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Microbiological and Nutritional Properties of Frankfurter-Type Fish Sausage

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Abstract

Fish meat is a common and broadly used food due to its high nutritional values yet the bones and flavour of fresh fish can be unpleasant. The unpleasant fishy flavour makes it difficult to handle and process. The fishy flavour is as a result of microbial presence and growth. Studies associated with microbial contaminations have concentrated more on the carcass. Such contaminations which affect the microbiological status of processed products can emanate from spices and other non-meat ingredients, environment, equipment and handlers. The successful application of processing/preservation technology results in the conservation of desirable qualities in stabilized and varietal fish products. This study sought to use fish in the manufacture of frankfurter-type sausages, which could have improved preservation characteristics without any adverse effects on sensory properties. The nutritional composition and microbiological safety of fresh fish and sausages were determined using the methods described by AOAC and ICMSF respectively. The study showed that, catfish sausages were higher in protein (15.69 %) and were lower in fat (10.66%) compared to the other sausages. Total Viable Counts (TVC) were within the accepted limits (10^6 and 10^7cfu/g) for fish and pork respectively. *E. coli* was not detected in any of the treatments during frozen storage for 6 weeks. It was concluded that catfish frankfurter has high nutritive value because it contained less fat but with higher crude protein. Like pork frankfurters, both catfish and mackerel sausages could be stored for six weeks without any negative effects on microbial quality.

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Introduction

The safety of meat for human consumption has become an essential part of the world's health debate Güngör and Gökoğlu (2010)[11]. Food safety aspects of the meat industry were discussed by Hur et al. (2008)[12] in sections which consider the growing awareness of food safety issues during the last two decades with respect to the importance of food inspection services, risk assessment and management to increasing life expectancy among populations in developed countries. Most meat processing plants have also begun to utilize the Hazard Analysis and Critical Control Point (HACCP) system in order to reduce pathogenic contaminations. Meat products are vulnerable to food borne pathogenic bacteria such as Listeria, Salmonella, and *E.coli* (Sachindra et al., 2005)[22]. Escherichia coli O157:H7 has been considered as an emerging pathogen since 1999 to be responsible for approximately seventy-three thousand (73,000) cases of infection, two thousand one hundred (2,100) hospitalizations and sixty-one (61) deaths in the U.S.A each year (USDA, 1999)[28]. Children and the elderly are more susceptible to developing complications such as hemolytic uremic syndrome (HUS) or thrombotic thrombocytopenic purpura (TTP), which may lead to kidney failure. Also, coliforms have been detected at various processing steps in the meat industry (Pavlov and Chukanski 2004)[21]. Therefore, efficient and effective preservation and or processing methods which prevent microbial contamination and extend product shelf life should be adopted in order to assure consumer safety.

African countries require food processing technologies that will meet the challenges of peculiar food security problems of the continent. Such technologies according to Anihouvi et al. (2012)[2] should be affordable by the poor sectors of the community and should be able to address the problems of food spoilage and food borne diseases which are prevalent on the continent (Olapade and Karim, 2011)[19].

For instance according to the FAO (2012)[9], eight percent (8%) of harvested fish never get to the market and higher values (20 - 40%) of spoilage were recorded in hot humid environments.

Fish spoilage can be as a result of lipid oxidation and hydrolysis which leads to the development of rancidity during storage at sub-zero temperatures. According to FAO (2013)[10] this is because large amounts of polyunsaturated fatty acid moieties are found in fish lipids; this is a major cause of deterioration of frozen fish. Moreover, storage facilities used by indigenous fish processors are problematic, because of high temperatures and humid climate (Oluwatoyin et al., 2010)[20]. Eating contaminated fish can cause illness (Sen, 2005)[24], hence the importance of awareness creation on the need to access reliable knowledge on the quality and safety of all meat products meant for human consumption. According to Lobb et al. (2007)[16] such critical measures of processing and preservation can help eradicate consumer's attitudes and perceived risks and consequences of consuming contaminated foods.

The main objective of the study was therefore to produce two frankfurter-type sausages using catfish and Mackerel.

The specific objectives were to assess the microbiological safety and nutritional characteristics of the sausages produced with or without fish.

