Comparative Analysis of the Energy and Nutrient Composition of Cooked and Uncooked Cow Intestines Consumed in Accra, Ghana

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ABSTRACT

***Background:** : The cow intestine is a delicacy cherished and eaten by many persons in West Africa, but there is a paucity of data on its nutrient composition.*

***Objective:** To compare and analyze the energy and nutrient (proximate, mineral [iron, phosphorus, copper, and zinc] and free fatty acid (FFA) [as oleic]) composition of cooked and uncooked cow intestines commonly consumed in Accra, Ghana.*

***Methods:** Samples of cow intestines were obtained from the markets by purposive sampling and subsequently processed for analysis. The nutrient composition was determined using standard methods. Statistical analysis was conducted using the independent sample t-test in IBM SPSS Statistics version 22 to compare the data obtained from the uncooked and cooked samples. A significance level of $P < 0.05$ was used to determine statistical significance.*

***Results:** Comparisons between the two samples showed that the moisture reduced significantly ($p=0.001$) after cooking and carbohydrate content in the uncooked sample was 6.13g/100g but disappeared after cooking ($p=0.000$). The ash content was significantly lower ($p=0.002$) in the uncooked sample (0.46 g/100g) than in the cooked sample (0.6 g/100g). However, the energy, fat, and protein content were significantly higher ($p<0.05$) in the cooked cow intestine than in the uncooked cow intestines. There was no significant difference in the concentration of FFA (as oleic) content of cooked cow intestines and uncooked cow intestines ($p=0.8093$). The zinc, copper, and iron concentrations reduced significantly ($p<0.05$) after cooking while the phosphorus content increased significantly ($p=0.000$) by 105.15% after cooking.*

***Conclusion**: The study provided data on some minerals, proximate, and FFA (as oleic) composition of uncooked and cooked cow intestines. Findings showed that cow intestines have a substantial nutrient composition that can make a significant contribution to nutrient intakes in the diet of individuals.*

Keyword: *cow intestines; minerals; proximate; oleic acid*

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INTRODUCTION

The increase in the human population as well as opulence in many countries has resulted in an increased demand for meat and meat products (1-2). Slaughtered animals such as cows provide many edible products besides the carcass meat (beef) that humans normally consume. Such products including offals (examples: intestine, tripe, liver, kidney, and tongue), cowhide, cow head, and cow foot, are an important part of the human diet in many homes in West Africa. Cow intestine for instance is often cheaper than regular meat (beef). It is thus a well-patronized delicacy for the preparation of pepper soup, light soup, vegetable soup, yam pepper soup, tomato stew, and a variety of other soups and sauces consumed in the region.

Meat and meat products are rich sources of micronutrients and trace elements (2-4), such as niacin, vitamin B_6 and B_{12}, zinc, phosphorus, and iron. This is important in view of the fact that deficiency of these micronutrients persists in many populations globally. According to one estimate, more than 2 billion people in the world are deficient in key vitamins and minerals, particularly vitamin A, iron, and zinc (5-6). In developing countries, the major cause of micronutrient deficiency is low content in the diet (7,8) and it is not uncommon for individuals to suffer deficiency in more than one micronutrient (5,6).

In spite of the popularity of meat offal in many West African cuisines, food composition tables in the region have little or no information on the micronutrient (iron, zinc, copper, and phosphorus), the proximate and free fatty acid composition of cow intestine. This paucity of information leaves room for several misconceptions. For example, anecdotal reports from dieticians indicate that cow intestines and offals are patronized by consumers as a low-fat alternative to meat. On the other hand, the contribution of animal products to saturated fatty acid intake is often overrated because of inaccurate food composition data and because losses that occur during cooking, as well as trimming before eating, are not usually considered (4). Accurate nutrient analysis for proper documentation and updating of food composition data (8) can effectively address these inconsistencies. Therefore, in this study, comparative evaluation of the energy, mineral, proximate, and free fatty acid (as oleic) composition of uncooked and cooked cow intestines were determined.

