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Proximate and Mineral Composition of Snail (*Achatina achatina*) Meat; Any Nutritional Justification for Acclaimed Health Benefits?

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ABSTRACT

The purpose of this research was to determine the protein, moisture, ash, fat, total carbohydrate, as well as the mineral content of snail (*Achatina achatina***)** meat, and relate that to acclaimed health benefits associated with its consumption. The results from the analysis showed that *A. achatina* meat is rich in protein (82.96%) and low in both total carbohydrate (3.26%) and fat (3.98%). The major minerals found in this study were calcium (585.5 mg/100 g), phosphorus (269.2 mg/100 g), potassium (331.8 mg/100 g) and zinc (39.0 mg/100 g). However, iron, and copper content of *A. achatina* meat were less than 10 mg/100 g. The results of this study revealed that, the meat of *A. achatina* is a good source of protein and minerals, and may be used to treat nutritional deficiencies and manage diseases such as high blood pressure, diabetes mellitus and stroke. It was evident from this study that, *A. achatina* meat is rich in protein and minerals, but low in fat, and that its consumption can promote good human health.
KEYWORDS: Snail meat, nutritional composition, health benefits, required daily allowance.

INTRODUCTION

In West Africa, snail meat has traditionally been a major source of protein in the diet of people living in the forest belt[1, 2]. The edible portion has 88.37% protein [3], calcium, magnesium, zinc, iron, with very low fat content[4,5 ,6, 7]. Its protein contains all the essential amino acids such as lysine, leucine, isoleucine and phenylalanine which are needed by the body for its metabolic activities [8, 9, 10]. In addition, there are claims that snail meat has medicinal value and can be used to treat ailments including whooping cough, anaemia, asthma, and high blood pressure due to their relatively low cholesterol level but high mineral content [11, 9]. In Ghana, snails form an essential part of the total animal protein source for the population. It contributes about 1 % of food [12]. Though snails have been acclaimed to be a rich source of protein and other essential nutrients required for good health, they are not regularly consumed in the diet of many Ghanaians. Attitudes of people to snail consumption vary within the sub-region. In the southern forest regions, snails are a delicacy for a large number of the populace and people are prepared to pay high prices for them. In the northern areas, snails are a taboo and many tribes will not touch, let alone eat them. This may be due to the fact that, majority of people in northern Ghana are Moslems, and Moslems do not eat snails [13]. In between the two extremes are those who take snails when they are in season during which they can be collected freely from the wild or bought cheaply from the market [14]. Ebenso [13] noted that the consumption of snail meat by rural communities is governed more by culture than by social status. There are unsubstantiated beliefs and fads surrounding the consumption of snails. It is for instance believed that, pregnant women who eat snails will eventually end up having babies with “drip mouth”.

These tendencies may partly be due to limited research to ascertain the veracity of these claims. In addition, nutritional reasons should be sought to either support or debunk claims of health benefits associated with the consumption of snail meat (Table 1). This current work therefore focused on determining the proximate and mineral content of snail (*A. achatina*) meat sample which was tray dried.

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Table 1: Medicinal uses of the African Giant snail among rural people

Part of Snail Used	Preparation	Conditions Used For
Meat	Soup	Suppression of hypertension Curtails aggression Malformation of bone structure Nourishment of lactating mothers Promotion of easy child labour Cure of anaemia Suppression of convulsion Whooping cough
Fluid	Soup	Stops bleeding from cuts Healing of amputated fingers Treatment of eye problems Circumcision of male children Suppression of small pox Anti-rheumatic

Source: Akinnusi, 1998

MATERIALS AND METHODS

Source and sample preparation

Snails for this work were obtained from snail farms in Kumasi, Ghana. They were sorted to remove dead snails and foreign materials. The snails were then washed with potable water and heated in water at 60 ^{o}C for 10 min to aid evisceration.

A tray dryer was used to dry the snail meat at 75 – 80 ^{o}C until it became crisp dry. The dried snail meat was milled into fine powder before being used for the proximate and mineral analyses.