Materials and Methods

Experimental Location and Design

There were four treatments in all:- which were coded as T1, T2, T3 and T4. T1 represented pork frankfurter without corn starch; which also served as negative control, T2 was Mackerel frankfurter, T3 was Catfish frankfurter and T4 was pork frankfurter with corn starch which serve as the negative control.

The experimental design was Complete Randomized Design (CRD).

Sausage Preparation

Filleted frozen fish, lean pork and pork fat were minced separately using a mincer (MA®Superwolf, Germany) with a grinding sieve diameter of 5mm. Other non-meat/dry ingredients used in preparing the sausages were curing salt (table salt plus sodium nitrite)($NaNO_2$), phosphate in the form of disodium phosphate, (Na_2HPO_4) and mixed spice. Each treatment was chopped in a bowl cutter to obtain desirable consistence at 15^0C. Dry ingredients were added during chopping together with water/ice in order to dissolve and ensure proper mixing of all ingredients, as well as to control the temperature of the meat batter.

Each treatment was filled into 26mm diameter casings using a manually operated filling machine, and tied off into 6cm lengths. The sausages were hot smoked for 1 hour and scalded at 70°C for 30 min to achieve a core temperature of 65°C. A meat thermometer was used to monitor the core temperature of the sausages in order to prevent over cooking. The scalded sausages were allowed to cool under running tap water, packaged and labelled for storage in a freezer for quality analysis and for further studies.

Parameters Measured

Physico-Chemical Properties

Proximate analysis (moisture, ash, fat, crude protein and carbohydrates) was carried out at the Soil Chemistry Laboratory of the Department of Crop and Soil Science, KNUST using AOAC (1990)[1] procedures. Ash was determined according to AOAC method 923.03.

Microbial Safety [Total Viable Counts (TVCS) and Isolation of Escherichia coli]

Total microbial load and presence of E. coli were determined weekly as described by (ICMSF, 2002)[15] for 6 weeks of frozen storage.

Statistical Analysis

Data obtained for proximate parameters were subjected to one way analysis of variance (ANOVA) using Genstat statistical package version-12 and significant differences between means were separated at 5% using Least Significant Difference test.

Results and Discussion

Okanović et al. (2013)[18] indicated that fish sausage has higher protein (17.32%) and less fat (21.06%) content than sausages made from meat of other farm animals. FAO (2001)[8] also reported lesser fat ranges in Mackerel (1.0% to 23.5%) and Catfish (2.1 to 3.8%) as well as protein (16% to 20%) and (17% to 19%) in Mackerel and Catfish respectively. However, protein and fat results from this study (Table 1) were higher, and the moisture content was lower than those reported by (IoM, 2002)[14]. IoM (2002)[14], had earlier published that sausages made from Catfish contained 74.5% water, 3.16% fat and 13.73% protein. T1 (pork sausage without corn starch) and T4 (pork sausage with corn starch) had significantly ($p<0.05$) higher protein than T2 (Mckerel), suggesting that not all fish species have higher protein than livestock meats; thus quality of protein in processed meat depends on the content used. Although high protein contents were shown in Catfish (T3), the protein contents for the two fishes were within the normal range of values of protein in fish (15-25%) (Huss, 1995)[13]. The differences in protein contents of the fish sausages could be due to differences in species, feed availability, sexual maturity, spawning and season of catching (Oduor-Odote and Kazungu, 2008)[17]. The presence of high levels of ash in T2 and T3 indicates that the total inorganic mineral contents in fish frankfurter are high probably due to the ability of fish to absorb certain trace elements from surrounding water (Tacon, 1992)[25]. The results obtained for ash contents are however within the ranges recorded by Burgaard and Jorgensen (2011)[3].

Other studies (Tozer, 2001)[27] have reported ash values in the range of 1.05 - 1.29 %, which are lower than ranges found in this study (3.7- 5.92 %). The proximate composition of fish is species specific (Shearer, 1994), so it is logic to see differences between the examined fish sausages. However all values were within the normal ranges of proximate composition (water 66-84%, protein 15-25 % and fat 0.1 -24 %) (Huss, 1995)[13].

