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Spices and Condiments in Ghana: Their Utilization in Comminuted Meat Products

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Abstract

Local spices were collected from seven major markets across Ghana, compiled and identified by their Scientific, Common and Local names, properties, part used and area found. Seven fresh pork sausages prepared using differing compositions of these spices were sensorily evaluated in a pre-trial and four selected and further evaluated in triplicate to determine their acceptability. A 10 member panel assessed the external appearance of uncooked products, internal colour, aroma, taste and the overall acceptability of cooked products. The data was analysed as a completely randomized block design using the nonparametric analysis as employed in Friedman's method and Wilcoxon's signed rank test. A total of fourteen local spices were collected. A 1.52% level of inclusion of the different composite spice mixes in the products was acceptable. The prekese based product was significantly judged the most acceptable (P=.05) while the dawadawa based product the least acceptable. In conclusion, preparing Ready to use composite-spice mixes from local spices to promote comminuted meat processing among meat handlers is feasible but must be done safely in order to keep the health value of the meat products.

Keywords: Spices, condiments, comminuted meat products, Ghana

Introduction

Studies have shown that pigs can yield on the average four to five times more meat than cattle per ton of live weight (Eusebio, 1980). Generally, presentation of meat is one of the factors that affect its marketing particularly pork marketing. In Ghana, marketing of pork is a major problem that thwarts the expansion of the pig industry. Processing of pork to give it the desired form utility is lacking. The technical know-how of meat processing in Ghana is low. To encourage meat processing, it will be necessary to make processing easy for farmers and meat handlers. This can be achieved by the production of Ready-to-use composite spice mixes and formula e.g. sausage mixes. Such spice mixes will allow meat handlers with even minimal knowledge of processing to be able to process meat products safely and correctly for the market in order to boost consumption as well as improve their incomes. Fortunately, Ghana is endowed with a lot of spices with the potential of being used in developing good seasoning mixes for meat products but in the light of that, much work has not been done to exploit these local spices to make the mixes.

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Spices are known and used for flavouring and preserving food ever since the ancient times (Bauer *et al.*, 2001). According to Lemay *et al.* (2002) and Farag *et al.* (1989), the addition of spices to meat and its products helps in development of colour and flavour as well as inhibit microbial growth. Rosemary, oregano, cinnamon, cloves and other spices act as antioxidants in meat and poultry products and retard rancidity in fatty foods (Karre *et al.*, 2013). In earlier food applications, Madsen and Bertelsen (1995) used spices as antioxidants and Lee *et al.* (1989) highlighted the importance of using ginger as an antioxidant in meat products. Rosemary spice increases the redness of pork sausage making it more desirable but may not be appropriate in poultry products (Karre *et al.*, 2013). The addition of spices to meat products according to Hand *et al.*, (1981) increased the overall desirability of the products. Spices remove the rawness in meat, masking the unpleasant smell, and add a tang and flavour to otherwise insipid foods.

Spices such as paprika, nutmeg, ginger, mace, the peppers (black, red, white), and garlic when added to some food systems enhance fermentation by promoting growth of lactic acid bacteria which alters the pH and subsequently prevents the growth of some other microorganisms (Ockerman and Basu, 2010). This anti-microbial property of spices helps to preserve food. Some spice oils are known to show better antibacterial properties than others when it comes to meat applications. Eugenol, coriander, clove, oregano and thyme oils are found to be effective at levels of 5–20 μl g^{-1} in inhibiting *Lactobacillus monocytogenes*, *Aeromonas hydrophila* and autochthonous spoilage flora in meat products (Tsigarida *et al.*, 2000; Skandamis and Nychas, 2001). Combining different spices into spice mixes help to attain better synergetic effect. Studies attribute the effect spices have on fermentation to the presence of manganese, an important growth factor for microbial cultures and an inhibitor to *Lactobacillus monocytogenes* and *Staphylococcus aureus* (Kang and Gung, 2000; Bacus, 1984; Zaika and Kissinger, 1984).