Proximate and Energy content analysis

The recommended methods of the Association of Official Analytical Chemists[15] were used to determine the crude protein, crude fat, ash, and moisture content of the dried snail. Total carbohydrate content was determined by difference. The Kjeldahl method (%N × 6.25) was used to determine the crude protein content of 1.0 g sample of dried milled snail. The crude fat content of the snail sample was determined using the Soxhlet extraction apparatus to thoroughly extract crude fat from 4.0 g of milled snail sample using petroleum ether (boiling point 40 – 60 ^{o}C), in the soxhlet method of fat determination. The weight of fat extracted divided by the weight of sample multiplied by 100% gave the per cent crude fat content. Ash was determined by incinerating 5.0 g of the milled snail sample at 550 ^{o}C overnight in a muffle furnace (Gallenkamp, England). The weights before and after ashing were used to calculate the per cent ash content. The moisture content was determined by drying 2.0 g of milled snail sample at 105 ^{o}C for 3 h using a thermostatically controlled forced-air oven (Gallenkamp, England). The difference in weight before and after drying was used to calculate the per cent moisture content.

Total carbohydrate was obtained by subtracting the per cent amounts of crude protein, crude fat, moisture, and ash from 100%. The energy value of the snail sample was obtained by multiplying the per cent composition of protein, fat, and carbohydrate by their corresponding Atwater values of 17, 37, and 17, respectively[16].The results are shown in Table 2.

Mineral analysis

Each mineral was determined in triplicate using reagents of analytical grade.

Determination of phosphorus content of snail

Phosphorus determination was carried out by the molybdenum blue method[17]. Two (2) grams of sample was dry-ashed and 5.0 ml of 5 M H_2SO_4 and 5 ml of 4% molybdate solution (25.0 g/l sodium molybdate in 5 ml H_2SO_4) added in a 100.0 ml volumetric flask. This was followed by the addition of 4 ml of 2% ascorbic acid. The mixture was then heated until a deep blue colour was developed. Deionised water was added to reach the 100 ml mark and the absorbance read at 655 nm using the atomic absorbance spectrophotometer (Perkin Elmer ASS, 5100 PC) against a blank. A standard curve was drawn by measuring absorbances at 655 nm of standard solutions containing 0.0 mg, 1.0 mg, 2.0 mg, 3.0 mg, 4.0 mg, and 5.0 mg of phosphorus in 100.0 ml deionised water. The phosphorus content of the snail sample was obtained from the standard curve. The result is shown in Table 3.

Determination of Iron, Calcium, Potassium, Copper, and Zinc content of snail

One (1.0) gram of milled snail sample was weighed into three different digestion flasks and 10.0 ml of nitric acid added to each flask and samples kept in a fumed chamber overnight. The flasks were then heated in a fumed

chamber until production of red nitrogen dioxide (NO_2) fumes ceased. The flasks were cooled and 4.0 ml of 70% perchloric acid ($HCLO_4$) added to each flask. The mixture was heated again to evaporate the content to dryness. The content of each flask was quantitatively transferred into a 50.0 ml volumetric flask and diluted to the mark using deionised water. Absorbance was read using the atomic absorbance spectrophotometer (Perkin Elmer AAS, 5100 PC) against a blank. The wavelengths at which the absorbances were read for iron, copper, zinc, calcium, and potassium were 248.3 nm, 324.8 nm, 213.9 nm, 422.7 nm, and 766.5 nm, respectively. The iron, copper, zinc, calcium, and potassium content in the samples were determined from their respective standard curves prepared from standard solutions of these minerals[17]. Results obtained for these minerals are shown in Table 3.

RESULTS AND DISCUSSION

Proximate analysis

Table 2 shows the proximate content of the snail sample analysed. Results of the proximate analysis on the snail samples showed that protein content was the highest as compared to all the other components that were analysed and this confirms report[18] on the nutritional protein value of snails' meat. This finding can also be attributed to the fact that, snail meat is basically made up of muscles and also the fact that proteins are indispensable constituents of every living cell. They form an essential component of both the nucleus and cell protoplasm and are found in most extracellular animal tissue fluid[19]. Proteins are known, among other functions, to repair worn out tissues[10, 20] and may account for it being used by traditional people to enhance the healing of amputated limbs (Table 1).

Being a good source of animal protein, snails can be used in a powdered form to prepare nutritious food for babies who are being weaned from breast milk, particularly in forested areas to prevent protein energy malnutrition among children under five years. Paradoxically, in forested areas where snails are available and can be picked freely from the environment, incidence of kwashiorkor, marasmic-kwashiorkor and stunted growth are common. The same conditions are also recorded among school going children[21]. Consumption of snail meat can therefore help in ameliorating these conditions.

