

Evaluation of Selected Local Spices on Sensory Characteristics of Fresh Pork Sausage

Coleman Fred Newman¹, Ohene-Adjei Samuel², Barnes Anna²

¹Department of Agriculture and Agribusiness, Methodist University College Ghana, Accra, Ghana

²Department of Animal Science, University of Ghana, Accra, Ghana

Email address:

colemanf27@yahoo.com (Coleman F. N.), ahemfo2005@gmail.com (Ohene-Adjei S.), arbarnes@ug.edu.gh (Barnes A.)

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Abstract: *Xylopiya aethiopia* (African pepper) and *Monodora myristica* (African nutmeg) are used as spices in Ghanaian local dishes and as traditional medicine. The objective of this study was to substitute two spices in “normal” fresh pork sausage formulation with selected local spices and evaluate their effect on sensory characteristics of the product. A 4x4 factorial design was used with 4 spice treatments (Control – *Syzygium Gaertner* (clove), *Allium cepa* (onion), *Piper nigrum* (white pepper) and *Myristica fragrans* (nutmeg); African pepper (AP) substituted for white pepper; African nutmeg (AN) substituted for nut meg (*Myristica fragrans*); and combination of AP and AN (AP*AN) at 4 inclusion levels (0%, 0.05%, 0.1% and 0.15%). AP and AN were obtained from the local market in Accra. They were cleaned, dried and blended. The spices were irradiated with dose of 10KGY to reduce microbial load. The experiment had three replicates each replicate was made up of 1b treatments. Six trained panellists evaluated the sausages using a 15 cm continuous scale on six sensory parameters (crumbliness, juiciness, palatability, saltiness, off flavour and overall liking), the formulated sausages with the selected local spices at varying concentrations did not differ ($p > 0.05$) from the control product in all the sensory parameters. However, AP treated sausage at 0.15% was overall rated high. The present study shows that *Xylopiya aethiopia* and *Monodora myristica* can be used to substitute for *Piper nigrum* and *Myristica fragrans* respectively, in the manufacture of fresh pork sausages without affecting the sensory attributes and overall liking of the product.

Keywords: *Xylopiya aethiopia*, *Monodora myristica*, Sensory, Fresh Pork Sausage

1. Introduction

Spices are dried seeds, flowers, fruits, barks, roots, leaves of plants or vegetative substances of different plants used in small quantities as food additives [1], and have been used in seasoning foods since time immemorial and at the same time serve as dietary supplements [2]. Spices can improve the palatability; enhance flavour and visual appeal of dull diets. Piquant flavours are valued for other properties like stimulation of appetite, carminative and anti-oxidant effects and promotion of digestion [3]. Some chemical food additives however, have adverse side effect on human health [4; 5]. Spices do not exhibit any toxicity at levels used and consumed [6] in view of these, spices have become the most ideal food additives. Research shows that deterioration of human health may correlate with food products and food

additives [5]. Most importantly, spices are used in preservation of meat and meat products such as sausages. Sausages play an important role in the nutrition of man. They are chopped or comminuted and seasoned meats that are formed into symmetrical shapes. They are more economical than whole meat cuts as they are produced from trimmings from primal cuts and by-products of meat [7]. Sausages are the most appetizing and widely utilized meat product among all processed meats, and are of many varieties depending upon mode of manufacturing [1].

The objective of this study is to evaluate two selected local spices (*African pepper and African nutmeg*) on sensory characteristic of fresh pork sausage.

Sausage manufacture evolved as a move or plan to economize and preserve meat that could not be consumed or utilized fresh at slaughter. The manufacturing of sausages by man began over two thousand years ago [8]. They are one of