Materials and Methods

The study employed an experimental laboratory design. Samples were obtained from two markets namely Makola and Agbogbloshie within the Ashiedu Keteke Sub Metro Area of Accra. These markets were purposively selected because they are the major markets where cow intestines can be obtained in large quantities (9). The samples were processed and analyzed in the chemistry laboratory of the Council for Scientific and Industrial Research (CSIR) – Food Research Institute of Ghana.

Procurement of the sample

Vendors were selected by purposive sampling because they were scattered at different locations throughout the markets. A total of 0.5 kg each of cow intestines was purchased at four different points of sale making it 2 kg. Altogether, sixteen samples were purchased.

Sample preparation

Samples from both markets were divided into two equal parts: one was analyzed as the uncooked sample while the other was cooked before analysis. The meat products were cooked by boiling separately inside an aluminum sauce pan on a Gerhadt electric burner (Gerhadt Bonn, App No, SN: 01191159). Water (500 ml) was added to the cow intestine and allowed to boil for 30 minutes. Cooked and uncooked samples were ground and homogenized separately with an industrial food blender (Panasonic, MX-AC300, Mixer Grinder) to ensure a uniform mixture of the different samples. Laboratory samples were collected from the homogenized mixture, vacuum packed, and frozen at $\leq -18\ ^{0}C$ until analysis. The homogenized samples were subjected to chemical analysis using the standard assay. Each analysis

was carried out in triplicate; however, the two most similar results were used to determine the mean.

Proximate Analysis

Moisture content of the homogenized samples was determined using the AOAC (Association of Official Analytical Chemists) procedure for the hot air oven method (10). The method involves drying the food sample under controlled pressure and temperature until constant weight is obtained. Moisture content is required to express the nutrient content per dry weight basis (11). Protein content was determined using the automated Micro-Kjeldahl method (10). The method is based on the digestion of proteins and other organic food components in the sample with sulphuric acid in the presence of a catalyst e.g. sodium or potassium sulphate to release nitrogen from protein and retain it as an ammonium salt. Ammonia gas is liberated upon the addition of excess alkali (concentrated sodium hydroxide) and distilled into a boric acid solution to form an ammonium-borate complex. The ammonia liberated from the complex is titrated with standardized hydrochloric acid. The amount of nitrogen in the sample is determined from the milligram equivalent of the acid used. Crude protein is determined by multiplying the nitrogen content with a conversion factor (6.25) which is specific to the food matrix (meat) (11). The fat content of the samples was determined using Soxhlet extraction method (10). In this method, the sample is hydrolysed by hydrochloric acid at 70-80^{0}C. Protein, if any, can be dissolved in the acid, and crude fat is then manually extracted by diethyl and petroleum ether. The solvent is removed by evaporation and the oil residue is dried and weighed (11). Ash was determined according to AOAC dry ashing methods (11). This method involves the separation of minerals from the food matrix by the destruction of the organic matter of the sample through dry ashing (11). Carbohydrates were determined by difference (12).

Energy Content Determination

Energy was determined by the "Atwater factor". The energy value of the samples was calculated by multiplying the values for fat, carbohydrate, and protein with 9:4:4 the "Atwater factors," respectively (13).

Determination of Mineral Content

Mineral contents of the samples were determined by Atomic Absorption Spectrophotometer (AAS). After wet digestion of the samples, zinc, copper, and iron content, were quantitatively measured by atomic absorption spectrophotometer (AAS) (11) at specific wavelengths (Zn (213.9), Cu (324.7) and Fe (248.3)) (11,14-15). Phosphorus was determined as phosphates (PO_4) in food products using spectrophotometric method (11). Phosphorus, as phosphate; in the test solution was made complex with molybdovanadate reagent (analar grade). The yellow colour formed was directly related to the amount of phosphorus in the sample and the absorbance measured by UV-VIS spectrophotometer (Cecil CE7400/7000 series) (11).

Free fatty acid as oleic acid content determination

Free fatty acid as oleic acid was determined by the ISO 660 (1996-05-05) method which involves the determination of acid value of the fat (14).

