Meat Research
Vol 3, Issue 1 Article 44
ISSN: 2790-1971
https://doi.org/10.55002/mr.3.1.44
http://www.bmsa.info/meatresearch

Research Article

Effect of replacing sodium erythorbate and nitrate with three Nigerian indigenous spices on the quality and sensorial characteristics of Frankfurter sausage

ES Apata*[1], EB Akinmade[1], OC Apata[2], OI Solana[3] and YO Uthman-Akinhanmi[3]

[1]Meat Science Laboratory; Department of Animal Production, Olabisi Onabanjo University Ayetoro Campus P.M.B 0012 Ayetoro, Ogun State, Nigeria

[2]Department of Wildlife and Ecotourism Management, University of Ibadan, Ibadan Oyo State, Nigeria

[3]Department of Home Science and Hospitality Management, Olabisi Onabanjo University, Ayetoro Campus, P.M.B 0012 Ayetoro Ogun state, Nigeria

***Corresponding author:**

ES Apata:
E-mail: ebunoluapata2008 @yahoo.com

Keywords:

Frankfurter sausage
Nigerian indigenous spices
Nitrate
Quality and sensory
Sodium erythorbate

Article Info:

Received: 19 January 2023
Accepted: 15 February 2023
Published online: 28 February 2023

Abstract

Sausage is a meat product that is prepared by combining different meat types that are commuted and seasoned with various spices and additives which include sodium erythorbate and nitrate. The main objective of this study was to evaluate the effect of replacing both sodium erythorbate and nitrate with three Nigerian indigenous spcies, *Parkia biglobosa*, *Piper guineense* and *Monodora myristica*, each of the spice constituted a treatment, while the control was a Frankfurter sausage with both sodium erythorbate and nitrate thus: T_0 = FF (control) T_1 = PB, T_2 = PG and T_3 =MM each contained 10% of the spices. The sausages samples were analyzed for physical, chemical, minerals and vitamins, microbiological and sensorial properties in a completely randomized design experiment and the significant means separated at $p<0.05$. Treatment 3 furnished highest yield, protein, mineral and vitamins, fiber, lowest microbial load, but highest eating properties and acceptability. It might be expressed from this study that indigenous spices are potential substitutes for sodium erythorbate and nitrate salts in sausage manufacture. From this study, it can be concluded that *Monodora myristica* can be used effective to replace the two salts in sausage to guarantee the quality and acceptability of the final product by consumers.

Introduction

Meat is the edible part of the skeletal muscle of an animal and it is highly perishable due to its high biological composition (Habiba et al., 2021; Siddiqua et al., 2018; Khatun et al., 2022). It is an excellent source of many important nutrients, which make it vulnerable to deterioration by micro-organisms of different sorts (Jay et al., 2008; Islam et al., 2018; Disha et al., 2020). Many works had been carried out to increase the shelf-life of meat and of these is the manufacture of meat to several meat products such as kilishi, suya, jerky biltong and sausage (Apata et al., 2022). Moreover, several antioxidants and spices have been added during the manufacturing process of sausages and other meat products to improve the quality of the products (Akter et al., 2022; Boby et al., 2021; Bithi et al., 2020; Jahan et al., 2018). Sausage manufacture evolved as a move to economize and preserve meat that could not be utilized fresh at slaughter, the process that began over two thousand years ago and constitutes one of the oldest prepared foods that cannot be consumed immediately and in the absence of modern preservation technology in order to overcome the problem of wastage and spoilage (Ali et., 2022; Hossain et al., 2021; Winjker et al., 2006). Sausages have been produced from different meats and different regions of the world and are so named after the meat types or regions (Sachindra et al., 2005). It is prepared from commuted and seasoned meat which is formed into various symmetrical shapes in which the products differ primarily in the variety of additives or spices used and the processing methods (David et al., 2013). Spices are seeds, flowers, fruits, roots or leaves of plants that are dried and used in small qualities as food additives such as locust beans, (*Parkia biglobosa*), guinea pepper (*Piper guineense*) and calabash nutmeg (*Monodora myristica*) among others which are very native to Nigeria (FAO, 2010).

