USING *SALMO SALAR* IN PORK BURGER PRODUCTION

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ABSTRACT
Increased nutritional and health issues among consumers has resulted in demands for fish and fish products compared to traditional animal protein sources. Minced pork and fish were allotted to three treatments: T0, T1 and T2 (control) in which minced pork was included at 0%, 50% and 100% respectively. No significant differences (p<0.05) existed in the protein, water holding capacity, fat content and percentage shrinkage of cooked burgers. The overall product acceptability was not significantly different (p>0.05) between control and 50% substitution with Salmo salar. The cost of producing burgers in this study reduced from GH¢ 17.33 (T2) to GH¢ 10.64 (T0) per kg. It was concluded that pork can be substituted with 50% Salmo salar in burgers to reduce cost of pro-

Keywords: *Salmo salar, nutritional and health issues; proximate composition, fat retention, moisture retention, sensory and consumer acceptability*

INTRODUCTION
Fish is the preferred and cheapest source of animal protein in Ghana and about 75% of total annual catch of fish in the country is consumed locally (Nunoo and Asiedu, 2013). According to FAO (2013), it is estimated that around sixty percent (60%) of developing countries depend on fish as main source of animal protein. Due to increased awareness of consumer's health issues, fish and fishery products have received more attention as potential protein resources (Shaviklo, 2008; Arason *et al.,* 2009). Nestel (2000) asserted that fish meat contains significantly lower lipids and higher water than beef or chicken, and is favoured over other white or red meats.

The nutritional value of fish, like other meat types comprises of moisture, protein, vitamins, minerals and calories (Steffens, 2006). According to USDA (2003) and Ocaño-Higuera *et al.* (2011), fish has higher essential amino acids compared to beef, as well as adequate dietary levels of long chain polyunsaturated fatty acids, including eicosapentaenoic and docosahexaenoic acids, which are good for the human body. The rapid increases in the world's population and limited supply of available food resources as well as shortages in protein intake requires urgent measures to fully utilize all fish resources (Olatunde *et al*., 2012). One approach proposed by Oduor-Odote and Kazungu (2008) is to reduce the loss that occurs in the postharvest sector and add value to raw fish in order to accelerate the growth of the fish industry worldwide. Value addition means additional activity or processes that alter the nature of a product from its natural form and thus, adding to its value at the time of sale (Oduor–Odote and Kazungu, 2008), as well as offering variety of protein sources for consumers (Kondaiah, 2004). The traditional sources of meat ingredients utilized in value added product such as loaves, burgers, hams and sausages have mostly been solely beef, mutton and pork, or a combination of these in different proportions to improve taste and nutritional value. Vicenten and Torres (2007) reported that other sources than these could be used for the production of burgers since red meat contain high levels of cholesterol. Some examples of fish used in burger production include tuna, tilapia, pangus, trout and sockeye. The demand for ready-to-eat products is gradually growing because of their convenience (Yerlikaya *et al*., 2005). According to Tokur *et al*. (2004) burgers prepared from beef or chicken are the most popular at several food service joints, though most health-conscious consumers would prefer other alternatives. It is therefore essential to make better use of fish by converting it to other forms of food such as fish burger in order to satisfy these group of consumers. FAO (2016) reported *Salmo salar* is a rich source of easily digested, high quality proteins containing all essential amino acids. The objective of this study was to determine the suitability or otherwise of *Salmo salar* in replacing portions of pork in burgers.

MATERIALS AND METHODS

Experimental location and raw materials used

The experiment was conducted at the Department of Animal Science, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi. Pork leg was obtained from the Kumasi Abattoir Company Limited. Frozen *Salmo salar* and other ingredients were obtained from the Kumasi Central Market, and transported on ice to the Laboratory and stored at 2°C for processing the next day.

Preparation of burgers

The fish was weighed individually and beheaded, eviscerated, under running tap water to remove all unwanted materials, after which it was filleted. The pork leg was also deboned and trimmed of any visible fat. Boneless pork and filleted fish were minced separately using a table -top meat grinder (MADO® Superwolf, Germany) through a 15.00 mm grinding sieve. Minced pork and fish were allotted to three treatments namely, T0, T1 and T2 (Control) in which *Salmo salar* (SS) was included at 100%, 50% and 0% respectively. All other ingredients used were the same for each treatment and each was repeated three times, labelled appropriately and kept frozen at -18°C for further analysis the following day. Ingredients used for formulating the respective treatments are shown in Table 1.