the oldest prepared foods, whether cooked or eaten immediately or dried to various degrees [9]. Fresh pork sausage comprises the vast majority of fresh sausage produced throughout the world, and can be in bulk, link, or patty form. Fresh pork sausage is usually considered to be the third most popular processed meat product outranked only by wieners and bologna [10]. *Xylopia aethiopica*, commonly known as african pepper, guinea pepper, Spice tree, ethiopian pepper belong to the family Annonaceae. It is locally known as, etso, soo, hwentia, chimba, kimba, (Ewe, Ga, Akan, Hausa and Dagbalin respectively) and consists of dried mature fruit and has characteristic odour and taste [11]. The fruits of *Xylopia aethiopica* are small with carpels of about 7-24, forming dense cluster. The fruits have dark brown colour when matured, cylindrical and are about 1.5-6 cm long and 4-7 mm thick [12]. The contours of the seeds are visible from outside. The dry fruits are an important spice used to prepare local dishes and soups in West Africa [13]. The chemical constituents of *Xylopia aethiopica* include essential oils, resins, annonacin, reberoside, avicien, rebersole, alkaloids, tannins, oxalate, and flavonoids [14]. The African nutmeg (*Monodora myristica*), also known as calabash nutmeg belonging to the family Annonaceae or custard apple family of flowering plants [15]. It is locally known as awerewa, ayikue, ariwo (Akan, Ewe and Ga). The tree can reach a height of 35 m and 2 m in diameter at breast height. Several studies reveal that almost every part of the tree is of economic importance [16; 17]. However, the most economically important part is the seed, which is embedded in a white sweet-smelling pulp of the sub-spherical fruit. The odour and taste of the *Monodora myristica* seed is similar to nutmeg.

2. Materials and Methods

2.1. The Study Area

The study was conducted at the Meat Science Laboratory and Microbiological Laboratory of the Animal Science Department of the College of Basic and Applied Sciences (CBAS) University of Ghana, Legon.

2.2. Experimental Design

The experiment was a factorial design with sixteen treatments (control-clove, onion, white pepper, and nutmeg, African pepper (AP), African nutmeg (AN) and mixture of AP and AN) at 4 inclusion levels (0%, 0.05%, 0.1% and 0.15% of the meat weight). There were three replicates. Products were evaluated for the effect of the spice mix on sensory attributes and microbiological load of fresh pork sausage.

2.3. Preparation of African Nutmeg (AN) and African Pepper (AP)

African nutmeg and African peppers were obtained from the local market in Accra. The spices were cleaned and washed thoroughly under running tap water and sundried.

The dried African nutmegs (AN) were cracked manually to extract the kernels. The kernels were blended and stored in Ziploc bags under a room temperature. The seeds of the African pepper (AP) were blended with the pods and stored into Ziploc bags under room temperature. Both spices were sieved with a fine net. The spices were irradiated with a dose of 10 KGY at the Ghana Atomic Energy Commission (GAEC) Irradiation Centre.

2.4. Sausage Preparation

Fresh whole pork carcass was obtained from the Livestock and Poultry Research Center (LIPREC) University farm and stored under refrigeration conditions (4°C) overnight. The carcass was cut up and deboned and the sausages formulated, after using 80% lean and 20% fat. The meat was comminuted using a table-top mincer through 5mm steel plate (Model Talleres Ramon, Spain). The comminuted meat was manually mixed thoroughly in a mixing bowl. The mixture was divided into 16 equal batches by weight and treatment assigned to the batches randomly. The respective spice mixes and water were added and mixed manually (50 times). The sausage mixture was stuffed into a natural casing using manual stuffer and linked into 15cm length. The products were bagged into Ziploc bags and sealed labelled and kept under freezing temperature (-10°C) prior to sensory and microbial analysis.

2.5. Sensory Evaluation

Ten panellists were screened for sensitivity to fishy and cardboard flavours using a nine two-fold dilutions of exudates from fresh tilapia and 10g of cardboard boiled in distilled water for 1 hr. Each set of flavour profile was provided with a distilled water control. The panellists were also screened for crumbliness and juiciness. Consequently, six panellists made up of 4 females and 2 males were short-listed to participate in the sensory evaluation. The samples were grilled (Electrical grill) separately based on treatments to an internal temperature of 71°C, for 45 minutes. The grilled sausages were sliced into uniform sizes approximately 15 g; randomly assigned labels and packed into respective coded 30ml containers and covered. The evaluation of the inclusion levels of the selected local spices was done by the use of a 15-point scale to evaluate crumbliness, juiciness, palatability, saltiness, off flavour and overall liking of the fresh pork sausage. Water and apple juice were provided to rinse off lingering odours after every sample.