Spices have been used as dietary supplements and enhancers as they improve the visual appeal and palatability of foods and meat products (Obadina and Ogundimu, 2011). The most important and commonest ingredients components of sausage manufacture are sodium erythorbate which is added for the preservation and nitrate for sausage colour enhancement (Badpa and Ahmad 2014). Consumers are demanding for meat products that have physiological functions to promote good health conditions and to prevent the risk of diseases which many speculated could arise from the use of the two additives (Apata et al., 2020). Therefore, attention has been geared towards the development of meat products (Sausage) using purely natural or indigenous ingredients or additives to replace the two conventional salts without any detrimental effects on the consumers or with any alteration to the quality of the meat product especially sausage that is commonly consumed worldwide (Jochen et al., 2010). The objective of this study therefore, was to evaluate the effect of using *Parkia biglobosa*, *Piper guineense* and *Monodora myristica* in replacement for sodium erythorbate and nitrate on the quality and sensorial characteristics of sausage.

Materials and methods

Meat samples acquisition

The meat (beef 1200g) and (Pork, 600g) used for this study were purchased from the main slaughter slabs at Ayetoro as well as the spices (*Parkia biglobosa*, *Piper guineense* and *Monodora myristica*) and were transported to the meat science laboratory of the Department of Animal Production, Olabisi Onabanjo University, Ayetoro campus where this study was conducted.

The meats were chilled at 4°C for 24hrs before been prepared for sausage manufacture. The meats were trimmed off all connective tissues and washed properly with clean tap water.

Processing of spices

The spices used in this study were processed following the method described by Apata et al. (2014, 2020). They were sorted out and milled with a laboratory blender (KCB 239K Kenwood, UK) and stored in sealed and labelled bottles before use.

Preparation of sausage

The meat 1,200g beef and 600g pork were minced with kenwood mincer (KW715836UK) and the batter was divided into 4 portions while spices were added to each portion that constituted the study treatments as follows:

T_0 = Frankfurter batter (control) (FF)
T_1 = Batter + *Parkia biglobosa* (PB)
T_2= Batter + *Piper guineense* (PG)
T_3= Batter + *Monodora myristica* (MM) as shown in Table 1 below:

Table 1. Ingredients composition of sausage

Ingredients	Treatments			
	T_0 (FF control)	T_1 (PB)	T_2 (PG)	T_3 (MM)
Beef (g)	1,200.00	1,200.00	1,200.00	1,200.00
Pork (g)	600.00	600.00	600.00	600.00
Red pepper(g)	45.00	45.00	45.00	45.00
White pepper (g)	38.00	38.00	38.00	38.00
Coriander(g)	30.00	30.00	30.00	30.00
Mustard(g)	13.00	13.00	13.00	13.00
Garlic (g)	13.70	13.70	13.70	13.70
PB (g)	-	10.30	-	-
PG (g)	-	-	10.30	-
MM (g)	-	-	-	10.30
Salt (G)	15.00	15.00	15.00	15.00
Sugar (g)	20.00	20.00	20.00	20.00
Ice (g)	15.00	20.00	20.00	20.00
SN (g)	10.00	-	-	-
SE (g)	0.30	-	-	-
Total	2,000.00	2,000.00	2,000.00	2,000.00

FF=Frankfurter, PB = *Parkia biglobosa*, PG= *Piper guineense*, MM= *Monodora myristica*, SN= Sodium nitriate, SE=Sodium erythorbate

Each of the sausage meats and spices were well blended according to David et al., 2013, Badpa and Ahmad, 2014).

Stuffing of sausage

Each of the treatment was fed into a Piston and stuffed into natural sheep intestine casing which was preserved in 10% NaCl (Wijnker et al., 2006) and rinsed properly with clean tap water after proper mixing following the procedures described by Savel and Smith (2009).

Sausage linking

The stuffed sausages were labeled and linked manually and were hung in a process room and they were allowed to stand in the room for 60 min at 8°C before they were moved into an oven and were cooked for 150min (2hrs 30min) at 85°C and 78% relative humidity to an internal temperature of 72°C (Savel and Smith, 2009).

Cold shower, standing and peeling sausages

The showering of sausages with cold water from the tap was carried out on and off at 1-2mins interval and the cooked sausages were allowed to stand overnight before peeling. The sausages were warmed one treatment after the other and were peeled manually and were allowed to cool to room temperature 27°C and were kept in refrigerator at 4°C for analysis later (Apata et al., 2022).

Physical analysis

Cooking loss and yield

The prepared sausage samples were weighed prior to cooking and reweighed after cooking and cooling and the cooking loss was calculated according to Lee et al. (2008) as follows:

Cooking loss = wtr – wtc /wr × 100

Where: wtr = weight of raw sausage before cooking (g) and wtc = weight of cooked and cooled sausage (g). Cooking yield was determined using the formula:

100 – cooking loss assuming that the sausages were 100% intact at processing (Omojola, 2008).

