Int. j. adv. multidisc. res. stud. 2025; 5(1):618-622

Received: 10-12-2024
Accepted: 20-01-2025

International Journal of Advanced Multidisciplinary Research and Studies

ISSN: 2583-049X

Effect of Processing Methods on the Nutritive Value of Adult Variegated Grasshopper (*Zonocerus variegatus*)

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DOI: https://doi.org/10.62225/2583049X.2025.5.1.3699
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Abstract

Entomophagy (insect eating) is an age long practice by man all over the world. The nutritive values of insects are affected by many factors including processing methods. Grasshopper is one of the edible insects in Nigeria. This study aimed at evaluating the effects of processing methods on the nutritive value of adult variegated grasshopper, *Zonocerus variegatus*. The grasshoppers were collected from an uncultivated farmland, washed, degutted and processed in three ways namely; boiling, roasting and frying. Processed *Z. variegatus* were analyzed for their proximate, minerals, vitamins and anti-nutrient profile. The data obtained were analyzed by One Way Analysis of variance and means separation was done by Duncan Multiple Range Test. The roasted grasshoppers were found to have the highest value of protein (41.54%) while the boiled insects recorded the least value (18.12%). The roasted also had the highest crude fibre (8.38%), while the raw had the least value (5.04%). The highest crude fat (37.11%) was found in the fried grasshoppers while the boiled had the least crude fat (1.59%). The fried grasshoppers recorded highest value of carbohydrate (3.43%). The roasted insects had the highest values in all the eleven minerals analyzed. Lead and Nickel were not detected in all the samples. Potassium was the highest across all processing methods, ranging from 88.01- 465.99 mg/100g while manganese was the least (0.44-1.46 mg/100g). Vitamins A, E, B_2, B_6 and B_{12} were also examined. The values for all these were highest in the roasted with 0.45, 0.48, 0.013, 0.99, and 2.63 respectively. The boiled grasshoppers had the least values in all the parameter examined except in Vitamin B_6 where it had a higher value of 0.84) than the fried (0.79) and raw (0.67). Tannin was highest in the fried grasshopper (4.51) and the least in raw grasshoppers (1.29). It can therefore be concluded that processing methods significantly affected the nutritive value of *Z. variegatus.*

Keywords: Entomophagy, *Zonocerus Variegatus*, Processing Methods, Minerals, Vitamins, Anti-nutrient

1. Introduction

Using insects as food otherwise known as entomophagy has been part of the traditional practices all over the world. However, different ethnic groups consume different insects and for different reasons (Premalatha *et al.,* 2011; Idowu and Modder, 1996; Tango, 1994) [19, 10, 27]. Edible insects generally have a high nutritional value (nutrient composition) which varies with species, life stage, sex, and diet. According to Ayensu *et al.* (2019) [4], the nutritional value of edible insects is widely recognized.

Insect consumption can be at various life stages with numerous methods of preparation, which include raw, fried, roasted etc. (Sun-Waterhouse *et al*., 2016) [26]. It was reported that the processing methods used have effects on the nutritive and anti-nutritive values of the insects. The grasshopper *(Zonocerus variegatus)* is a seasonal pest in Africa (Kekeunou *et al.*, 2006) [12], has a large population during the dry season in Nigeria and has been reportedly eaten in many parts of the country (ldowu and Modder, 1996) [10].

The feeding habits of grasshoppers according to Finke *et al.* (2014) [9] have influenced their chemical composition. Idowu *et al.* (2004) [11] observed that the adult stage of *Z. variegatus* have a high protein content as well as a high mineral value and it is used as a supplementary protein source and inexpensive substitute for meat in a developing country like Nigeria. Ademolu *et al*. (2006) [1] also noted that the crude fat of *Zonocerus variegatus* was low, especially in the adult stage and the carbohydrate

content was said to be very low in the first three instars and increased in the later instars. The body of *Z. variegatus*, is composed of chitin, a form of carbohydrate, has been reported to increase in size during post-embryonic development.

The nutritional compositions of edible insects between and within species varies depending upon the metamorphic stage, habitat, and diet of the insect as well as the preparation and processing methods applied before consumption (Rumpold and Schluter, 2013) [22]. The nutritive value or functional qualities and composition of *Z. variegatus* may be impacted because of the processing methods used. It is therefore important to determine the possible effects of different processing methods on the nutritive composition of *Z. variegatus*.

2. Materials and Methods

The adult variegated grasshoppers used in this work were collected from uncultivated farmland in Ibadan, Oyo State, Nigeria. The collected grasshoppers were degutted by making a hole at the joint between the thorax and abdomen with the aid of a chopstick. The sample was then washed and divided into four groups; Group A is the raw grasshopper, Group B was boiled on fire for 5 minutes, Group C was fried in hot vegetable oil for 5 minutes and Group D was roasted on red-hot charcoal for 5 minutes. They were then package separately and subjected to proximate, minerals, vitamins and anti-nutrient analyses.