2.6. Statistical Analysis

The sensory data were subjected to analysis of variance using proc mixed of SAS 9.1 (SAS Institute, Cary, NC, USA). Probability differences between means were compared using bonferroni multiple comparison adjustment. Differences were considered significant at the $p < 0.05$ level at 0.5.

3. Results

3.1. Sensory Evaluation

Results of evaluated fresh pork sausages treated with varying levels of AP and AN on a 15-point scale for crumbliness, juiciness, palatability, saltiness, off flavour and overall liking are presented below.

3.2. Crumbliness and Juiciness

Results for crumbliness and juiciness are shown in Table 1. Inclusion levels of AN (0.05%), and AP*AN (0.05*0.05%) had the highest scores (8.9), for crumbliness and AP*AN (0.15*0.15%) had the lowest scores (7.8) as compared to the control product (8.2). Statistical analysis of the data indicated no significant ($p > 0.05$) differences between any of the treatments. Although mean scores indicated that AP*AN (0.1*0.05%) and AP*AN (0.1*0.15%) had the highest scores value (7.6) for juiciness and AP*AN (0.15*0.1%) score the lowest (5.9) as compared to the control (6.6), statistical analysis of the data indicated no significant ($p > 0.05$) differences between any of the treatments compared to the control. Hence sausages formulated with the selected local spices at varying concentrations did not differ ($P > 0.05$) from the control product in terms of terms of juiciness.

Table 1. Mean Crumbliness and Juiciness.

Treatment	Crumbliness		Juiciness	
	Mean	SEM	Mean	SEM
Control	8.2	±0.6	6.6	±0.74
AN (0.05%)	8.9	±0.6	6.2	±0.74
AN (0.1%)	8.3	±0.61	6.4	±0.74
AN (0.15%)	8.4	±0.6	6.6	±0.74
AP (0.05%)	8.6	±0.59	6.2	±0.74
AP (0.1%)	8.4	±0.59	6.6	±0.74
AP (0.15%)	8.7	±0.59	6.3	±0.74
AP*AN (0.05*0.05%)	8.9	±0.6	6.9	±0.74
AP*AN (0.05*0.1%)	8.7	±0.59	6.8	±0.74
AP*AN (0.05*0.15%)	7.9	±0.59	6.7	±0.74
AP*AN (0.1*0.05%)	7.9	±0.6	7.6	±0.74
AP*AN (0.1*0.1%)	8.0	±0.59	6.8	±0.74
AP*AN (0.1*0.15%)	8.6	±0.6	7.6	±0.74
AP*AN (0.15*0.05%)	8.1	±0.59	6.7	±0.74
AP*AN (0.15*0.1%)	8.4	±0.6	5.9	±0.74
AP*AN (0.15*0.15%)	7.8	±0.59	6.1	±0.74
P-value	0.62		0.47	

SEM, standard error of mean.

AP; African pepper, AN; African nutmeg, AP*AN; combination of AP and AN.

Levels of inclusion (%) are indicated in parenthesis.

3.3. Palatability and Saltiness

The results for palatability and saltiness are shown in Table 2. Mean scores indicated that although AP treated sausage at 0.15% and AP*AN (0.1*0.1%) inclusion levels had the highest scores (9.1) for palatability and AN (0.1%) and AP*AN (0.05*0.1%) had the lowest scores (7.9) as compared to control product (8.1). Statistical analysis of the data however indicated no significant ($p > 0.05$) differences between any of the treatments compared to the control. Mean

scores for saltiness indicated that AP*AN (0.05*0.1%) treated sausage had the highest scores (8.3) and AN (0.15%) scored the lowest (6.5) as compared to the control product (6.6). Statistical analysis of the data showed no significant ($p > 0.05$) differences between any of the treatments compared to the control.

3.4. Off Flavour and Overall Liking

Evaluation of the off flavour and overall liking of the samples at varying concentrations of the local spices are shown in Table 3.

Table 2. Mean Palatability and Saltiness.