Thermal shortening

Sausages thermal shortenings were determined following the procedures described by Apata (2011). The lengths of raw sausages were taken prior to cooking and were retaken after cooking and cooling and calculated as follows:

Lsr – Lsc/ Lsr × 100

Where Lsr = Length of raw sausage (cm) and Lsc = Length of cooked and cooled sausages (cm)

Water holding capacity (WHC)

The WHC of sausages was determined using the filter paper press method. Whatman paper No. 40 was put in 38% H_2SO_4 for 24 hours at 60% relative humidity to diffuse out water freely through the paper. 5g of sausage from each treatment was homogenized and 300mg sausage sample was put on the Whatman paper No. 40 and placed between two slides on which a 100g weight was placed on the top slide for 5min to exert a downward force and to release water from the sausage according to Honikel (2009). The water released from the sausages wetted the paper and the boundary of the wetted area was demarcated using a sharp pencil and was measured in percentage of the ratio of the diameter of the sausages to the diameter of the water wetted paper as follows:

WHC = DS/DWP × 100

Where Ds = Diameter of sausage (mm) and Dwp = Diameter of wetted paper (mm)

Shear force values of sausages

The sausages instrumental tenderness was determined by shearing 10g of sausages at three locations using Warner-Bratzler v-notch blade shearing instrument. The averages forces for cutting the sausages in three locations were recorded as the shear force for sausages in each treatment as described by Buldassini et al. (2021).

Chemical analysis of sausages

The moisture content, crude protein, ether extract (fat), ash, crude fibre were determined following the methods described by AOAC (2005) while the nitrogen free extract (NFE) or carbohydrate (CHO) was determined by calculation as follows:

100 – Proximate composition (moisture + protein + fat + ash) (AOAC, 2005) and the pH of sausage samples was evaluated using the method described by Marchiori and deFelicio (2003).

Minerals and vitamins

The mineral composition of prepared sausages was determined using the traditional method of sample digestion and filtration following the methods described by AOAC (2005), Ward and Legako (2017) while vitamins component of the sausage was evaluated using (AOAC, 2005) method of analysis.

Microbiological analysis

The microbial loads of sausages were determined following the methods prescribed by ICMSF (1998) APHA (2001) and AOAC (2005).

Sensorial evaluation of sausages

The sensory evaluation of sausage samples was conducted following the procedures of Iwe (2002) and AMSA (2015). A 10 member semi-trained panelists randomly selected from the students and staff of the Department were used. Sensorial characteristics of the sausages such as color, flavor, tenderness, juiciness, texture and overall acceptability were scored on a 9-point hedonic scale on which 1 = dislike extremely, 5 = neither like nor dislike and 9 = like extremely.

Experimental design and statistical analysis

The experimental set-up was a completely randomized design, while the results were presented as standard error of the means. Data collected were subjected to analysis of variance (ANOVA) using (SAS, 2002) statistical package. The significant differences between the means were separated with Duncan multiple range test of the same package.

Results and discussion

There were significant differences ($p<0.05$) in all the physical properties of sausages prepared with three indigenous spices Table 2. Cooking loss (18.50) thermal shortening (19.30) and shear force (4.80) values were higher in sausage with *Parkia biglobosa* (PB) inclusion (T_1) than in other treatments, while these variables were significantly lower ($p<0.05$) in sausage with *Monodora myristica* (MM) (T_3) in comparison with other sausage cooling yielded was significantly higher ($p<0.05$) in sausage with MM and lower in one with PB while water holding capacity (WHC) was higher in Frankfurter (FF) control (T_0) sausage (62.30) followed by that with MM (56.50). The cooking loss and thermal shortening of the sausages increased across the treatments, up to T_2 and decreased at T_3 showing that probably PB and PG inclusion in sausage supported loss and shrinkage while MM did not which resulted in high cooking yield in sausage with MM as well as water holding capacity (WHC). These results were in agreement with the findings of Omojola (2008) and Apata et al. (2014) who reported that most of the natural spices used in processing meat contributed to the loss in the yield of the meat products, but contrary to the effect of MM which supported both the cooking yield and WHC probably it acted as an inhibitory agent against the draining of juice from the sausage in which it was included. However, the shear force, that is, the value of the instrumental measure of tenderness was relatively high in sausage with MM (T_3) but it was not offensive to the consumers as the subjective tenderness results showed.