Data Analysis

Data obtained from chemical analyses were analysed using the IBM SPSS Statistics version 22. Results were summarized as means and standard deviations. The percentage difference between samples in the nutrient composition after cooking of the samples were calculated. Data from the uncooked and cooked samples were compared using the independent sample t–test. A significant difference was established at $p<0.05$.

RESULTS

Proximate and free fatty acid (oleic) composition of cow intestines

The proximate and free fatty acid (FFA) (as oleic) composition of an uncooked and cooked sample of cow intestines is shown in Table 1. The moisture content of the uncooked sample was 74.53±0.19 g/100g.and that of the cooked sample was 61.63±0.06 g/100g. The percentage difference was 17.31%. Comparisons between the two

samples showed that the moisture reduced significantly (p=0.001) after cooking and carbohydrate content in the uncooked sample was 6.13 g/100g but disappeared after cooking (p=0.000). The ash content was significantly lower (p = 0.002) in the uncooked sample (0.46 g/100g) than in the cooked sample (0.6 g/100g). However, the energy, fat, and protein content were significantly higher (p < 0.05) in the cooked cow intestine than in the uncooked cow intestines. There was no significant difference in the concentration of FFA (as oleic) content of cooked cow intestines and uncooked cow intestines (p = 0.8093).

Table 1: Proximate and free fatty acid (oleic) composition of cow intestines

Parameter	Uncooked	Cooked	P-Value	%Difference After Cooking
Moisture g/100g	74.53±0.19^{a}	61.63±0.06^{b}	0.0001	-17.31
Energy kcal/100g	145.80±0.86^{b}	265.10±0.95^{a}	0.0001	81.82
Ash g/100g	0.46±0.01^{b}	0.60±0.01^{a}	0.0022	30.43
Fat g/100g	9.16±0.13^{b}	18.16±0.02^{a}	0.0001	98.25
Protein g/100g	9.44±0.04^{b}	25.44±0.19^{a}	0.0001	169.49
Carbohydrates g/100g	6.13±0.16^{a}	0.00±0.00^{b}	0.0003	-100.00
FFA (As Oleic) g/100g	3.14±0.48^{ba}	3.24±0.18^{ab}	0.8093	3.18

Means in the same row with the different superscripts (a-b) were significantly different at P < 0.05.

Table 2: Micronutrient content of cow intestine

Sample	Uncooked (mg/100g) Mean ± SD	Cooked (mg/100g) Mean ± SD	p-value	%Changes After Cooking
Zinc	1.06±0.04^{a}	0.02±0.00^{b}	0.000	-98.10
Phosphorus	43.60±0.56^{b}	89.44±1.82^{a}	0.000	105.15
Copper	1.12±0.04^{a}	0.47±0.01^{b}	0.000	-58.30
Iron	9.59±0.33^{a}	1.22±0.00^{b}	0.000	-87.28

Means in the same row with the different superscripts (a-b) were significantly different at P < 0.05.

Table 2 presents the mineral content of the cow intestine. The zinc, copper, and iron concentrations reduced significantly (p<0.05) after cooking while the phosphorus content increased significantly (p=0.000) by 105.15% after cooking.

DISCUSSION

The moisture content of uncooked cow intestines (74.53 g/100 g) reported in this study is similar to a previous study report that indicated that a typical meat muscle contained about 75 g/100 g moisture (16). The high moisture content of

animal products reduces their keeping quality (17,18). Therefore, the high percentage (75%) observed in the cow intestines makes them more prone to spoilage due to microbial activities. However, after cooking, the moisture in the cow intestines was reduced to 61.63%. This reduction observed after cooking may be attributed to the coagulation of protein and the leaching of moisture into the broth when heat was applied (19). Further, the change may also be linked to other important factors like duration and method of cooking, temperature, size of the sample, and heat penetration (13,17, 19). The reduction in moisture content during cooking is expected to result in an increase in the concentration of other nutrients in the cooked cow intestine sample.