Treatment	Palatability		Saltiness	
	Mean	SEM	Mean	SEM
Control	8.1	±1.01	6.6	±0.59
AN (0.05%)	8.4	±1.01	7.6	±0.6
AN (0.1%)	7.9	±1.01	7.2	±0.59
AN (0.15%)	8.1	±1.01	6.5	±0.59
AP (0.05%)	8.1	±1.01	7.1	±0.59
AP (0.1%)	8.7	±1.01	7.4	±0.59
AP (0.15%)	9.1	±1.01	6.9	±0.59
AP*AN (0.05*0.05)	8.5	±1.01	7.1	±0.59
AP+AN (0.05/0.1%)	7.9	±1.01	8.3	±0.59
AP*AN (0.05*0.15%)	8.2	±1.01	7.0	±0.59
AP*AN (0.1*0.05%)	8.9	±1.01	7.3	±0.6
AP*AN (0.1*0.1%)	9.1	±1.01	7.7	±0.6
AP*AN (0.1*0.15%)	8.1	±1.01	7.1	±0.59
AP*AN (0.15*0.05%)	8.9	±1.01	7.1	±0.59
AP*AN (0.15*0.1%)	9.0	±1.01	7.5	±0.59
AP*AN (0.15*0.15%)	8.4	±1.01	6.8	±0.59
P-value	0.15		0.21	

SEM, standard error of mean.

AP; African pepper, AN; African nutmeg, AP*AN; combination of AP and AN.

Levels of inclusion (%) are indicated in parenthesis.

Table 3. Mean Off-Flavour and Overall-Liking.

Treatment	Off flavour		Overall liking	
	Mean	SEM	Mean	SEM
Control	4.2	±1.17	8.8	±0.95
AN (0.05%)	4.7	±1.19	8.9	±0.97
AN (0.1%)	3.7	±1.18	8.3	±0.95
AN (0.15%)	4.3	±1.18	8.5	±0.97
AP (0.05%)	4.5	±1.19	8.1	±0.95
AP (0.1%)	4.1	±1.20	8.7	±0.95
AP (0.15%)	4.6	±1.21	9.1	±0.95
AP*AN (0.05*0.05)	4.0	±1.21	8.1	±0.95
AP*AN (0.05*0.1%)	4.1	±1.20	8.3	±0.95
AP*AN (0.05*0.15%)	3.5	±1.20	8.0	±0.95
AP*AN (0.1*0.05%)	4.4	±1.19	8.8	±0.95
AP*AN (0.1*0.1%)	4.7	±1.18	8.9	±0.95
AP*AN (0.1*0.15%)	3.9	±1.20	8.8	±0.95
AP*AN (0.15*0.05%)	3.9	±1.21	9.1	±0.95
AP*AN (0.15*0.1%)	3.7	±1.19	9.3	±0.95
AP*AN (0.15*0.15%)	4.1	±1.19	9.2	±0.96
P-value	0.96		0.62	

SEM, standard error of mean.

AP; African pepper, AN; African nutmeg, AP*AN; combination of AP and AN.

Levels of inclusion (%) are indicated in parenthesis.

Mean scores for off flavour showed that AN at 0.05% and

AP*AN at 0.1*0.1% inclusion levels had the highest scores (4.7), while AP*AN at 0.05*0.15% had the lowest score (3.5) as compared to the control product (4.2). Statistical analysis of the data showed no significant ($p > 0.05$) differences between any of the treatments compared to the control. Mean scores for overall liking indicated that although AP*AN at 0.15*0.1% inclusion level had the highest score (9.3), and between the two individual local spice treatments, sample treated with AP at 0.15% concentration had a higher score (9.1) and AN at 0.05% concentration had (8.9) among its inclusion levels. AP treated sample at 0.05% and AP*AN at 0.05*0.05% inclusion levels scores the lowest (8.1) as compared to the control products (8.8), and statistical analysis of the data indicated no significant ($p > 0.05$) differences between any of the treatments.