Table 1: Ingredients used in burger formulation with and without *Salmo salar*

	Treatment		
Ingredient (kg)	**T0**	**T1**	**T2**
Fish	2.00	1.00	0.00
Pork	0.00	1.00	2.00
Salt	0.02	0.02	0.02
Mixed spices*	0.04	0.04	0.04
Total	2.06	2.06	2.06

**Mixed species consisted of the following in g/kg; powdered garlic (12), chilli pepper (8), black pepper (8) and ginger*

Parameters measured

Cooking loss, pH, Water Holding Capacity (WHC) and Shrinkage in diameter

Cooking loss (%) was calculated as described by AOAC (2010) after pan frying in vegetable oil at 110ºC for 4 min.

Acidity (pH) was determined using approximately 5 g of mashed samples of each treatment homogenised thoroughly with 10 ml distilled water. The mixtures obtained were allowed to stand for 15 minutes after which a pH meter (pH -037, China) was used to read the pH. The procedure was repeated three times for each treatment. Water Holding Capacity was determined using the procedure described by Lin and Huang (2003).

Percentage shrinkage in cooked burgers was calculated as described by AOAC (2010).

Proximate composition, fat and moisture retentions

Samples were taken from each treatment and triplicates were made for protein, ash, fat and moisture determinations according to the methods described by AOAC (2010). Moisture and fat retentions were calculated using the equations by El-Magoli *et al*. (1996).

Sensory attributes

Thirty (30) untrained consumer panellists made up of students and teaching assistants of the Department of Animal Science evaluated the sensory attributes of cooked burgers. The sensory evaluations were based on appearance, taste, tenderness, flavour, juiciness, texture, mouthfeel and acceptability using a 9-point hedonic scale. Water was provided to each panellist to rinse the mouth between burger evaluations. Each treatment was coded with a 3-digit random number to ensure fairness among panel-member evaluations.

Statistical analysis

All data generated from the study were analysed using SPSS version 20.0 for windows. Analysis of variance (ANOVA) was used in a Completely Randomized Design (CRD) and significant differences between treatment means were obtained using Duncan's test of homogeneity at 5%.

RESULTS AND DISCUSSION

The results obtained for cooking loss, pH (raw), water holding capacity (cooked) and shrinkage of cooked burgers produced with and without *Salmo salar* are shown in Table 2. Cooking loss reduced in *Salmo salar* treatments, and the control treatment (T2) without *Salmo salar* recorded significantly higher ($p<0.05$) losses. Percentage cooking loss ranged from 21.99% (T1) to 30.93% (T2). Differences in cooking loss of burgers had negative economic implications as well as eating quality. This is so because the weight lost results from draining of fat and moisture components in the burger during cooking. Both fat and moisture are important determinants of quality eating characteristics (Lonergan and Lonergan, 2005). The pH of the raw products ranged from 5.82 (T2) to 5.84 (T1), and there were significant differences ($p<0.05$) among treatments. The pH recorded seemed to have some positive effects on WHC because as the pH increased, WHC of the products also increased significantly ($p<0.05$). This observation agrees with Nott *et al*. (1999) who proposed that pH is commonly known to be one of the most important factors to affect WHC of a food product. It was evident from the results that increased pH caused a significant ($p<0.05$) increase in WHC and a corresponding reduction in cooking loss of burgers. The observed values of WHC ranged between 37.50% (T2) and 39.76% (T1). Shrinkage reduced significantly ($p<0.05$) in the burgers containing *Salmo salar* compared to those without. The observed differences in shrinkage were due to the fact that 100% *Salmo salar* burgers had significantly ($p<0.05$) lower cooking losses compared to the control treatments. Percentage shrinkage in burgers ranged from 12.92% (T0) to 19.28% (T1) after cooking.