Spice mixes or preparations for processing meat must however be affordable so that the aim of promoting meat processing and increasing incomes of meat handlers and processors is not defeated. It is therefore pertinent to base any such formulation on local spices. However, this potential has not been exploited probably because there is not enough reliable information available on these spices in different parts of the country. The mere identification of these local spices by name both in local and English; Common and Scientific are not well documented. This creates an initial difficulty in identifying whatever potential is available for their use as composite spices for the meat industry. Information on the sensory properties of these spices does exist in literature but are scattered. As an initial step towards the formulation of composite-spices for the meat industry, the identification by name and compilation of sensory properties of local spices was found to be a necessary objective for this study. The study thus restricts itself to two main objectives: Compilation and identification of all the common local spices found on the Ghanaian market; and to develop Ready-to-use composite spices or seasonings for producing comminuted meat products using pork.

Materials and methods

Spices were collected from seven major markets across the country: Bolgatanga, Tamale, Techiman, Kumasi, Accra, Cape Coast and Takoradi. During the collection of spices, interviews were conducted to find out from sellers the sensory properties, uses and local names of these spices. Spices collected were sorted and cleaned. Those with testa example *Monodora myristica* were removed before grinding. Spices with high moisture content like onions and ginger were peeled, cut into pieces and sun-dried

before grinding. Spices were ground into micro-ground flour using an electric blender and packed into tightly closed clean containers and stored in the freezer until use.

Preparation of composite spices

Spices were broadly grouped into three based on their dominant sensory properties for example, spicy spices are the peppery-tasting-spices (e.g. paprika, ginger and West African Black pepper). Spices were selected from each of these groups and used to prepare different formulations of composite mixtures with a commercial composite-spice as the reference. Seven different formulations of composite-spices were then prepared under the following code-names:- Nugcoft (reference composite spice), Nugcoft 'D' (Dawadawa based composite spice), Nugcoft 'Pe' (Pepper based composite spice), Nugcoft 'K' (Karandafi based composite-spice), Nugcoft 'A' (Ayerewamba based composite-spice), Nugcoft '0' (Onion based composite-spice), and Nugcoft 'P' (Prekese based composite-spice).

Pre-trial test

An amount of 1.52% each of the above formulated composite-spices was used to prepare seven types of fresh pork sausages to give seven-product types. A 5-member panel was used to obtain acceptability scores for the seven product types. Out of this, four products; Nugcoft (control), Nugcoft '0', Nugcoft 'D' and Nugcoft 'P' were selected for the main study.

Preparation of experimental products

Pork used for the study was obtained from a sow carcass of 80 kg weight produced at the University of Cape Coast Teaching and Research farm, Cape Coast. Preparation of the fresh pork sausages was carried out at the meat laboratory of the University Teaching and Research farm, Cape Coast. The above selected product types were prepared in three batches (replications) on different days. The preparation of all the four-product types followed the same procedure. Lean pork and fat were minced through a grinder with 5mm diameter holes in its plate. The minced lean and fat plus the other ingredients were mixed in a bowl (at a very low temperature) in the following order: lean, fat, salt, spices and cold water. Immediately after mixing, the dough was stuffed into a 40-80 mm diameter hog casings with a manual stuffer. The stuffed products were linked into 6-8 cm lengths to give sausages of about 35-40 grams each. The sausages were packed into polythene bags, sealed and kept under freezing temperature (-18^0c) prior to sensory evaluation the next morning.

Sensory evaluation

A 10-member panel consisting of 5 males and 5 females was used. Panel members were schooled as regards the following steps of sensory analysis:

i. individual assessment.
ii. washing of mouth after each tasting.
iii. waiting a few minutes after each tasting before the next.

These panel members were thus dabbed 'trained' panel members.

Criteria for selection

i. Sex

ii Members must be able to know what to expect of sausages (i.e. members must be sausage eaters and know what to expect from the organoleptic characteristics).