4. Discussion

Sensory Evaluation

Crumbliness, texture and flavour are important criteria for evaluating eating quality of meat and meat products. Methods of cooking of meat products can affect some characteristics of meat products such as crumbliness and juiciness [18]. In this study, panellists evaluated fresh pork sausage, substituted with two local spices at varying inclusion levels (between 0%-15%) using a factorial design. White pepper was substituted with African pepper (*Xylopiya aethiopica*) and nutmeg was substituted with African nutmeg (*Monodora myristica*). Sensory attributes evaluated were crumbliness, juiciness, palatability, saltiness, off-flavor and overall acceptability. Statistical analysis showed no significant ($p > 0.05$) differences among treatments with substituted local spices compared to the control on all the sensory attributes measured. The historical use of spices and the long established recipes for sausage production and the difficulty of objective evaluation of combination effects of spices on flavour have resulted in a dearth of knowledge on the effects of spices on sensory attributes. The findings of [19] indicated that spices improve texture, juiciness and flavour of meat and meat product. Addition of spices induced a decrease in hardness in nnam gon [20].

Juiciness is one of the most important sensory quality attributes when evaluating consumer liking [21]. A study conducted by [22] reported that plants phenolic compounds contribute to quality and nutritional value in terms of modifying colour, taste, aroma, juiciness and flavour, it also provides health beneficial effects. The low juiciness scores might be due to loss of moisture from the products during the storage time (1 day) and during the grilling. The primary functions of spices are to improve flavour of meat and meat product, texture and colour [23]. The results were in accordance with findings of [24] who reported decreasing trend in chicken sausages as results of loss of moisture from the products during storage. Similarly, [25] also reported that reduction in pH and denaturation of protein at low pH and degradation of muscle fibre protein by bacterial action can lead to a decrease in juiciness of

sausage. Juiciness and tenderness decreased with an increasing temperature from 62- 75°C, while crumbliness and chewing time increases [18]. To reduce the variance in sensory attributes due to changes in cooking temperature in this study, all treatments were grilled to an internal temperature of 71°C. All the treatments were acceptable by the trained panellists.

The quality of meat and meat product is defined by its palatability and this can be achieved by organoleptic evaluation. The higher score for the AP treated sausage at 0.15% (Table 3) was probably due to the fact that the panellists are used to its distinctive flavour and aroma in Ghanaian dishes. The present study reveals that the two-spice mixture (0.1*0.1%) was rated higher as compared with the control, which agreed with findings of [26]. The essential oil contents in spices are noted for flavour and taste enhancer [27]. Spices add six basic tastes to finished products such as sweet, salty, bitter, sour, spicy and hot [23] Spices are not only used for flavouring food but are also used to enhance latent flavour of food [28]. The results from the study showed that all the treatments were within the same range. According to the study conducted by [28], spices have a low sodium contents that can be used as salt substitute. The present study reveals the correlation between spice and salt in meat products. Low concentration of salt however negatively affects tenderness and crumbliness of turkey breast meat [29]. A study by [30] reported that the addition of spices and herbs in a reduced sodium content of bologna sausage resulted in better sensory attributes. Although saltiness was tested under the hypothesis that the substitute spices may potentiate the perception of salt, no significant differences in saltiness were observed between any of the treatments compared to the control. Flavour comprises mainly of taste and aroma and is an indicator of consumers' purchase intent and preferences. The sensory scores of off flavour were not statistically different among the treatment means. Flavour can be developed during processing, cooking and through spices and complex reactions [31]. Many compounds that contributed to the overall odour of fresh sausages have been identified as spiciness caused by phenols and terpens in spices. The results from the present study observed AP treated sausages had an increasing trend of overall liking as the inclusion levels increases which agree with [32] findings that 15g of *xylopiya aethiopica* gave smoked fish better palatability, texture, colour, and flavour was rated overall liking. Coatings with essential oils of rosemary and oregano had a significant effect on consumer perception of odour, flavour and overall acceptance of beef. [33]. Sensory analysis revealed that the overall liking is directly proportional to the concentration of the spices used. Addition of spices may cause some changes in the meaty flavour of fresh pork sausages; however, these changes were acceptable to the panellists. Thus the present study revealed that AP and AN can be used to substitute for white pepper and nutmeg without affecting the sensory characteristics of fresh pork sausages.

