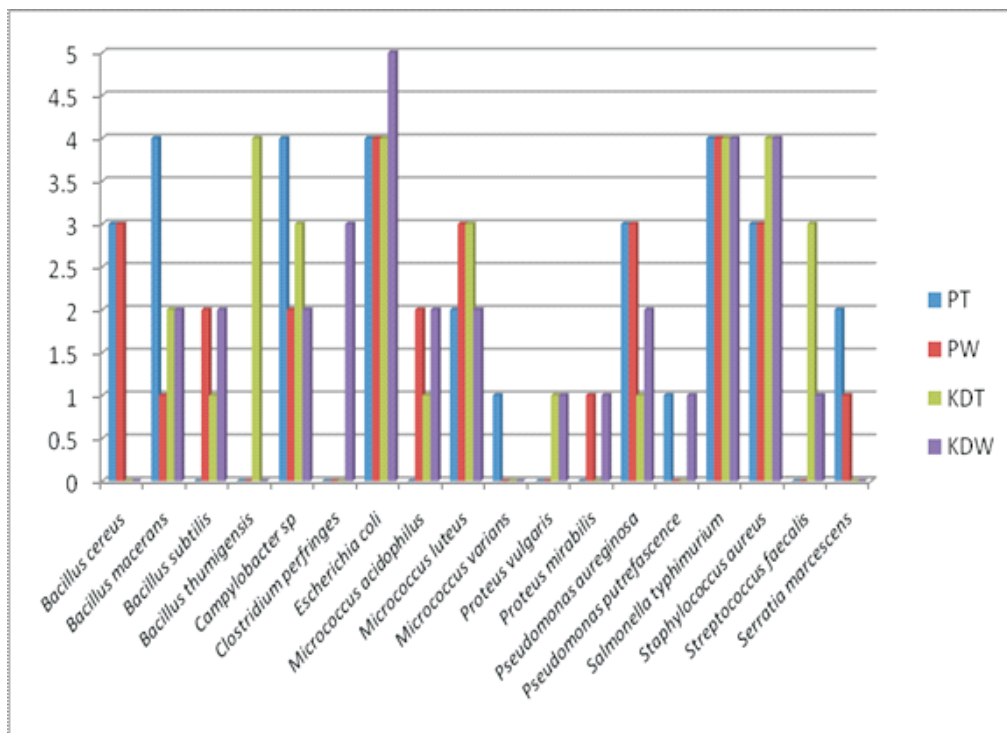


Fig. 1a: Frequency of occurrence of bacteria isolated from dried meat tissues (kundi and ponmo) and water used to soak