Panel-testing

Samples of the experimental products were removed from the freezer and cooked. To cook, samples were steamed for about 1-2 minutes and deep fried for about 3-5 minutes to a yellowish-brown colour. Four samples, one of each product type were placed on a side plate in two forms: (1) raw state (2) cooked state and presented to each panel member. Samples were blind-coded as ABCD in the first batch, 1,2,3,4 in the second and w, x, y, z, in the third. A questionnaire was self developed and provided to panel members to score products

on a 10-point rating scale ranging from 1 (poor) through 10 (excellent) for external appearance of uncooked products, internal colour, aroma and taste of cooked products. They were also required to rank samples in decreasing order from '1' through '4' based on the overall acceptability. The overall acceptability was judged as the overall impression of the product in terms of external appearance of the uncooked product, internal colour, aroma and taste of cooked products.

Experimental design and statistical analysis

The experiment involved four treatments evaluated in three replications with sex as block. The data collected was analyzed as a completely randomized block design (CRBD) using the non-parametric analysis as employed in Friedman's test and Wilcoxon's signed-rank test.

Results presentation and analysis

Table 1: Identification of local spices

Scientific name	Common name	Part used	Properties and Uses	Area found
Piper guineense	West African Black Pepper Twi/fanti Suro-wisa Ga Gbowisi/Gbowyei Ewe Kate/Kukuli Hausa Masoro	Seeds	Eugenol essential oil Flavouring soups, rice etc. its oil is utilized in perfumery and soap making	Closed forests of Ashanti and Eastern Regions
Aframomum melegueta	Grains of Paradise. Twi/Fanti: Fam-wisa/Wisa Ewe: Awusa/ Dzekuli. Hausa: Yaagyi	Seeds	Paradol and volatile oils Flavouring food, alcoholic liquors and veterinary medicines	Forest areas of Eastern, Western and Ashanti Regions
Fructus foeniculi	Thyme/Fennel. Twi/Fanti: Nketenkete Ga: Nketenkete Ewe: Nketenkete	Fruit	Phenol ether anethole ketone fenchome Seasoning meat, foods used as a carminative and aromatic	Forest areas of Ashanti and Eastern Regions
Parkia clappertoniana	West African locust Bean Twi/Fanti: Osonkoran Ga: Ateomi Ewe: Ewa/ewo Hausa: Dawadawa	Pulp and seeds	Alkaloids, cyanogenic glycoside Condiment in soups and in 'Dozim' drink.	Savanna and deciduous regions of Ghana/Tamale.
Eugenia caryophyllata	Cloves Twi/Fanti:Pepple/Prekomba Ga: Pepple Ewe: Pepple Hausa: Kananfari	Dried un-opened flower bud	Eugenol Baking, gravies, and flavouring meat	Thick forest of Ashanti Region.
Xylopia aethiopica	Ethiopian pepper (Peppercorn) Twi/Fanti: Hwentia Ga: So Ewe:Tsuo Hausa: Kimba	Fruits and seeds	Avoceine', 'rubersole' fat Flavouring porridge and meat; ground seeds are added to snuff; mixed with *Piper guineense*	Forest of Western and Ashanti Regions