Table 2: Proximate and energy analysis of tray-dried snail meat sample

Sample	Protein (%)	Fat (%)	Ash (%)	Moisture (%)	Total Carbohydrate (%)	Energy kJ/100 g
Dried snail meat	82.96±2.12	3.98±0.11	3.22±0.09	6.58±0.23	3.26±0.13	1613.00±8.98

It is evident from Table 2 that, the crude fat content of snail meat is relatively low, confirming findings by Murphy[22]. Besides, snail meat is low in cholesterol[23]. With the rising incidence of diabetes, hypertension, and other cardiovascular diseases, resulting from the excessive consumption of saturated fatty foods, particularly from animal sources, coupled with physical inactivity, the eating of snail meat may help in curtailing the high incidence of diet related non-communicable diseases. Research has shown that, women over 45years or older who consumed both poultry and red meat over a 10-year period, were diagnosed as hypertensive [24] while other studies indicated that, diet high in red meat is a contributing factor to the risk of type 2 diabetes [25].

The ash content of a food sample gives an indication of the number and amount of minerals present. Snails eat from varied food sources including the soil, and this may account for the relatively high ash value obtained in this work. Ash value obtained in this work was within the range reported by Gernadi [26] and Mead [27].

The final moisture content attained (6.58%) was achieved after six hours of drying between 75 and 80 ^{o}C. The moisture content was quite low and the dried snails could be kept safe for a considerable period of time when packaged properly. This can therefore be available for use during the dry season when they are in short supply and exorbitantly expensive.

The value obtained for total carbohydrate was relatively low. This was to be expected as snail meat is basically animal protein, and with the slow nature of its locomotion, it only needs to store small amounts of glycogen for this purpose. Animals have limited capacity to store glycogen in their bodies and excess amounts are metabolised into fat[28]. It could be speculated that, the extremely slow pace of snail movement may not necessitate the storage of large amount of carbohydrate in the form of glycogen. There is consequently not enough glycogen left to be converted to fat, which may have accounted for the low per cent of fat obtained in this study.

The energy value obtained was quite high (±8.98 kJ/100 g) compared with values obtained by Oduro et al. [29] (390.92 – 435.97 kJ/100 g). This may be due to the low moisture content of the dried snail sample. In this work Snail meat can therefore provide significant amount of calories in the diet.

Mineral analysis of snail samples

All forms of living matter require many inorganic elements for their normal life processes. Calcium, phosphorus, iron, zinc, copper, magnesium, manganese, cobalt, iodine, and a few others have definite demonstrable functions in the bodies of animals. The mineral nutrients are interrelated and do not play independent self-sufficient roles in the human body. For instance, calcium and phosphorus are in a definite relationship in the formation of bones and teeth [30, 31], and so are iron and zinc shown to reduce the morbidity of diarrhoeal disease and pneumonia [32].

Results obtained from the mineral analysis showed that snail meat has high calcium content as compared to potassium, phosphorus, zinc, iron, and copper.

Iron content

Iron forms a component part of the haem groups of the oxygen-carrying proteins haemoglobin and myoglobin and of the electron-carrying mitochondrial protein cytochrome C[33]. Iron plays an essential role in coupled oxidations and reductions (by inter-conversion of its reduced or ferrous state with its oxidized or ferric state) in such processes as oxygen transport and cellular respiration [34, 35].

Iron-sulphur enzymes are another important class of iron-containing enzymes. They also function in electron-transferring reactions of mitochondria. An example is NADH-ubiquinone reductase [36, 37]. Iron is also found in the intracellular cytochrome enzyme system, which functions in energy production and cellular respiration. Moreover, various non-haem enzymes use iron as an active site [37].

Although the value obtained for iron was lower (Table 3) than that reported by Watson[38] for dried *Achatina* sp., it was fairly high and this may account for its use in combating iron deficiency anaemia[11] in which the number of red blood cells is normal but the level of haemoglobin in the cells is relatively low[30, 10]. In general, iron from animal sources is absorbed more readily than that from cereals or vegetables, as iron from plant sources form complexes with phytates and oxalates in the plant [39, 35]. This makes snail meat an excellent source for the supply of iron in the diet. This may account for use of snail meat in treating anaemic condition (Table 1). According to the world health organisation (WHO), iron deficiency is the number one nutritional disorder in the world[48]. It affects more than 30 per cent of the world's population. Iron deficiency anaemia may result from a low dietary intake, inadequate intestinal absorption, excessive blood loss, and/or increased needs. Women of childbearing age, pregnant women, older infants and toddlers, and teenage girls are at greatest risk of developing iron deficiency anaemia because they have the greatest need[39, 40].