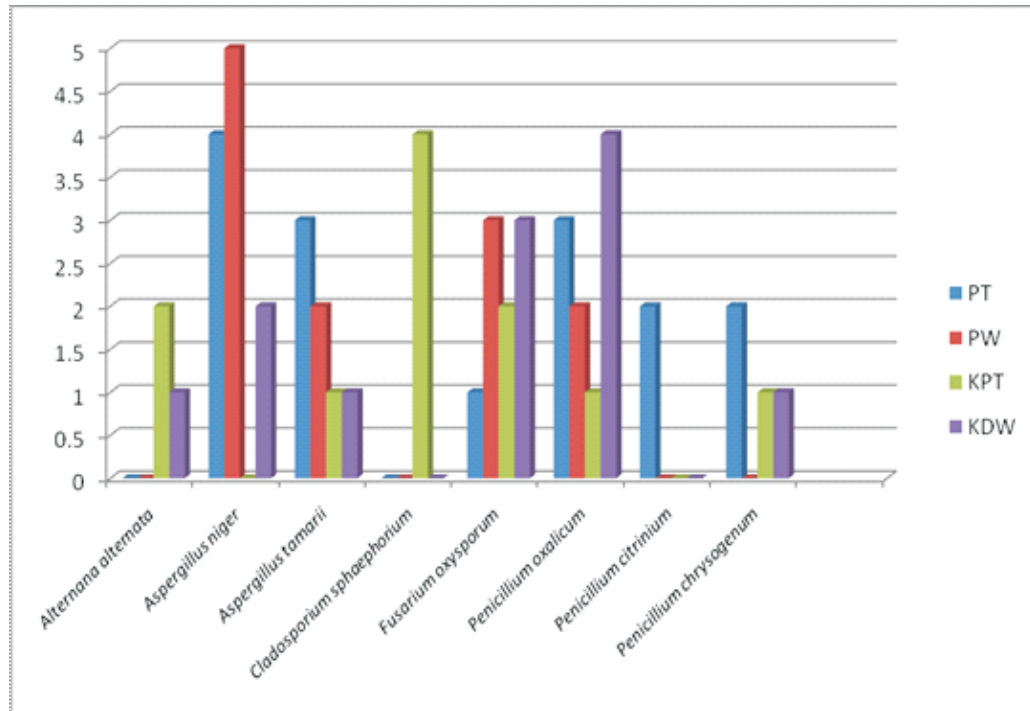


Fig. 1b: Frequency of occurrence of fungi isolated from dried meat tissues (kundi and pommo) and water used to soak

Discussion

Meat has been tagged a perishable food, because of its ability to deteriorate within a short period of time if not properly handled, processed or preserved. Meat is rich in carbohydrate which the bacteria can utilize for energy; abundant amounts of proteins which putrefactive bacteria can utilize for energy and high water content that is essential for bacteria growth (Thomas, 2012). This was further corroborated by Kołożyn-Krajewska and Dolatowski (2012); the constituent of meat that makes it nutritious also causes its susceptibility to microbial infections.

The shelf life or keeping qualities of meat is prolonged if a combination of preservation methods is adopted; by so doing the meat quality assurance is increased in accordance with the measure of the microbial load assessment (Yousuf *et al.*, 2008).

The findings of this study however, shows

that despite the application of preservation techniques (cooking and sun-drying), a number of harmful bacteria and fungi of public health importance were identified. This may be attributed to the stages in the processing and storage methods adopted for the dried meats (kundi and pommo).

The production processes involve the use of carcass, cutting, cooking for 15–30 min, drying and sun-drying or smoking for about 18–30 h, cooling, storage and packaging in sacks and jute/mat bags. Kundi is a stable product with a shelf-life of 6–12 months or even up to two years under ambient temperature (Idufueko, 1984; Okonkwo and Obanu, 1984). But their storage in jute bags may predispose to high humidity that will favour the growth of microbes by providing a conducive medium for their proliferation.

The isolated bacteria that are of zoonotic importance were *Salmonella sp.*,

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Clostridium sp., *Escherichia coli*, *Bacillus sp.*, *Pseudomonas sp.*, *Micrococcus sp.*, *Staphylococcus aureus*. This is also similar to the findings of WHO (2007) and Biswas et al, (2011); which state that bacterial pathogens commonly identified with meat contamination and cause infections in humans include *Salmonella sp.*, *Campylobacter sp.*, *Staphylococcus aureus*, *Escherichia coli*, *Listeria sp.*, *Clostridium sp.*, *Bacillus sp.*, and *Vibrio sp.*

All these findings are also in compliance with the findings of Clarence *et al.* (2009); that gram negative bacteria account for approximately 69% of the cases of bacteria food borne disease. Members of the gram negative bacteria such as the *E. Coliare* widely distributed in the environment contaminated food and water are the major sources by which bacteria are spread.

According to Fakolade and Omojola (2008), there was an increase in microbial load of organisms on dried meat samples after six months of storage due to moisture absorption from the environment. However, little or no information is available on the mycoflora of dried meat, hides and skin in Nigeria (Akanoe*etal.*, 1983).

However, the fungi identified from the dried meat products (kundi and ponmo) include the following viz; *Aspergillusniger*, *F u s a r i u m c o m p a c t i c u m*, *Fusariumoxysporum*, *Fusariumsacchari*, *P e n i c i l l i u m c h r y s o g e n u m*, *Penicilliumcitrinin* and *Penicilliumoxalicu m*. This is also in tandem with the isolation of previous study carried out by Adeyeye (2016) on dried meats sampled from some commodity markets in Ibadan. It has been further proven that majority of these fungi are mycotoxigenic and the mycotoxin levels in the sun-dried meat (kundi and ponmo) samples is of public health concern and proper attention is needed for the control of quality. Adequate preservation and storage of these products before sales

and consumption to prevent food poisoning must be ensured (De Saeger, 2011; Adeyeye, 2016).

Furthermore, when comparison was carried out between the microbial loads of the two dried meats (kundi and ponmo), it was observed that the kundi samples have higher values and higher degree of contamination. This can be attributed to higher level of crude protein of kundi which was determined through proximate analysis when compared with the ponmo samples (Adeyeye, 2016). Also, it has been established that microbes thrive better in highly proteinaceous media (Pathak, 2008); hence the higher microbial load in kundi than ponmo.