			to prepare 'Kurobow' for the skin	
Myristica fragrans	Nutmeg Twi/Fanti:Nutmeg Ga: Nutmeg Ewe: Nutmeg	Dried kernel	Alcohols, myristicin and eugenol Flavouring foods and baking; used as a carminative	Aburi areas in the Eastern region.
Capsicum annuum	Paprika/Chili/cayenne Twi/Fanti: Meko/muoko Ga: Shito Ewe: Atadji Hausa: Tankwa	Fruit	Phenolic substance Capsicin Used as condiment in stews and soups.	Found across the country
Monodora myristica	Monodora Twi/Fanti: Ayerewa Ayerewam-amba Ga: Maalai Ewe: Ayiku Hausa: Elmiya	seeds	Used as condiment in Soup, seasoning meat Flavour in pomade and medicine.	Evergreen and deciduous Forest of Western Region
Allium cepa	Onions Twi/Fanti: Gyeene/Anyoo Ga: Sabolai Ewe: Asabolai Hausa: Al-basa	Bulb	Antioxidants quercetin and sulfur Used as seasoning in meat	Found across the country
Allium sativum	Garlic Twi/Fanti: Garlic Ga: Garlic Ewe: Garlic Hausa: Talfanur-wa	Bulb	Sulfur compounds – allicin, ajoene, alin etc. Used as seasoning in meat and meat products	Found in dry sandy soils across the country
Zingiber officinale	Ginger Twi/Fanti Akakaduro Ga Kakatsofa Ewe Nkrama/Nkrawusa Hausa Tsita/Kakadoro	Rhizome	Gingerol Used in seasoning meat, for drink preparation and in medicines	Found across the country
Sorghum halepense	Sorghum leaves Twi/Fanti: Ewio/Ahaban Ga: Karundafi Ewe: Karundafi Hausa: Karundafi	Leafy stalk	Phenols, antibiotic properties Used in colouring rice, beans etc.	Found in Savanna areas of Northern and Upper regions of Ghana
Tetrapleura tetraptera.	Tetrapleura Twi/Fanti: Prekese/Esem Ga: Prekese Ewe: Aprekese	Fruits	Aridanin Flavouring soups and porridge. Jam production.	Thick forest of Ashanti Region

Sensory evaluation

The results show the feasibility of using local spices found on the Ghanaian market in preparing composite seasonings for meat processing. There is a definite threshold of taste for every substance which varies with the individual and with environmental factors such as temperature. An experienced chef usually tastes his delicacies at the temperature at which they will be served, since heat and cold alter the flavour of many preparations. It is thus the responsibility of

any compounder to take into consideration the sensitivity of each individual spice, temperature, taste and general appearance when selecting flavouring agents for preparation.

External appearance of products

Generally, the incorporation of different composite-spices into the meat products did not affect the external appearance of the uncooked products much giving them a similar appearance. Other factors like punctured casing, unequal sizes and hanging casing ends however contributed to some variations in the external appearance of the products. However, there was no significant difference in the external appearance of the different uncooked products.

Internal colour

The general trend for the internal colour of products is shown in Table 2. The dark colour of the prekese fruit could have been strongly imparted to the products to give the prekese based product (Nugcoft 'P') a slightly darker internal colour than the other products. On the whole however, the internal colour of the different products did not show any significant variations.

Table 2: Acceptability rating based on internal colour of products

Product Type	Median Scores	Rank Totals
Nugcoft (control)	7.0	9[a]
Nugcoft 'P'	7.0	9[a]
Nugcoft '0'	7.0	7[a]
Nugcoft 'D'	6.3	5[a]
Range	2-10	

Rank Totals with the same superscript are not statistically significant at 95% level of testing

Aroma of products

The same level, 1.52% of different composite-spices was used in each product type. The general trend for the aroma of products is shown in Table 3. Although the same level, 1.52% of different composite-spices was used in each product type, the aroma of the products differed. This indicates that certain types of spices are more appropriate to use in meat products than others. Rankings showed that the prekese based product (Nugcoft 'P') had the highest acceptable aroma compared to the dawadawa based product which was least accepted for its aroma probably because the associated smell of dawadawa could not mask the rawness of the pork contributing to a lower acceptable aroma of the product. Probably, reducing the percentage composition of the dawadawa and increasing that of the sharp spices like garlic and onions could help remove the rawness of the pork and improve upon the product by making the aroma more acceptable. However, there was no significant difference between the aromas of the different products.

Table 3: Acceptability rating based on aroma of products

Product Type	Median Scores	Rank Totals
Nugcoft 'P'	7.0	10.0[a]
Nugcoft '0'	7.0	9.0[a]
Nugcoft (control)	7.0	7.5[a]
Nugcoft 'D'	6.0	3.5[a]
Range	2 – 10	

Rank Totals with the same superscript are not statistically significant at 95% level of testing.