Table 3 shows results for nutrient composition, as well as fat and moisture retentions of cooked burgers produced with and without *Salmo salar*. Percentage protein contents were significantly different ($p<0.05$) among treatments; ranging from 21.51% (T0) to 17.33% (T2). The observed differences were attributed to higher protein contents of fish than pork (Fakagawu, 2014). Burgers showed significantly ($p<0.05$) lower moisture contents in T0 but these increased significantly ($p<0.05$) when 50% pork was replaced with *Salmo salar*. Lawrie and Ledward (2006) reported that a decrease in protein content in meat and meat products might be due to higher moisture, which is evident in this study. Fat contents were significantly ($p<0.05$) higher in T0 (100% *Salmo salar*) but reduced significantly (*p<0.05*) in T1 when pork was partially substituted with 50% *Salmo salar*. The higher fat contents in treatments with 100% *Salmo salar* (T0) may lead to reduced shelf-life resulting from potentially increased rate of rancidity due to auto-oxidation of fatty acids present. The ash contents of all treatments were significantly (*p<0.05*) different. Treatment T2 (100% pork) was significantly higher (*p<0.05*) in ash compared to treatments T0 (100% *Salmo salar*) but this reduced significantly (*p<0.05*) when 50% pork and 50% *Salmo salar* were used in burger production (T1). There were however no significant differences (*p>0.05*) between T0 (66.44%) and T2 (67.71%) in terms of fat retention, but both T0 and T2 were significantly higher than T1 (57.52%). Similarly, no significant differences (*p>0.05*) existed between T0 (63.44%) and T2 (63.23%), but both T0 and T2 were significantly (*p<0.05*) higher compared to T1 (56.12%) in terms of moisture retention ability. Retaining moisture after cooking meat is considered an important product characteristic which positively influences juiciness and consumer acceptability (Lonergan and Lonergan, 2005). The higher the amount of fat retained, the more likely a burger would be presumed to be juicy and tastier, since fat is considered a carrier of taste (Lawrie and Ledward, 2006).

The responses of consumer panels during sensory evaluation of burgers produced with and without *Salmo salar* are reported in Table 4. Panellists recorded quite high values, ranging from 5.70 to 7.73 for all the sensory parameters tested. It could be deduced that most of the taste panelists generally preferred pork burger to fish

Table 2: Cooking loss, pH, Water holding capacity and Shrinkage

Parameter	Burger type			*p*-value	SEM
	T0	T1	T2		
Cooking loss (%)	24.39^{a}	21.99^{a}	30.93^{b}	0.080	2.671
pH (raw	5.95^{b}	5.84^{a}	5.82^{a}	0.170	0.040
WHC (cooked) (%)	39.02^{b}	39.06^{b}	37.50^{a}	<0.000	0.513
Shrinkage (%)	12.92^{a}	17.30^{b}	19.28^{c}	<0.001	1.879

^{abc}Means in the same row with different superscripts are significantly different (p<0.05). T0= Fish burger, T1= 50% fish + 50% pork burger, T2= pork burger. WHC= % water holding capacity.

Table 3: Nutritional composition, fat and moisture retentions of burgers with or without Salmo salar

Parameter (% as-is)	Type of burger T0	T1	T2	*p-value*	SEM
Protein	21.51^{c}	17.33^{a}	19.64^{b}	<0.001	1.209
Moisture	48.02^{a}	56.25^{c}	53.25^{b}	<0.001	2.204
Fat	17.54^{c}	13.88^{a}	14.26^{b}	<0.001	1.162
Ash	2.75^{b}	2.50^{a}	3.50^{c}	<0.001	0.300
Fat retention	66.44^{b}	57.52^{a}	67.71^{b}	0.03	3.206
Moisture retention	63.44^{b}	56.12^{a}	63.25^{b}	0.02	2.409

^{abc}Means in the same row with common superscripts are not significantly different (p<0.05). T0= Fish burger, T1= 50% fish + 50% pork burger, T2= pork burger.

burger. According to Lawrie and Ledward (2006) high pH improves juiciness of products. FAO (2007) further stated that pH is important for the taste and flavour of meats. Relating the pH (Table 2) to the juiciness, flavour and taste of burgers in this research, it was observed that the result supports Lawrie and Ledward (2006) and there were no significant differences ($p>0.05$) between T0 and T2 in terms of aftertaste, tenderness, flavour, juiciness and texture.