The amount of carbohydrate in fish muscle is generally small to be of any significance in any balanced diet (FAO, 1985)[7]. Fish is usually less than 1% but 2-5% can be obtained in fatty species and striated muscle where carbohydrate occurs as glycogen and as part of the chemical constituents of nucleotides (FAO, 2013)[10]. Carbohydrate was added to T2, T3 and T4 in the form of corn flour. Treatment T3 recorded significantly higher ($p<0.05$) carbohydrate (3.51 %) followed by T4 (2.51%), T2 (2.24%) and T1 (1.89%). Meat muscle normally contains only traces of carbohydrates, in the form of sugars, sugar phosphates and glycogen (Wilson, 2002)[29].

The chemical content can be a source of free ribose after post mortem autolytic changes (FAO, 2013)[10]. Therefore the high carbohydrate reported in this experiment could be due partially to the 1.2% corn flour added to treatments T2, T3 and T4. However T1 which had no corn flour added during product formulation recorded 1.18% carbohydrate.

Microbial Counts and Isolation of E. coli.

Tables 2.0, 2.1 and 2.2, show Total Viable Count (TVC) in raw minced meats, raw sausage batters and cooked frankfurters, respectively. The TVCs in all the analysis were within accepted limits (pork= 10^7 and fish= 10^6 cfu/g) as recommended by ICMSF (2002)[15]. Though the TVCs observed were within accepted limits, raw minced pork recorded higher counts numerically (2.5×10^5 cfu/g) than Mackerel (1.9×10^5 cfu/g) and Catfish (1.8×10^5 cfu/g). The low TVC in minced catfish and Mackerel could be as a result of high ash contents (Table 4.2). Tacon (1992)[25] reported that high mineral contents can sometimes retard the growth of certain microorganisms.

TVCs obtained after chopping minced meats into batter (Table 2.1) were also within accepted limits by ICMSF (2002)[15].

The observed TVCs values ranged from 4.4×10^4 cfu/g (T3) to 2.5×10^5 cfu/g (T1). There was a one log reduction in TVCs of minced Mackerel and Catfish after batter production.

Also the addition of non- meat ingredients (spice mix, water, phosphate, corn starch) may have reduced microbial population in raw fish batter. Sachindra et al. (2005)[22] reported that micro- organisms could gain access into sausage from meat, spices, and other ingredients, from environment, equipment, and handlers during processing. Thus the observed one log reduction in TVCs of the fish based batter is not in conformity to the assertion by Sachindra et al. (2005)[22]. However processing minced pork to obtain raw pork batter (T1 and T4) (Table 3.0) did not change the microbial counts (T1 and T4).

Table 2.2 is the TVC for frankfurters during frozen storage. The observed counts were all within acceptable limits; since 10^6cfu/g is the maximum permissible level for aerobic plate counts in meat products ICMFS (2002). Thus, all the frankfurters analysed over the six weeks of frozen storage can be classified as acceptable for human consumption. E. coli were not detected in this study at all stages of sampling (Table 2.3 to Table 2.5). In fact, no growth was observed during week five and six of frozen storage. This could be attributed to the fact that, the production process of cooked meats in this study was not compromised in any way. De Roever (1998)[6] indicated that, the presence of E. coli in food is an indicator of cross-contamination.

Tacon, (1992)[25] reported of presence of E. coli in pork sausages. Several authors found that E. coli O157:H7 was associated with derived retail meat products (Chinen et al., 2001; Chapman et al., 2001)[5,4]. Of the 1750 ground pork and fish samples analyzed, 20 (1.1%) were positive for E. coli O157 (Samadpour et al., 2006)[23].

The use of curing salt (containing nitrite) in the formulation of the frankfurter could also have contributed to eliminating pathogenic organisms in the products during storage because nitrite is effective as antimicrobial addictive in meat systems.

The spices used in this experiment had no E. coli presence. It has been suggested that several factors (environmental factors) may contribute to the presence of pathogens, including poor handling, poor hygiene practices, cross-contamination from food handlers and storage conditions (Chinen et al., 2001)[5]. This indicates that sufficient hygienic measures for microbial control were put in place during the manufacturing process of the study.

Conclusions and Recommendations

Catfish frankfurter was higher in protein compared to mackerel and pork sausages. Lower fat contents were also recorded in Catfish sausages.