Taste of products

Taste of the prekese based product was highly accepted. Prekese is very rich in easily assimilated carbohydrates with more than half being sugars. This might have contributed to the good taste of the prekese based product (Nugcoft 'P') making it a better acceptable product as shown by the ranking in Table 4. There was no significant difference between male and female rankings in this study.

Table 4: Acceptability rating based on taste of products

Product Type	Median Scores	Rank Totals
Nugcoft 'P'	7.0	8.5[a]
Nugcoft '0'	7.0	8.5[a]
Nugcoft (control)	7.0	7.0[a]
Nugcoft 'D'	7.0	6.0[a]
Range	2 – 10	

Rank Totals with the same superscript are not statistically significant at 95% level of testing.

Overall acceptability rating

Overall acceptability of products was based on the overall impression of the products in terms of external appearance of the uncooked products, internal colour, aroma and taste of cooked products. The general trend for overall acceptability is shown in Table 5. The prekese based product (Nugcoft 'P') was judged the best in terms of internal colour, aroma and taste. It was also judged as the best product in terms of overall acceptability. On the contrary, Nugcoft "D" was judged the least in terms of internal colour, aroma, taste and overall acceptability. There was a significant difference between Nugcoft 'D' and the other three products: Nugcoft 'P', Nugcoft and Nugcoft '0' at 95% level of testing (P = .05).

Table 5: Overall acceptability rating of products

Product Type	Median Scores	Rank Totals
Nugcoft 'P'	21.5	12[a]
Nugcoft (control)	21.5	8[a]
Nugcoft '0'	21.0	7[a]
Nugcoft 'D'	21.0	3[b]
Range	8 - 29	

Rank Totals with the same superscript are not statistically significant at 95% level of Testing.

Discussion of results

A total of fourteen local spices were collected and their local and English names identified as well as their Common and Scientific names. Documenting this information is a positive move towards identifying whatever potential is available for their use in formulating composite spices for the meat industry. Information on the sensory properties of these spices have also been compiled and included as an initial step towards helping meat processors determine an ideal level of inclusion of individual spices in the composite mixes for the meat industry. Although costing of the composite spice mixes was not done, they could still be considered "affordable" considering the fact that on the Ghanaian market, foreign or imported spices are often more expensive than local ones.

Sensory evaluation results showed that Nugcoft 'P', the prekese based product had the darkest colour which probably comes from the dark-coloured prekese fruit. Also, the prekese based product (Nugcoft 'P') was judged the best product in terms of internal

colour, aroma and taste. Sensory parameters are vital qualities that often play significant roles in consumers' purchase of meat products. Feiner (2006) and Van Oeckel *et al.* (1999) report that consumers often consider colour the primary visual characteristic of meat and its' products prior to deciding what to buy. Consumers often relate the freshness and overall quality of a product with its colour (FAO, 2010). The high content of easily assimilated carbohydrates mostly sugars found in prekese and the dark colouration it impacts to its products probably contributed to Nugcoft "P" being judged the overall best accepted product. However, there were no significant variations in the internal colour of the different products.

Although the same level, 1.52% of different composite-spices was used in each product type, the aroma of products differed. This indicates that the use of certain spices in meat and its products is more appropriate than others. According to Haywood (1982), prekese is associated with a strong caramel-like smell and might have contributed to the prekese based product (Nugcoft 'P') being selected as the best product in terms of aroma. According to Osei-Tutu and Nhancale (2010), when prekese is used in food and medicines, the sweet smell enhances the taste and increases its acceptability. Ratings for aroma of the dawadawa based product in this study were similar to that of other studies in which the aroma of dawadawa was reported to be offensive to some consumers (Achi, 2005; Afribiz, 2011). This offensive smell may have influenced ranking of the product by the panel. Teye *et al.* (2013) in a preliminary study to determine the effect of dawadawa (*Parkia biglobosa*) on sensory and nutritional qualities of meat products such as smoked pork sausage and burgers, reported that the use of dawadawa up to 4g/kg meat in the meat products increased the crude protein content significantly ($P < .001$) and had no effect ($P = .05$) on the sensory characteristics of the products. Thus, they recommend that dawadawa could be used in meat products up to 4g/kg meat for improved crude protein content. Hopefully, adapting the level of inclusion of up to 4g/kg of dawadawa as recommended by Teye *et al.* (2013) would make such products less offensive and more acceptable to panellists.