2.1 Proximate Analysis

The proximate analysis of each processed grasshopper was carried out by the method of the A.O.A.C. (2000) [3] to determine the crude protein, crude fibre, ash content; crude fat and moisture content, while the carbohydrate content was obtained by difference, that is, % carbohydrate = 100 – (%moisture content +% ash +% crude fat +% crude protein).

2.2 Minerals

Mineral analysis of the dried insect sample was performed to evaluate the concentration of magnesium (Mg^{2+}), zinc (Zn^{2+}), calcium (Ca^{2+}), iron (Fe^{2+}), sodium (Na+), potassium (K+) and phosphorus (P), copper (Cu^{2+}) and manganese (Mn^{+}). Mg^{2+}, Zn^{2+}, Ca^{2+} and Fe^{2+} were determined using a BuckVGP210Atomic Absorption Spectrophotometer (AAS). Na^{+} and K^{+} were assessed using a Corning 410 Flame Photometer and phosphorus was determined calorimetrically using a Gallen Kamp (U.K.) Spectronic 20 photospectrometer.

2.3 Vitamins

Assays of vitamins A, E, B2, B6 and B12 of the different processed insects were carried out following the method of the A.O.A.C (2000) [3]. Each of these parameters was determined in triplicates.

2.4 Anti- Nutrient

Levels of organic contaminants such as tannin, total phenol, alkaloids and oxalates were investigated on the raw, boiled, roasted and fried samples of the variegated grasshopper.

2.5 Data Analysis

Data collected from the chemical analyses were subjected to one-way analysis of variance (ANOVA) using the Minitab (1998) computer package and where there were significant differences, means separation was done using Student-Newman- Keuls (SNK) test.

3. Results and Discussion

The results of the proximate, minerals, vitamins and anti-nutrients properties of processed grasshopper are presented. Table 1 shows the proximate analysis of the different processed variegated grasshopper. The highest value of 41.54% protein content was recorded for the roasted insects while the lowest of 18.12% was recorded for the boiled. Significance differences existed between all the different methods of processing examined.

This report showed that grasshopper is highly proteinous and the protein value recorded in roasted group in this work is higher than what has been reported before and also higher than the protein contents of some convectional sources like beef, 22.2%, pork 21.6%, Giant snail 18.28% (Idowu *et al.*, 2004) [11].

Proteins are organic compounds consisting amino acids which are the building blocks and could be either essential or nonessential. Protein is the basis of all organism activity and constitutes many important materials such as enzyme, hormones, and hemoglobin. Proteins are the most abundant biological macromolecules, occurring in all cells and all parts of cells, they are also the molecular instruments through which genetic information is expressed. Therefore, ensuring a steady source of protein is very important for humans and animals.

The protein content recorded in this work is in agreement with the value of 48.65% reported by Ogunleye and Omotosho (2005) but contradicts the low value of 27.05% reported by Idowu *et al.*, (2004) [11].

The moisture content was reduced by processing methods, the frying method showed a higher reduction than the roasted.

The fat content in this work was low except in the fried which may be because of the oil used in frying. The carbohydrate content was very low and completely absent in the raw sample, the highest value of 3.43% in the fried is also traceable to the oil used in frying it. Fats and carbohydrates are important nutritive elements in the human body. They are the main energy source in the body (Alamu *et al.*, 2013) [2].

The fibre content recorded in this work is high. This is an indication that grasshopper is rich in fibre.

Minerals are said to be of great importance in metabolic and physiological activities of living organisms. According to Talwar (1989), Iron, zinc, copper, and manganese act in strengthening the immune system and also act as antioxidant and cofactors of enzyme. In the same vein, magnesium, zinc, and selenium are important in preventing cardiomyopathy, muscle degeneration, growth retardation, impaired spermatogenesis, immunologic dysfunction, and bleeding disorder (Chaturvedi *et al.*, 2004). Iron deficiency is a major problem in children and pregnant women's diets especially in Africa (Orr, 1986) [17]. Magnesium helps to maintain normal muscle, regulates blood sugar levels and nerve function as well as keeps the heart rhythm steady, (Saris *et al.*, 2000) [24].

The results obtained for the mineral analysis in this work is higher than what was presented in the work of Ademolu *et al*, (2006) [1], except the phosphorus content of 218 higher than 160.37 recorded in this work.

The processed *Z. variegatus* was also analyzed for their vitamin contents. Vitamins A, E, B_2, B_{12} and B_6 were examined. There was no significant difference among all the parameters for the different processing methods except the Vitamin B_2.