The Ash content of cow intestines which was approximately 0.5 g/100 g in the uncooked sample and 0.6 g/100 g in the cooked sample as expected was lower than the 1 g/100 g reported by a study in Zurich on the composition of a typical meat muscle (4). This study reported muscle instead of the intestine, thus indicating that there is more mineral in muscles than in the cow intestine. However, The Ghana food composition table updated in 1975 reported a lower figure (0.2 g/100 g) for cow intestines (20). These differences may be attributable to the type of feed or pasture of animals as this that can influence the level of specific minerals which in turn affects total ash content (17). Thus, when pasture/feed is deficient in minerals, particularly phosphorus, and cobalt, the amounts in the muscle are reduced (17).

The content of fat in uncooked intestines was 9 g/100 g which was observed to be higher than what was reported by Gerber (4) in beef. Gerber's report found that, the nutrient composition of a typical muscle of meat contained about 3 g/100 g fat (4). Several factors may affect the level of fat in a meat sample. Cooking further resulted in a higher fat content (18.16 g/100g) in cow intestines. This was expected because the moisture loss increased other proximate components of the cow intestine. Several authors have reported varying results in the fat composition after heat treatment of meat, although their studies did not use exactly the same samples used in the study, hence a general statement cannot be drawn from this study (21-24). It was observed in this study that, the broth obtained on cooking the meat showed that fat leached during cooking with the presence of translucent colour. Fat from meats is generally known to be more saturated fats. It will be imperative to encourage the public to discard the fatty broth rather than use it in cooking as it is usually the case. Another option is to freeze the broth so that much of the fat can easily be skimmed off before the broth is used. This is necessitated by the negative health implications of consuming saturated fat above the recommended level. Such consequences include risk of atherosclerosis, hypertension, obesity, cardiovascular diseases, cancers, and dyslipidemia (25).

Uncooked samples of cow intestines had a mean protein content of 9.44 g/100 g, and this was lower when compared to the 20% of meat muscle reported by Gerber (4). After cooking, protein content increased to 25.44 g/100g. The percentage increase of about 169% may be attributed to the decrease in the moisture content which increased the concentration of other nutrient content in the cow intestine (4, 17, 26).

In this study, uncooked cow intestines were found to contain 6.31 g/100 g of carbohydrates. However, this was lost after cooking by 100%. Several studies have shown that meat is deficient in carbohydrates (4, 20). However, it was reported that freshly slaughtered meat might contain carbohydrates in the muscle and the liver where the glycogen is mostly stored (17). Hence, immediately after rigor mortis there is almost 2.5% carbohydrate present in the form of lactic acid, glucose, and derivatives (17). However, when meat is cooked, the carbohydrate present if any is lost in the process as shown in this study.

FFA as oleic acid is derived by determining the acid value of food which is a measure of the number of fatty acids which have been liberated by hydrolysis from the glycerides due to the action of moisture, temperature, and/or lipolytic enzyme, lipase (14). Free fatty acid (FFA) that was

analysed as oleic in the uncooked sample recorded a mean concentration of 3.14 g/100g. However, after cooking there was a marginal increase in the oleic acid content. This observation goes to confirm the previous report which stated that cooking animal products increases their FFA as oleic (15). However, this percentage increase was not statistically significant (p=0.8093) in the meat sample.

In this study, the zinc content of the uncooked cow intestine had values lower than what was reported by previous researchers (26-28). The differences may be attributable to the differences in animal breeds, their feeding systems, age of slaughter of the animal and geographical locations (26). Thus, zinc content in the sample (cow intestines) was 1.06mg/100 which was within the range (0.5 mg- 4.9 mg/100) in different meat cuts (beef and veal) in other studies (26-28).It was also lower in the zinc content of beef (3.6 mg/100) reported in the West African food composition table (29) and in a study by William (30) (4.6 mg/100 g). Also, zinc content of the sample was slightly lower when compared to USDA (36) and FAO (29) value of 1.42 mg/100 g. After cooking, the zinc content of uncooked intestines reduced by 98%. This is contrary to the West African food composition table that had higher zinc content for cooked beef (29). Gerber and colleagues (26) also found a significant increase in zinc content of beef cuts after cooking. The authors attributed the increase to longer exposure in cooking utensil for beef brisket. It is possible that the zinc in the cow intestine leached into the broth during cooking. This however, indicated that it might not be the best option to throw away the broth after cooking due to the micronutrient that night have leached into it, but to freeze and remove the fat at the surface while the remaining broth is used for cooking.