Table 3: Some mineral composition of dried snail meat sample

Sample	Mineral composition (mg/100g)					
	Fe	Cu	Zn	Ca	K	P
Dried sail meat	9.8±0.3	3.3±0.1	39.0±1.4	585.5±5.6	331.8±4.6	269.2±3.9

The Recommended Daily Allowance (RDA) for iron varies in the sexes and during the physiological states of pregnancy and lactation. The RDA value for men (70 kg weight) is 10 mg and for adolescent girls (weighing 55 kg) is 18 mg. In pregnant and lactating women, their RDA is between 30 – 60 mg[36, 39].

Thus, adequate consumption of snail meat in the diet, especially by adolescent girls, pregnant and lactating women, can go a long way in ameliorating the iron deficiency problems they encounter.

Copper content

Copper is a component part of the enzyme tyrosinase, which is necessary for melanin pigment formation in the body. Copper is also part of the molecule lysyl oxidase (which enables cross-linking and normal function of the connective tissue collagen and elastin of bone, skin, and blood vessels), and of many other enzyme systems [41]. Because copper plays a role in ensuring the normal functioning of the connective tissues of the bone, and snail meat being a good source of copper, it may account for its use in combating malformation of bone structure by traditional people (Table 1).

Copper stimulates the absorption, proper utilization, and synthesis of iron into the haemoglobin and cytochrome molecules [42]. Because of this role that copper plays, supplementary iron capsules (for pregnant women, anaemic conditions, etc.) normally contain adequate amount of copper for effective performance of the drug [30, 42]. Snail meat having high levels of these two mineral nutrients could be a good dietary source for those requiring these minerals in their clinical and physiological states. Because the RDA of copper is between 2.5 to 5 mg [43], consumption of 100 g of snail meat in the diet can meet this requirement. Snails are among the good sources of copper in the diet.

Zinc content

Over 80 enzymes are known to require zinc as part of their prosthetic groups. These include alcohol dehydrogenase, carbonic anhydrase, DNA and RNA polymerases, and carboxypeptidase [36, 37]. Zinc is found in high concentrations in the prostate gland, sperm cells and the eyes, where it is presumed to play important functions and virtually all tissues of the body [44, 36, 37]. Along with vitamin A, zinc plays a role in dark adaptation and night vision [30, 45]. This may explain why traditional people eat snail meat as a means of treating eye problems (Table 1). It could be conjectured that, snail being mostly nocturnal, need to store adequate amount of zinc to enable it adapt to dark conditions explaining the high value obtained.

Zinc participates in nucleic acid and protein metabolism, affecting their synthesis and structure and their roles in cell development, division, and differentiation [45]. In experiments on animals and human beings, it has been shown that zinc supplementation may help in the optimal healing of burns, surgical incisions, and reduction in child mortality [30, 46, 47]. This observation buttresses the reason for use of snail meat by traditional people in healing amputated fingers when adequately consumed as part of the meal (Table 1) because it is a rich source of zinc. Zinc deficiency is considered to be among the ten largest contributing factors to the problem of morbidity in developing countries with high mortality [48]. Zinc supplementation during pregnancy may play a role in improving both maternal and child health [49, 50]. This may account for use of snail meat in nourishing lactating mothers (Table 1).

Consumption of 100 g of dried snail meat in the diet can alone provide the daily requirement (RDA for adults is 15 mg) of zinc to the body.

Calcium content

Calcium and phosphorus serve as the main structural elements. Ninety nine per cent of body calcium is present in bones and teeth and only one per cent in the soft tissues and body fluids[30, 51]. As a result, meat and offal are generally low in their calcium content (between 9 and 11 mg/100 g) although readily absorbed by the body[52, 53]. This cannot however be said of snail meat, as the mineral analysis indicated a high level of calcium. Calcium was found to be the most abundant mineral present in *A. achatina* and a rich source of the mineral. Watson[38] reported calcium values of 650 – 700 mg/ 100 g for dried *Achatina* sp. Calcium is essential for the normal clotting of blood30. This may account for the use of snail meat fluid to stop bleeding from cuts (Table 1).