The associated smell of dawadawa could not mask the rawness of the pork. This probably contributed to the product being the least accepted by the panel in terms of aroma. In addition to the level of inclusion suggested by Teye *et al.* (2013), reducing the percentage composition of the dawadawa and increasing that of the sharp spices like the garlic and onions in this study could help reduce or completely remove the rawness of the pork and therefore improve the aroma and acceptability of the product. However, there was no significant difference in the aroma of all the different products.

Dawadawa is also rich in easily assimilated carbohydrates with less than half being sugars. These sugars are exploited and used to prepare a sweet drink called 'Dozim'. With such properties, it's surprising to find out that the taste of the dawadawa based product (Nugcoft 'D') was evaluated by the panel as the least accepted. One would have expected the darker nature of dawadawa to impart more colour to the dawadawa based product, Nugcoft 'D' as was the case in the prekese product and consequently increase the acceptability of the product. This was however not the case. The low level of acceptability may have resulted from the aroma of the dawadawa rather than the colour. If the aroma of the dawadawa product could be regulated, then probably an increase in the level of inclusion of the dawadawa could still enhance the taste of the product due to its assimilated carbohydrates and make it more acceptable.

Sex is often a factor which influences taste and thus was the basis for selecting equal number of males and females for the sensory evaluation. Generally, men are known to

evaluate products with bitter taste better than women, while women are known to evaluate sweetness in products better than males (University of Copenhagen, 2008). However, in this study, there was no significant difference between the scores provided for taste by both males and females. Taste is markedly affected by smoking and this was taken care-of by not selecting any smoker to serve on the panel. For overall acceptability, there was significant (P = .05) difference between Nugcoft 'D' and the other three products: Nugcoft 'P', Nugcoft and Nugcoft '0'.

Conclusion

Fourteen local spices were collected and identified. All these local spices were readily available on the Ghanaian markets and could be easily obtained by farmers and individuals for the preparation of Ready-to-use composite-spices-to enhance meat processing. The results establish the fact that Ready-to-use composite-spices make processing of meat easier by providing an appropriate amount of a particular type of spice required in meat products. The sensory evaluation results in terms of overall acceptability rating showed that the 1.52% level of inclusion of the different composite-spices was acceptable. However, an increase in the percentage composition of the sharp spices like garlic and onions in the Nugcoft 'D' product (Dawadawa based product) could increase its acceptability.

In view of enhancing the acceptability of the Nugcoft 'D' product, it is recommended that future research on composite-spices should be geared towards the combination of different levels of inclusion of the individual spices. Also to promote the use of these composite-spices:

1) The effect of storage on the composite spice mixes and that of the meat products prepared using these spice mixes must be considered. This is a very important food safety issue that must be critically looked into in order to keep the health value of the processed meat products.
2) The cost analysis due to processing and formulation of these composite spices must also be made to ascertain and confirm their feasibility and affordability.

References

Achi, O. K. (2005). The potential for upgrading traditional fermented foods. African Journal of Biotechnology, 4: 375-380.

Afribiz Report (2011). Locust Bean: An African Indigenous. Agriculture Crop, Written by the Editorial Staff. Accessed on 10th February, 2012 from www.Afribiz.info/Food and Agriculture.

Bacus, J. (1984). Utilization of microorganisms in meat processing. Research Studies Press LTD. Letchworth, Hertfordshire, England; Wiley, New York P 1-170.

Bauer, K., D. Garbe and H. Surburg (2001). Common Fragrance and Flavour Materials. Preparation, Properties and Uses, Wiley-VCH, Weinheim, p. 293.