5. Conclusion

The use of *Xylopiya aethiopic*a (African pepper) and *Monodora myristica* (African nutmeg) in the formulation of fresh pork sausage had no significant ($P > 0.05$) effect on the sensory characteristics of the finished product. However, AP treated sausage at 0.15% and AP*AN (0.1*0.1%) inclusion levels had the highest scores (9.1) for palatability and for overall liking, AP*AN at 0.15*0.1% inclusion level had the highest score (9.3), and between the two individual local spice treatments, sample treated with AP at 0.15% concentration was rated best overall liking (9.1). The present study has shown that *Xylopiya aethiopic*a and *Monodora myristica* can be used to substitute for *Piper nigrum* and *Myristica fragrans* respectively in the manufacture of fresh pork sausages without affecting the sensory attributes and overall liking of the product.

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References

- [1] Food and Agriculture Organization (FAO) (2010). Meat Processing Technology For Small-To Medium-Scale Producers. pp 103-221.
- [2] Obabina, A. O. and Ogundimu, A. A. (2011). Microbial contamination of selected dietary supplements in a typical tropical market in Nigera. *Nigerian Food J.* 2 (4).
- [3] Takeda, J., De Silva, S., Muthuraman, P., Rahman, S. M. and Kawet, L. (2008). Spices in Sri Lanka, India and Bangladesh with Special Reference to the Usages and Consumptions. *Agri. Bull.* 93: 1-25.
- [4] Bridges, J. and Bridges, O. (2007). Risk assessment of food additives and Contaminants. *Food Control.* 19 (5): 33–51.
- [5] Tuula, E. T. (1994). The Adverse Effects of Food Additives on Health: A Review of the Literature with Special Emphasis on Childhood Hyperactivity. *The Journal of Orthomolecular Med.* 9 (4).
- [6] Oiyee, S. O., Konyole, S. and Ngala, S. N. (2012). Effects of Rosemary Spice (*Rosmarinus Officinalis* L.) and Nitrite Picking Salt Combination on Keeping and Organoleptic Quality of Beef Sausages [http://www.textroad.com/pdf/IBASR/J.%20Basic.%20Appl.%20Sci.%20Res.,%202\(4\)4008-4015,%202012.pdf](http://www.textroad.com/pdf/IBASR/J.%20Basic.%20Appl.%20Sci.%20Res.,%202(4)4008-4015,%202012.pdf).
- [7] Jihad, M., Quasem, A. S. M. and Ali, F. A. (2009). Nutritive Value of Seven Varieties of Meat Products (Sausage) Produced in Jordan <http://www.pjbs.org/pjnonline/fin1168.pdf>. Retrieved 10th May 2014.
- [8] Oscar, E. (1998). History of the sausage. *The British barbecue pit.* http://www.oscarterprises.f2s.com/home_page.html retrieved 13 June 2014.
- [9] Food and Agriculture Organization (FAO) (1985). Small Scale Sausage Production: FAO *Animal Production and Health Paper* 52.
- [10] Jay, B. W. (2011). Manufacture of Fresh Pork Sausage. Nassau foods seasonings. pp 12.
- [11] Orwa, C., Mutua, A., Kindt, R., Jamnadass, R. and Simons, A. (2009). "Xylopiya aethiopic" *Agroforestry Database 4.0*. World Agroforestry Center. Retrieved 1 January 2014.
- [12] Tairu, A. O., Hofmann, T. and Schieberle, P. (1999). Identification of the key aroma compounds in dried fruit of *Xylopiya aethiopic*a. p. 474–478. In: J. Janick (ed.), *Perspectives on new crops and new uses*. ASHS Press, Alexandria, VA.
- [13] Acquaye, D., Marianna, S., Wudeneh, L. and Jim, S. (2001). *Xylopiya. Agribusiness in Sustainable Natural African Plant Products* http://pfdnp.org/crop_specs/XYLOPIA.pdf retrieved 24 May 2014
- [14] Ekeanyanwu, R. C. and Etienajirhevwe, O. F. (2012). In vitroanthelmintic potentials of *Xylopiya aethiopic*a and *Monodora myristica* from Nigeria. *Afr. J. Biochem. Res.* 6 (9), pp. 115-120. <http://www.academicjournals.org/AJBR>. Retrieved on 26th June 2014.
- [15] Okafor, J. C. (2003). Some useful tropical plans in health care delivery, Forestry commission HQ Enugu pp 3-8.
- [16] Okigbo, R. N. and Igwe, M. (2007). The antimicrobial effects of *Piper guineense* (uziza) and *Phyllanthus amarus* (ebbenizo) on *Candida albicans* and *Streptococcus faecalis*. *Act. Microbiol. Immunol. Hung.* 54 (4): 353366.
- [17] Okafor, J. C. (1987). Development of forest tree crops for food supplies in Nigeria. *Forest Ecol. Manual* 1: 235-247.
- [18] Food and Agriculture Organization (FAO) (1999). Manual on simple methods of meat preservation. *Animal production and Health Paper: 79: 56 -72*.
- [19] Aidells, B. and Kelly, D. (1998). *The Complete Meat Cookbook. A Juicy and Authoritative Guide to selecting seasoning and cooking today's Beef, Pork, Lamb and Veal*. Published by Rux Martin/Houghton Mifflin Harcourt. pp 241-254.
- [20] Manejo Djiogue, J. E. Nguimbou, R. M., Tatsadjieu, L. N., Mang Y. D. and Njintang, N Y. (2016) Effect of spices formulations on the physicochemical and sensory properties of Nnam gon, a Cameroonian dish prepared with cucurbitaceae seeds. *Food Science & Nutrition*.
- [21] Resurreccion, A. V. A. (2004). Sensory aspects of consumer choices for meat and meat products. *Meat Sci.* 66: 11–20.
- [22] Abisoye, A. D., Olawumi, B. T. I. and Fatmata, J. F. (2013). Antimicrobial and antioxidant properties of selected local spices used in "kunun" beverage in Nigeria. *Acta Sci. Pol., Technol. Aliment.* 12 (4): 373-378.
- [23] Jay. B. W. (2017). Basic of spice and other non-meat ingredients.
- [24] Zargar, F. A., Sunil, K., Zuhair F. B. and Pavan, K. (2014). Effect of pumpkin on the quality characteristics and storage quality of aerobically packaged chicken sausages. *Springerplus.* 3: 39.