Table 2. Physical properties of sausage as affected by indigenous spices

Variable	Treatments T_0 (FF control)	T_1 (PB)	T_2 (PG)	T_3 (MM)	SEM
Cooking loss (%)	14.80^b	18.550^a	14.70^b	12.50^c	2.200
Cooking yield (%)	85.20^b	81.50^c	87.30^b	87.50^a	1.30
Thermal shortening (%)	15.30^c	19.30^a	18.10^b	13.10^d	2.31
WHC (%)	62.30^a	49.60^d	51.00^c	56.50^b	1.20
Shearforce (N)	2.50^c	4.80^a	3.55^b	3.50^b	3.10

Abcd: Means on the same row with different superscripts are statistically significant (p<0.05); FF= Frankfurter, PB = *Parkia biglobosa*, PG =*Piper guineense*, MM= *Monodora myristica*, SEM = Standard error of means. WHC =Water holding capacity

The results of chemical composition and pH are presented in Table 3. The moisture content and fat were significantly lower (p<0.05) in sausage with MM (T_3) while crude protein, ash, fiber and carbohydrate (CHO) were higher compared with other treatments. Excessive moisture could predispose meat or meat product to the proliferation of micro-organisms and subsequent spoilage of the product. The amount of moisture in sausage with MM (T_3) was not as high as it was obtained in other treatments which could make it not vulnerable to microbial overload as could be observed in the microbial profile of (T_3). The protein content of sausage with MM was relatively higher as well as the ash content and fiber of which might have contributed to high acceptability of the sausage coupled with the moderately available fat in the sausage which might aided the juiciness of the sausage. These results were in tandem with the findings of Seo et al. (2015) who reported the spices or plant materials inclusion in sausage improved the quality properties and palatability. There was no significant difference (p<0.05) in the pH values across all the treatments, but T_3 had the least pH (p<0.05) of 6.20 with this range 6.20 – 6.4 of pH. The sausages could be exposed to micro-organisms attack if not served for a long time, however, the spices having microbial inhibitory actions might confer the sausages a relatively longer shelf-life group by the microbial profile of sausages in Table 5.

Table 3. Chemical composition and pH of sausage as affected by indigenous spices

Variable	Treatments T_0 (FF control)	T_1 (PB)	T_2 (PG)	T_3 (MM)	SEM
Moisture (%)	53.47^a	52.27^b	52.17^b	51.15^c	0.04
Crude protein (%)	2.43^b	20.53^b	2.56^a	21.63^a	0/09
Ether extract (fat) (%)	9.27^a	7.10^b	5.13^c	5.10^c	0.19
Ash (%)	3.37^c	4.50^b	4.55^b	5.87^a	0.03
Crude fibre (%)	0.80^c	1.47^b	1.87^b	2.95^a	0.02
NFE (%)	13.36^b	16.10^a	16.59^a	16.25^a	0.03
Ph	6.45	6.30	6.47	6.20	0.01

Abcd: Means on the same row with different superscripts are statistically significant (p<0.05); FF= Frankfurter, PB = *Parkia biglobosa*, PG =*Piper guineense*, MM= *Monodora myristica*, SEM = Standard error of means, NFE = Nitrogen free extract (CHO)

The results of minerals and vitamins composition of sausage are shown in Table 4. Sausage with MM (T_3) elicited highest (p<0.05) values of both minerals and vitamins followed by sausage in T_2 and least (p<0.05) in control (FF). There was increase in the value of minerals and vitamins across the treatments and got to the peak with T_3 which indicated that MM could be richer in minerals and vitamins than other spices tested in this study. It was also obvious that all the spices used might have contributed by way of releasing their nutrients contents into the sausage batters especially during cooking. These results correlated with Aika et al. (2009) who reported that spices have tremendous effect on the quality of sausage.

Table 4. Some minerals and vitamins composition of sausage as affected by indigenous spices (mg/100g)

Variable Minerals	Treatments T_0 (FF control)	T_1 (PB)	T_2 (PG)	T_3 (MM)	SEM
Calcium	175.00^c	256.00^b	256.70^b	270.00^a	3.73
Iron	7.33^b	7.40^b	7.55$_b$	8.67^a	0.08
Magnesium	63.33^d	80.00^c	85.33^b	98.20^a	3.12
Potassium	62.30^d	76.67^c	88.33^b	95.00^a	2.89
Sodium	348.30^d	378.30^c	390.10^b	410.00^a	4.25
Phosphorus	221.70^d	238.30^c	225.20^b	237.80^a	4.08
Vitamins					
Thiamine	0.12^b	0.11^c	0.12^b	0.16^a	0.01
Riboflavin	0.09^d	0.13^c	0.15^b	0.17^a	0.00
Niacin	2.10	1.77	2.13	2.30	0.07

Abcd: Means on the same row with different superscripts are statistically significant (p<0.05); FF= Frankfurter, PB = *Parkia biglobosa*, PG =*Piper guineense*, MM= *Monodora myristica*, SEM = Standard error of means.