Cross and Overby (31) reported that, the level of micronutrients differed significantly with respect to the type of meat and depended largely on whether the meat was cooked or uncooked. In the study, the degree of losses might be due to the cooking process pertaining to the temperature and length of time the meat was cooked and also the water-holding capacity of the intestines (moisture content). The aluminium cooking utensil was used to cook the cow intestines in this study and the resultant effect saw a reduction in the zinc composition contrary to other previous studies in which zinc content increased when cooked for a long time in stainless steel cooking utensils (26). Deficiency in zinc consumption may lead to growth retardation and increased susceptibility to infections related to weakening immunity (32-34). The recommended dietary allowance (RDA) for zinc is 8 mg/day, thus, these losses could help to cushion the effect of zinc deficiency and meet RDA (35).

Phosphorus content increased in cow intestines from 43.60 mg to 89.44 mg/100g (105%) after cooking. The results suggest that phosphorus does not readily leach out of the intestines. However, the resulting reduction of moisture level during cooking results in a concentration of phosphorus content. The phosphorus content of the uncooked sample in this study was lower than the 64mg/100g reported by both USDA (36) and FAO (29). Breeds and feeding systems used coupled with different ages at slaughter affect the nutrient compositions of meat (26) and this may account for the differences observed. The disparities regarding the uncooked and cooked intestines are due to cooking processes that affect the various minerals in different ways (26).

It was reported in this study that, the copper content of uncooked cow intestines was 1.12 mg/100g, which was shown to be higher than the range of values reported by Chan *et al*., (27) on copper content in uncooked lean cuts in beef and veal (0.055 mg to 0.190 mg/100 g). The content observed was also higher than the 0.09 mg/100 g value reported for beef by the West African food composition table (29). These discrepancies may be because of differences in breeds and feeding systems as well as differences in ages at slaughter (26). Copper is an important mineral that functions as a component of several metalloenzymes acting as oxidases to achieve the reduction of molecular oxygen (31, 36-37). Ferroxidases are also copper enzymes that are

found in plasma and the main function is for ferrous iron oxidation that is needed to achieve iron binding to transferrin (38); hence deficiency of copper may lead to anaemia with its attended complications. Hence, including this meat portion in the diet may help provide adequate contents of copper in the body and hence prevent deficiencies.

Generally, iron content (9.59 mg/100g) for the uncooked intestines in this study was more than the 1.8 mg/100 g reported by Williams (30) in beef. It was also higher than the iron content of beef (2.1 mg/100g) reported in the West African food composition table (29). After cooking, the uncooked cow intestines iron decreased by 87% (1.22 mg/100g). This finding indicated that iron may have leached during cooking in the meat samples. This finding is contrary to a report by Gerber et al. (26) who found that iron content increased after cooking veal and was significantly higher in other beef cuts. Again, findings from this study differed from studies that reported that cooking meat in stainless steel utensils increased the iron content (39-40). The difference may be due to the fact that the meat samples from this current study were cooked in an aluminum pan and not stainless steel (made from iron, chromium, nickel, manganese, and copper) used by other researchers.

CONCLUSION

This study provided data on uncooked and cooked cow intestines' proximate, free fatty acid, and mineral composition. Cow intestines have a substantial protein composition which further increases significantly after cooking. Also, cow intestines had considerable amounts of iron, zinc, copper, and phosphorus that can contribute to the nutritional quality of an appropriately diversified diet and hence, improve the nutrient intake of individuals. Cooking generally had a significant effect on the nutrient composition of cow intestines.

Further studies should be done to ascertain the amino acid profile, fatty acid profile, and cholesterol levels of these products, and to determine the health risk associated with eating these products in terms of fatty acid profile and cholesterol levels. It will also be very important to replicate the study in other countries in West Africa to come up with comprehensive data that can be added to the food composition tables of West African countries. Furthermore, consumers should be encouraged to consume cow intestines in moderation and diversify their diet to include other sources of proteins like meat muscle, fish, and plant proteins to obtain an adequate diet.

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