- [25] Jay, J. M. (1996). *Modern Food Microbiology*. New Delhi: CBS Publishers and Distributors; 1996.
- [26] Sodzim, A. (2012). *Extension Of Shelf Life Of Pork Using Spices (Plant Extracts: Xylopi aethiopica, Allium sativum and Piper nigrum)*. Thesis. Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.
- [27] Ekanem, E. O. and Achinewhu, S. C. (1998). Effects of spices application on microbiological quality and acceptance of West African clam meat processed by intermediate-moisture technology. Proc. Silver Jubilee Anniversary conference. O. Oduguwa, A. O. Fanimo and O. A. Osinowo (ed) Nig. Soc. Anim. Prod.
- [28] Hui, Y. H, Wai-Kit, N. P., Roger, W. R. and Owen, A. Y. (Ed) (2005). *Meat Science and Applications*. 382-2384.
- [29] Goli, T., Ricci, J., Bohuon, P., Marchesseau, S. and Collignan, A. (2014). Influence of sodium chloride and pH during acidic marinantion on water retention and mechanical properties of turkey breast meat.
- [30] Carraro, C. I., Machado, R., Espindola, V., Campagnol P. Cezar, B. and Pollonio, M. A. R. (2012). The effect of sodium reduction and the use of herbs and spices on the quality and safety of bologna sausage. *Cienc. Technol. Aliment. Campinas*. 32 (2): 289-295.
- [31] Dinesh, D. J., Dong, U. A., Ki, C. N. and Cheorun, J. (2013). Flavour Chemistry of Chicken Meat: A Review. *Asian-Aust. J. Anim. Sci.* 26 (5): 732–742.
- [32] Anyanwu, C. N., Egbuche, C. T, Osuigwe, D. I. Nwaihu E. C., and Anyachi, N. J. (2016). Organoleptic Assessment Of Clarias Gariepinus (Burchell, 1822) Treated With Xylopi aethiopica (Dunal, 2008) After Exposure To Dermestes Maculates (De Geer, 1774).
- [33] Pelaez Vital, A. C., Guerrero, A., Monteschio, J. O., Valero, M. V., Carvalho, C. B., de Abreu Filho, B. A, Madrona, G. S. and do Prado I. N. (2016). Effect of Edible and Active Coating (with Rosemary and Oregano Essential Oils) on Beef Characteristics and Consumer Acceptability.