Microbes were present in both fish and pork sausages but lesser Total Viable Counts (TVC) were recorded as frozen storage weeks increased. In fact TVCs recorded were all within the accepted limits as recommended by International Commission on Microbiological Specification on Food. E. coli was not detected in all raw ingredients as well as their respective frankfurter samples. This indicates that sausages were produced under good hygienic conditions and proper handling practices were adhered to at all stages of processing.

It can therefore be concluded that catfish frankfurter has high crude protein, less fat, and is safe for consumption after processing into sausage and frozen stored for six weeks.

It is recommended that, further work could be

Table 1.0 Proximate composition(%) of sausage used (As - Is)

Source	Moisture	Protein	Fat	Carbohydrate	Ash
Frankfurter- type					
T1	60.02^{b}	14.26^{b}	19.27^{b}	1.89^{c}	4.37^{b}
T2	55.98^{c}	13.29^{c}	23.30^{a}	2.24^{bc}	5.56^{a}
T3	64.87^{a}	15.69^{a}	10.66^{c}	3.21^{a}	5.92^{a}
T4	60.95^{b}	14.64^{b}	18.69^{b}	2.51^{b}	3.57^{c}
F.pr.	<.0001	0.0005	<.0001	0.0022	<.0001

Superscript ^{abcd} across rows are significantly different ($p<0.05$)

T1= pork frankfurter without corn starch, T2= mackerel frankfurter, T3 = catfish frankfurter and T4 = pork frankfurter with corn starch

Table 2.0 Total Viable Counts (TVCs) for raw minced meat

Type of minced meat	TVC cfu/g	Recommended TVC (cfu/g) (ICMSF, 2002)[15]
Pork	2.5×10^{5}	10^{7}
Mackerel	1.9×10^{5}	10^{6}
Catfish	1.8×10^{5}	10^{6}

Table 2.1 Total Viable Counts (TVCs) for raw sausage batter

Type of frankfurter	TVC cfu/g	Recommended TVC (cfu/g) (2002)
T1	2.5×10^{5}	10^{7}
T2	9.9×10^{4}	10^{6}
T3	4.4×10^{4}	10^{6}
T4	1.1×10^{5}	10^{7}

T1= Pork frankfurter without corn starch, T2= Mackerel frankfurter, T3 = Catfish frankfurter and
T4 = pork frankfurter with corn starch

Table 2.2 Total Viable Count (TVCs) of sausages during frozen storage

Storage (week)	Type of frankfurter TVCs (cfu/g)				Recommended TVC (cfu/g) (ICMSF 2002)[15]			
	T1	**T2**	**T3**	**T4**	**T1**	**T2**	**T3**	**T4**
1	1.7×10^5	1.9×10^5	7.1×10^4	1.2×10^5	10^6	10^5	10^5	10^6
2	7.6×10^4	2.3×10^4	9.0×10^4	6.0×10^3	10^6	10^5	10^5	10^6
3	5.0×10^3	2.0×10^3	2.2×10^4	7.3×10^3	10^6	10^5	10^5	10^6
4	2.7×10^4	3.7×10^4	8.0×10^3	7.0×10^2	10^6	10^5	10^5	10^6
5	8.4×10^4	1.3×10^5	4.4×10^4	9.3×10^4	10^6	10^5	10^5	10^6
6	9.0×10^4	1.3×10^5	3.0×10^5	2.6×10^4	10^6	10^5	10^5	10^6

Table 2.3 Isolation of organism (*E. coli)* in raw minced meat

Minced meat	*E. coli*
Pork	Not detected
Mackerel	Not detected
Catfish	Not detected

Table 2.4 Isolation of organism (E. coli) in raw sausage batter

Type of sausage batter	*E. coli*
T1	Not detected
T2	Not detected
T3	Not detected
T4	Not detected

Table 3.0 Isolation of Organism (E. coli) in Frankfurter-type Sausage during frozen storage (1-6weeks)

	Sausage Type			
Storage week	T1	T2	T3	T4
Week 1	ND	ND	ND	ND
Week 2	ND	ND	ND	ND
Week 3	ND	ND	ND	ND
Week 4	ND	ND	ND	ND
Week 5	ND	ND	NG	NG
Week 6	NG	NG	NG	NG

*ND - Not Detected ; *NG - No Growth

done to determine amino acids and mineral compositions in catfish and mackerel sausages.

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