Moreover, appearance, mouthfeel and overall acceptability of T0 (fish burger) were significantly lower ($p<0.05$) than T2 (100% pork burger), but T2 was not different significantly ($p>0.05$) from T1 with regards to these attributes. The taste panellists detected no significant differences ($p>0.05$) between Treatment T1 and Treatment T2 in all sensory attributes. The costs of producing burgers reduced from GH¢17.33 (T2) to GH¢10.64 (T0) per kg (Table 4). This reduction indicates that a processor could potentially save some money in the cost of producing *Salmo salar* burgers compared to pork burgers and possibly accrue more profits. Also, the reduction in cost of producing burgers by using *Salmo salar* may lead to a reduction in the current market/retail price of normal burgers on the market. All things being equal, a reduced price of burger may encourage or motivate all categories of consumer-income brackets to buy and consume more burgers and possibly result in reduction in protein deficiency problems in poorer communities (Akwetey and Knipe, 2012).

CONCLUSIONS AND RECOMMENDATIONS

Burgers produced solely with *Salmo salar* were higher in percentage crude protein and fat compared to pork burgers, and higher cooking losses were observed in all-pork burgers. Partially replacing pork with *Salmo salar* resulted in improved appearance, mouthfeel and acceptability of burgers. Consumer panellist seemed to prefer pork to all-fish burgers, however, the sensory qualities of the burgers produced with pork alone and those containing 50% *Salmo salar* and 50% pork were similar. More so, the cost/kg of producing burgers reduced appreciably with the use of *Salmo salar,* and burgers containing

Table 4: Sensory attributes and costs of producing burgers

Attribute	Type of Burger			SEM	*p-value*
	T0	T1	T2		
Appearance	5.70^{a}	6.53^{b}	7.03^{b}	0.387	0.01
Aftertaste	6.77	7.10	7.43	0.190	0.33
Tenderness	6.67	6.97	7.00	0.105	0.54
Flavour	6.77	7.00	7.33	0.163	0.41
Juiciness	6.83	7.00	7.23	0.115	0.50
Texture	6.60	6.70	7.10	0.153	0.35
Mouth feel	6.37^{a}	6.70^{b}	7.30^{b}	0.272	0.04
Acceptability	6.33^{a}	7.17^{b}	7.73^{b}	0.406	0.01
Cost (GH¢/kg)	10.64	13.98	17.33	-	-

^{abc}Means in the same row with common superscripts are not significantly different ($p<0.05$). Sensory scale: 1=Dislike extremely to 9= like extremely

Salmo salar shrank less during cooking compared to all-pork burgers. *Salmo salar* could be used as substitute to pork at 50% in burger production without any negative effects on nutritional quality and eating characteristics. It is recommended that further work should be done to improve flavour, taste, mouthfeel, appearance, juiciness and texture of burgers produced with 100% *Salmo salar*.

REFERENCES

Akwetey, W.Y. and Knipe C.L (2012). Sensory attributes and texture profile of beef burgers with gari. *Meat Science*, 92 (4): 745–748.

Arason, A., Karlsdottir, M., Valsdottir, T., Slizyte, R., Rustard, T., Falch, E., Eysturskard, J. and Jakobsen, G. (2009). Maximum resource utilization – value added fish by-products. Nordic Innovation Centre, Project Number: 04275, Reykjavik, 35-46.

Association of Official Analytical Chemist (AOAC) (2000). Official Methods of Analysis. 15th Edition. Washington DC.

El-Magoli, S.B., Laroia, S. and Hansen, P.T.M. (1996). Flavour and Texture Characteristics of Low Fat Ground Beef Patties Formulated with Whey Protein Concentrate. *Meat Science,* 4(2): 179-193.

Fakagawu, N.K. (2014). Protein requirements: methodological controversy amid a call for change. *American Journal of Clinical Nutrition,* 99(4):761-762.

Food and Agriculture Organization (FAO). (2007). Meat Processing for Small to Medium Scale Producers, Bangkok.