Literature search shows no publication on soaking time of preserved meat, so there is paucity of information on this subject matter, and this study probably is the first of its kind in this subject area. This study however, observed that by soaking of dried meat samples, the texture of the meat becomes soften, loose and there was reduction in the microbial loads of the meat sample irrespective of the type, while there was a corresponding increase in the microbial loads in the water used. As the dried meat stays longer in the water, there is also a corresponding increase in the microbes released from the tissue into the water. The study further shows that a correlation exists between the duration of soaking of the dried samples of meat (kundi and ponmo) and microbial loads. This may be due to the property of water as a universal solvent, in which it improves protein solubility and brine strength to inhibit microbial proliferation thereby improving the meat shelf life (Sebranek, 2015).

This study has established that despite subjecting the dried meat (kundi and ponmo) to preservative treatments of heat and sun-drying, the microbial load which include bacteria and fungi that are of public health importance were isolated. It was

observed further that the microbial load was lesser for ponmo than kundi and the soaking of the dried meat in water over a period of time reduces the microbial load in the meat (kundi and ponmo) with the lowest microbial count found after 24hours.

It is therefore recommended that consumers of dried meat (kundi and ponmo) in this part of the world, especially Nigeria should endeavour to soak dry meat for a minimum of 24hours before they are used for food.

References

- Adeyeye, S.A.O., 2016.** Quality and safety assessment of sun dried meat product (kundi) from Ibadan, Oyo state, Nigeria. *Cogent Food & Agriculture*, 2: 1209074
- Akhtar, J., and Pandey, R.K., 2015.** Meat drying technology and drying characteristics of meat and meat products.
- Alonge, D.O. 1999.** Textbook of meat hygiene in the tropics, Farmco Press, Ibadan, Nigeria. Revised ed. pp. 58.
- Biswas, A.K., Komdaiah, N., Anjaneyulu, A.S.R., and Mandal, P.K., 2011.** Causes, concerns, consequences and controls of microbiological contaminants in meat- a review. *International Journal of Meat Science*, 1 (1): 27-35, 2011. DOI: 10.3923/ijmeat.2011.27.35
- Clarence, S. Y., Obinna, C. N., and Shalom, N.C., 2009.** Assessment of bacterial quality of ready to eat food (Meat pie) in Benin city metropolis, Nigeria. *African Journal of Microbiological Research*, 3(6): 390–395
- Clinical and Laboratory Standards Institute.** Performance standards for antimicrobial disk susceptibility tests; approved standard; **2012.**
- De Saeger, S., 2011.** Determining mycotoxins and mycotoxigenic fungi in food and feed. A volume in Woodhead Publishing Ltd. pg 415-427. ISBN 978-1-84569-674-0
- Fakolade, P.O., and Omojola, A. B., 2008.** Proximate composition, pH value and microbiological evaluation of “Kundi” (dried meat) product from beef and camel meat. Conference on International Research on Food Security, Natural Resource Management and Rural Development. University of Hohenheim, Tropentag. Pp. 3345.
- Fasanmi, O.G., Balogun, F.A., Makinde, G.E.O. and Fasina, F.O. 2017.** Review of microbial zoonoses in slaughterhouses and identified potential critical risk points along red meat processing chain in Nigeria. *CAB Reviews*, 12(25):1–12.
- Food and Agricultural Organization 2003.** Global production and consumption of animal source foods. *Journal of Nutrition*, 11(2):4048-4053.
- Food and Agricultural Organization 2014.** Basic hygiene practice: control of hygiene and safety. Animal production and health. http://www.fao.org/ag/againfo/the_mes/en/meat/quality.html
- Food and Agriculture Organization (FAO) 2013.** Current worldwide annual meat consumption per capita, Livestock and Fish Primary Equivalent. <http://faostat.fao.org/site/610/DesktopDefault.aspx?PageID=610#ancor>
- Groot, M.J., and van Hooft, K.E., 2016.** The hidden effects of dairy farming on public and environmental health in the Netherlands, India, Ethiopia, and Uganda, considering the use of