A reduced blood calcium level increases the irritability of nervous tissue and very low calcium level may cause convulsion[30, 54]. This may explain the use of snail meat in the suppression of convulsion (Table 1). Concentrations of calcium above the normal range depress nerve irritability[30, 54], a plausible reason for the use of snail meat in curtailing aggression (Table 1) because of its high calcium content.

In addition, snail is a source of calcium ortho phosphate, a chemical substrate employed in curing kidney diseases[3].

The RDA of calcium for adults and children between 4 and 14 years is 800 mg. An RDA of 1200 mg is required for women during pregnancy and lactation, and for teenagers between 15 and 22 years[30, 55]. Consumption of 200 g of dried snail in the diet can alone provide the daily requirement of calcium to pregnant and lactating women as well as to teenagers. This again goes to support the idea of snail meat usage in the nourishment of pregnant and lactating women by traditional people (Table 1). This is due to the increased requirement of calcium during pregnancy and lactation, and snail meat, with its high calcium content, readily provides the needed calcium.

The incorporation of snail meat, in the powdered form, into foods meant for weaning infants is also highly recommended because of the high requirement of calcium during infancy and childhood when the skeleton is actively growing[51].

Potassium content

Potassium is the principal intracellular cation and in conjunction with sodium plays a very important role in the regulation of water and electrolyte balance as well as acid-base balance in the body[56]. Excess potassium loss from the body, as in diabetes and in diarrhoea, or loss in the urine after the use of diuretic drugs employed in the treatment of hypertension, can also lead to serious potassium depletion[57]. This may explain the use of snail meat in the suppression of hypertension among rural people (Table 1). Besides, there is strong evidence that potassium lowers blood pressure, when it is consumed in our foods[58, 59]. Specifically, potassium has been noted to reduce both systolic and diastolic blood pressure in people with normal and high blood pressure[58, 60]. Potassium also reduces salt sensitivity, an independent risk factor for heart disease. Eating enough potassium-rich foods reduces or prevents blood pressure response to dietary sodium, possibly by stimulating excretion of sodium chloride, or inhibiting sympathetic nerve response[61]. Potassium influences the contractility of smooth, skeletal, and cardiac muscles and profoundly affects the excitability of nervous tissue[30, 62]. The influence potassium brings to bear on the contractility of these muscles may explain the use of snail meat in the promotion of easy child labour (Table 1) as

childbirth is more of a muscular activity[62]. Potassium deficiency is manifested by muscular weakness, increased nervous irritability, mental disorientation, and cardiac irregularities[30, 62]. This may be another good reason why traditional people use snail meat in suppressing convulsions (Table 1).

Phosphorus content

Phosphorus has more functions than any other mineral element in the body. It forms a complex with calcium that lends rigidity to bones and teeth[63]. About 80% of the body's phosphorus is found in the skeletal tissues[30, 63]. Phosphorus functions as a phosphate, and as a phosphate, this mineral is essential for the growth and development of bones and teeth[64]. It serves as a co-factor for numerous enzymes and activates several of the B complex vitamins. It also affects the production of the molecule adenosine triphosphate, which is crucial for energy storage[64]. Inadequate phosphorus intake results in abnormally low serum phosphate levels known as hypophosphatemia. The effect of hypophosphatemia includes loss of appetite, anaemia, muscle weakness, bone pain, rickets (in children), osteomalacia (in adults), increased susceptibility to infection, numbness and tingling of the extremities, and difficulty in walking[64]. Severe hypophosphatemia may result in death[64]. This may account for use of snail meat to provide anti-rheumatic effect.

Compared to data obtained by Oduro et al.[29] (239.89 – 264.99 mg/100 g), the value obtained for phosphorus in this work (269.2 mg), was slightly higher. Watson[38] reported higher values for phosphorus (405 – 435 mg/100 g) in his work.

CONCLUSION

From the results obtained on the mineral content of snail meat, it could be said that snails are an excellent source of minerals and thus recommended for growing babies, teenagers, pregnant, and lactating women. It is also recommended for use by people suffering from diabetes and hypertension and generally for people who would want to maintain good health. In addition, snail meat can be used to develop complementary foods for children under 5 years to prevent rickets, iron deficiency anaemia, and protein energy malnutrition. The consumption of snail meat can help prevent postpartum haemorrhage, night blindness, osteoporosis, hypophosphatemia and can increase high density lipoprotein. Results obtained in this study give credence to most of the nutritional and health claims made by traditional people.

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