Eusebio, J. A (1980). Pig Production in the Tropics, Longman Inc, New York.

FAO (2010) Gunter Heinz and Peter Hautzinger Meat Processing Technology for Small-To Medium-Scale Producers. pp. 103-221.

Farag, R. S., Z. Y. Daw and S. H. Abo-Raya (1989). Influence of some spice essential oils on Aspergillus parasiticus. Journal of Food Science, 51(1): 74-76.

Feiner, G. (2006) Meat production Hand book, Practical Science and Technology, CRC Press, Bola Raton Boston, New York, Washington D. C. Wood Head Publishing Limited. Cambridge, England, pp. 459-469.

Hand, L. W., C. H. Crenwelge and R. N. Terrelli (1981). Effect of wheat

Gluten, soy Isolate and Flavouring on Properties of Restructured Beef Steak. Journal of food science, 46: 1004-1011.

Haywood, D. J. (1982). Characteristic Flavours of local Flavouring plant. Journal of Natural Products, 37(1): 132.

Karre, L., K. Lopez and K. J. Getty (2013). Natural antioxidants in meat and poultry products. Meat Science, 94(2): 220-227. Accessed on October 12th, 2013 from http://www.ncbi.nlm.nih.gov/pubmed ?

Kang, D. H. and D. Y. C. Gung (2000). Simulation of starter culture for further reduction of food borne pathogens during salami fermentation. Journal of Food Protection, 63: 1492-1495.

Lee, Y. B., Y. S. Kim and C. R. Ashmore (1989). Antioxidant Property in Ginger rhizome and its application to meat products. Journal of Food Science, 51(1): 20 – 23.

Lemay, M. J., J. Choquette, P. J. Delaquis, C. Gariépy, N. Rodrigue and L. Saucier (2002). Antimicrobial effect of natural preservatives in a cooked and acidified chicken meat model. International Journal of Food Microbiology, 78: 217–226.

Madsen, H. L. and G. Bertelsen (1995). Spices as antioxidants, Trends in Food Science Technology, 6: 271-277.

Osei-Tutu, P. and B. Nhancale (2010). Hidden Forestry Revealed: Characteristics, Constraints and Opportunities for Small and Medium Forest Enterprises in Ghana. Issue 27 of IIED small and medium forest enterprise series. 70pages. Accessed on October 12th from http://www.IIED+small+and+medium+forest+enterprise_series'source=gbs_metadata_r&cad=6

Ockerman, H. W. and Lopa Basu (2010). Fermented Meat Products. Production and Consumption Accessed on October 25th, 2013 from https://kb.osu.edu/dspace/bitstream/handle/1811/45275/fermented?sequence=1

Skandamis, P. N. and G. J. E. Nychas (2001). Effect of oregano essential oil on microbiological and physico-chemical attributes of minced meat stored in air and modified atmospheres. Journal of Applied Microbiology, 91: 1011–1022.

Teye, G. A., F. Taame, K. O. Bonsu and M. Teye (2013). Effect of Dawadawa (Parkia biglobosa) as a spice on sensory and nutritional qualities of meat products: A Preliminary study. International Journal of Current Research, 5(02): 110-112. Accessed on October 25th, 2013 from http://www.journalcra.com

Tsigarida, E., P. Skandamis and G. J. E. Nychas (2000). Behaviour of Listeria monocytogenes and autochthonous flora on meat stored under aerobic, vacuum and modified atmosphere packaging conditions with or without the presence of oregano essential oil at 5°C. Journal of Applied Microbiology, 89: 901–909

University of Copenhagen (2008). Girls have superior sense of taste to boys, Science Daily. Accessed on August 28th, 2013, from http://www.sciencedaily.com/releases/2008/12/081216104035.htm

Van Oeckel, M. J., N. Warnant and C. V. Boucque (1999). Measurement and prediction of poultry colour. Meat Science, 52: 347-354.

Zaika, L. L. and J. C. Kissinger (1984). Fermentation enhancement by spices. Journal of Food Science, 49(1): 5-9.