Food and Agriculture organization (FAO). (2013). Report on dietary protein quality in human nutrition. *British Nutrition Foundation Nutrition Bulletin*, 38: 421-428.

Food and Agriculture Organization (FAO). (2016). The State of World Fisheries and Aquaculture. Contributing to food security and nutrition for all. www.fao.org/3/a-i5798e.pdf. Accessed 10/04/2017.

Kondaiah, N. (2004). Value Added Meat Products and Development of Processed Meat Sector. *Natural Product Radiance*, 3(4): 281-283.

Lawrie, R.A. and Ledward, D.A. (2006). Lawrie's Meat Science, Seventh Edition, Woodhead Publishing in Food Science, Technology and Nutrition, Cambridge.

Lin, K.W and Huang, H.Y. (2003). Konjac/ Gellan Gum Mixed Gels Improve the Quality of Reduced-Fat Frankfurters. *Meat Science*, 65: 749-755.

Lonergan., H.E. and Lonergan, S.M. (2005). Mechanisms of Water-Holding Capacity of Meat: The Role of Post Mortem Biochemical and Structural Changes. Elsevier Ltd. *Meat Science,* 71: 194-204.

Nestel, P.J.N. (2000). Fish Oil and Cardiovascular Disease: Lipids and Arterial Function. *American Journal of Clinical Nutrition,* 71: 228-231. https://pubmed.ncbi.nlm.nih. gov/ 10617976.

Nott, K.P., Evans, S.D. and Hall, L.D. (1999). Quantitative Magnetic Resonance Imaging of Fresh and Frozen-Thawed Trout. *Magnetic Resonance Imagine,* 17(3): 445-455. www.sciepub.com/reference/236396.

Nunoo, F.K.E. and Asiedu, B. (2013). An Investigation of Fish Catch Data and Its Implications for Management of Small-scale Fisheries of Ghana. *International Journal of Fisheries and Aquatic Sciences* 2(3): 46-57.

Ocaño-Higuera, V.M., Maeda-Martinez, A.N. Marquez-Rios, E. Canizales-Rodriguez, D.F., Castillo-Yanez, F.J., Ruiz-Bustos, E., Graciano-Verdugo, A.Z. and Plascencia-Jatomea, M. (2011). Freshness assessment of ray fish stored in ice by biochemical, chemical and physical methods. *Food Chemistry*, 125(1): 49-54.

Oduor-Odote, P.M. and Kazungu, J.M. (2008). The Body Composition of Low Value Fish and their Preparation into a Higher Value Snack food. *Western Indian Ocean Journal* *of Marine Science,* 7(1): 111-117.

Olatunde, K.A., Bamgbose, O., Arowolo, T.A., George, F.O.A and Bada, B.S. (2012). Effect of Processing and Storage on the Trace Metal Concentration and Freshness Quality of Catfish (Clarias gariepinus). *Food Science and Quality Management,* 9: 1-7.

Shaviklo, G.R. (2008). Fish Protein Isolate: A New Source of Protein Ingredient. *Info Fish International*, 4: 45-48.

Steffens, W. (2006). Freshwater Fish-Wholesome Foodstuffs. *Bulgarian Journal of Agricultural Science,* 12(2): 320-328.

Tokur, B., Polat, A., Beklevik, G. and Ozkutuk, S. (2004). Changes on The Quality of Fish Burger Produced from Tilapia (*Oreochromis Niloticus*) During Frozen Storage. *European Food Research and Technology*, 218: 420-423. doi: 10.1007/s00217-004-0879-4.

United States Department of Agriculture, (USDA) (2003). National Nutrient Database. Available at: www.nal.usda.gov/fnic/foodcomp/search/.

Vincente, S.J.V. and Torres, E.A.F.S. (2007). Formation of four cholesterol oxidation products and loss of free lipids, cholesterol and water in beef hamburgers as a function of thermal processing. *Food Control,* 18: 63-68.

Yerlikaya, P., Nahan, G., and Harun, U. (2005). Quality Changes of Fish Patties Produced from Anchovy During Refrigerated Storage. *European Food Research and Technology,* 220: 287-291.