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- antibiotics and other agro-chemicals. *Front Public Health*, 4:1–9.
- Idufueko, A. S., 1984.** Self-sufficiency in animal protein supply under changing economic fortunes. *Nigerian Journal of Animal Production*, 11, 14–21
- Isenberg, H., 2004.** Clinical microbiology procedures handbook. American Society for Microbiology.
- Kołożyn-Krajewska, D. and Dolatowski, Z., 2012.** Probiotic meat products and human nutrition. *Processes in Biochemistry*, 47(12), 1761-1772.
- Landers, T.F., Cohen, B., Wittum, T.E., and Larson, E.L., 2012.** A review of antibiotic use in food animals: perspective, policy, and potential. *Public Health and Reproduction*, 127(1): 4–22. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3234384/pdf/phr12700004.pdf>
- McDermott, P.F., Zhao, S., Wagner, D.D., Simjee, D., Walker, R.D., and White, D.G., 2002.** The food safety perspective of antibiotic resistance. *Animal Biotechnology*, 13:1, 71–84, DOI: [10.1081/ABIO-120005771](https://doi.org/10.1081/ABIO-120005771).
- Müller, O., and Krawinkel, M., 2005.** Malnutrition and health in developing countries. *CMAJ*, 173: 279–286.
- Murray, P.A., 1999.** Manual of clinical microbiology. 7th ed
- Nummer, B.A., 2002.** Historical origins of food preservation. National Center for Home Food Preservation. <https://nchfp.uga.edu>
- Obi, I.U., 1990.** Statistical methods of detecting differences between treatment means. Snap. Press, 2nd ed. Enugu, Nigeria. pp 24-35, 19
- Obiri-Danso, K., Hogarh, J.N., and Antwi-Agyei, P., 2008.** Assessment of the contamination of singed hides from cattle and goats by heavy metals in Ghana. *African Journal of Environmental Science and Technology*, 2(8):217-221.
- Okaka, J.C., Akobundu, E.N.T., and Okaka, C.A.N., 2006.** Food and Human Nutrition, an Integrated Approach. O. J. C. Academic Pub. Enugu, Nigeria
- Okiel, W., Ogunlesi, M., Alabi, F., Osiughwu, B., and Sojinrin, A., 2009.** Determination of toxic metal concentrations in flame treated meat products, Ponmo. *African Journal of Biochemical Resources*, 3(10):332-339.
- Okonkwo, T.M., and Obanu, Z.A., 1984.** Traditional production of hot-smoked meat in Nigeria. *Study of the production technology. Proceedings 9th Annual Conference of the Nigerian Society for Animal Production*, University of Nigeria, Nsukka, Enugu State, Nigeria.
- Olusola, F.P., and Omojola, A. B., 2010.** Relevance of dried meat product (Kundi), an Intermediate Moisture Meat (IMM), for food security.
- Ostry, V. and Reprich, J. 2001.** The occurrence of moulds in meat and meat products (II) (In Czech Republic). *Hygiene*, 6, 17-21
- Pathak, A.K., 2008.** Various factors affecting microbial protein synthesis in the rumen. *Veterinary World*, 1(6): 186-189
- Saucier, L., 1999.** Meat Safety: Challenges for the Future. St-Hyacinthe, Québec: Food Research and Development Center, Agriculture and Agri-Food Canada. <http://www.meatscience.org/meetings/MIRC/2000/saucier.htm>.

- Schonfeldt, H.C., and Hall, N.G., 2012.** Dietary protein quality and malnutrition in Africa. *British Journal of Nutrition*, 108: 69-76.
- Sebranek, J.G., 2015.** An overview of functional non-meat ingredients in meat processing: The current tool box. Animal Science conference proceedings and presentations. 4.
- Steel, R.G.D., and Torrie, J.H., 1980.** Principles and Procedures of Statistics. McGraw Hill book. New York
- Thomas, J., 2012.** Microbiological and sensory properties of beef. In L.M. Nollet (Ed.), *Handbook of meat, poultry and seafood quality*(2nd ed.). Oxford: Wiley-Blackwell.
- Vilar, I., Garcia Fontan, M. C., Prieto, B. T., Ornadijo, M. E., and Carballo, J. 2000.** A survey on the microbiological changes during the manufacture of dry-cured lacon, a Spanish traditional meat product. *Journal of Applied Microbiology*, 89: 1018–1026.
- WHO 2017.** Antimicrobial resistance in the food chain.
https://www.who.int/foodsafety/areas_work/antimicrobial-resistance/amrfoodchain/en/

Received: 14th July, 2021

Accepted: 10th December, 2021