The number of microbes on sausage with MM (T_3) were very low (p<0.05) compared with those of other treatments Table 5. The sausage in control (T_0) (FF) had the highest (p<0.05) microbial load of TVC (5.50), TCC (6.50) and TFC (1.20) followed by sausage with PB (T_1). These results could be due to the high contents of pepper in MM and PG which could be lower in PB and control which could make the sausage more vulnerable to microbial attack than sausage with MM in particular. The report of Aquirree Zabal et al. (2000) indicated that Paprika and garlic which are spices could have detrimental and destructive effect on microorganisms in sausage. This have semblance with the results of spices tested in this study most especially MM and PG due to few numbers of micro-organisms the sausages they were included elicited. It was observed in this study that TCC (Total coliform count) were more in number.

This could probably due to the handling of the meat samples from the slaughter slab and during the handling of the sausages however, the number was not as high as 10^7cfu/g which was reported to be pathogenic if consumed on any meat or meat product (Insausti et al., 2001).

Table 5. Microbiological profile of sausage as affected by three indigenous spices (cfu/g)

	Treatments				
Variable	**T_0 (FF control)**	**T_1 (PB)**	**T_2 (PG)**	**T_3 (MM)**	**SEM**
TVC	5.50^a	4.70^b	3.60^c	2.45^d	3.20
TCC	6.50^a	6.70^a	5.40^b	4.27^c	2.00
TFC	1.20^a	1.00^a	0.37^b	0.23^c	0.10

Abcd: Means on the same row with different superscripts are statistically significant ($p<0.05$); FF= Frankfurter, PB = *Parkia biglobosa*, PG =*Piper guineense*, MM= *Monodora myristica*, SEM = Standard error of means. WHC =Water holding capacity

Table 6 shows the results of sensorial evaluation of sausages prepared from three indigenous spices. Sausage prepared with MM (T_3) inclusion educed higher ($p<0.05$) in sausage with PG (T_2) and in control (T_0) treatment (FF). All except one of the eating qualities favored the overall acceptability of sausage with MM (T_3). The color (6.50), flavor (6.70), juiciness (6.60) and texture (7.00) were higher than those of other sausages, hence high acceptability of the sausage by the panelists. The better foregoing eating properties coupled with high WHC, protein, mineral and vitamins, low level of microbial number as well as moderate fat in meat and meat products induces the consumers to accept any meat or meat products (Apata et al., 2016). At the same time spices do make significant contributions to meat products acceptability as to drain their natural nutrients into the final meat product rendering it more palatable and acceptable (Rusumen et al., 2003; Lee et al., 2008; Apata et al., 2022).

Table 6. Sensorial characteristics of sausage as affected by indigenous spices

	Treatments				
Variable	**T_0 (FF control)**	**T_1 (PB)**	**T_2 (PG)**	**T_3 (MM)**	**SEM**
Color	5.00^b	5.20^b	3.60^c	6.50^a	0.37
Flavor	3.10^d	5.50^b	4.10^c	6.70^a	0.60
Juiciness	4.40^c	5.50^b	4.50^c	6.60^a	0.47
Tenderness	5.10^a	5.30^a	4.20^b	4.10^b	0.53
Texture	4.20^c	5.60^b	4.30^c	7.00^a	0.54
OA	5.10^c	6.20^b	4.00^d	7.30^a	0.57

Abcd: Means on the same row with different superscripts are statistically significant ($p<0.05$); FF= Frankfurter, PB = *Parkia biglobosa*, PG =*Piper guineense*, MM= *Monodora myristica*, SEM = Standard error of means. WHC =Water holding capacity

Conclusion

Spices contribute to the quality of meat products as they possess antimicrobial, antioxidant and palatability attributes. The present study reveals that three Nigerian indigenous spices *Parkia biglobosa*, *Piper guineense* and *Monodora myristica* can be included in Frankfurther sausage with good physical, chemical, microbiological and sensory characteristics especially *Monodora myristica* (MM) which elicited higher and better quality characteristics in Frankfurter sausage. It is therefore, recommended that 10g *Monodora myristica* (MM) can be included in Frankfurter sausage since it gave the higher nutrients and eating qualities.

Conflict of interest

The authors declare no conflicts of interest.

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