Vitamin B_{12} had the highest values across all the processing methods in this work, followed by Vitamin B_6. The lowest values were seen in Vitamin B_2 in all the processing methods used. A reduction in vitamin contents was observed with all the processing methods when compared to the values in the raw sample except the roasted method where the vitamin contents are more than in the raw sample.

This result contradicts the report of Punzo, (2003) [20], in which he reported that Vitamin C was present in the body of *Z. variegatus*, which was actually reported absent in this work. He also reported that Vitamin A (Retinol) was the highest value of all the three vitamins which is contrary to the report of this work but his report on vitamin B_2 being the lowest, is agreement with the findings of this work.

A general decrease in vitamin content was observed in this work except in the B_{12} values that increased with all the processing methods employed. Also, the roasting method produced the highest effect on the vitamin contents of *Z variegatus*. This result agreed in part with the work of Roy *et al.*, (2001), that degradation of food results in loss of vitamins.

It was generally believed that reduction may be due to oxidation from exposure to enzymatic and chemical degradation and effect of processing temperature. Vitamins are a group of organic compounds that are necessary for metabolism in human bodies, they cannot be synthesized in the human body and so they must be constantly supplied from food (Alamu *et al*., 2013) [2]. Vitamin B comprises of components of coenzymes. Vitamins K and A are required for normal blood clotting and proper vision, respectively. Many studies have shown that edible insects contain appreciable amounts of vitamins (Ekpo and Onigbinde, 2005) [8]. The high vitamin content of edible insects presents them as a highly potentially good source of food supplement for malnourished people and animal.

The anti-nutrient properties of the different processed *Z. variegatus* are presented in Table 4. The tannin, total phenol. alkaloid and oxalates contents were examined. Oxalates had the highest values across all the methods used. These anti-nutrients have the ability to bind with protein, inhibit enzymes, lower the absorption of minerals and vitamins in the gastrointestinal tract. The highest value of 29.54 was recorded in the roasted sample.

Tannin has the least values in all the processing methods employed in this work. Tannins are said to have both toxic and therapeutic functions. They have the ability to precipitate proteins, inhibit enzymes, lower absorption of minerals and vitamins from the gastrointestinal tract as well as show great health benefits such as the potential to retard starch digestion leading to a reduction of the post prandial hyperglycemia in diabetic patients. Though it has been reported that tannin content can be reduced by heating (Okon and Ekpo 2008) [15], reported that boiling and fermenting reduced tannin in cowpea but in this work, boiling, roasting and frying increased the tannin contents in variegated grasshopper. However, the results of this work were in agreement with the report of Nafisa *et al* (2008) [13], that toasting and boiling increased tannin and phytate contents. The value reported for tannin in raw *Z. variegatus* in this work, (1.28), is lower than the 0.43 reported by Ekop *et al.,* (2010) [7]. Schiavone *et al*, (2007) [25] also submitted that 0.15-0.2% tannin improved the performance and well-being of broiler chicken. Moreover, the values recorded in this work are below the permitted level of 150-1400mg for mixed diet and 560-2600mg per day for vegetarians.

Frying had the highest effect on the total phenol among all the processing methods used but there was a general increase in the value of total phenol across all processing methods and significant differences existed among them. Phenols are plant constituents with redox properties responsible for antioxidant activity. They avert cells damage which results from free radical oxidation reaction. It was said that regular eating of phenol can promote anti-inflammatory capacity of human being. They can also act with some fat- soluble vitamins like E and C as reducing agents to protect human body's specific tissues against oxidative stress. (Nantogo *et al.,* 2011) [14]. The value of 2.26Mg TAE/g recorded in the raw sample of this work was increased by all the processing methods to 5.55 (frying), 3.94 (roasted) and 4.26 (boiled). Yi *et al.,* (2011) [29] had earlier reported that phenols enhancement was associated with thermal destruction of cell wall and sub cellular compartments which result in increased levels of free phenolic compounds or inactivation of deteriorative enzymes.

The same trend was observed in the alkaloid contents in this work. Boiling had the highest effect on the alkaloid content of 9.76 as compared to the 0.65 in the raw. Alkaloids are said to protect plants from predators as well as regulating their growth. Alkaloids are also known for their anesthetics, cardio-protective and anti-inflammatory properties (Nantogo *et al.* 2011,) [14]. Yi *et al.,* (2011) [29], reported that alkaloids are degraded by heat, which contradicts the result obtained from this work.

The oxalate content of the *Z. variegatus* in this work was the highest affected among all the anti-nutrients considered and the roasting method had the highest increase from 8.05 in raw to 29.54 in roasted. Oxalate is an organic acid found in plants but can be synthesized by the human body. When in high quantity, it can prevent the body from absorbing beneficial nutrients in the digestive tracts. There had been reports that processing methods such as boiling, fermentation and roasting reduce oxalate levels in plants. Ramos *et al.,* (2020) [21] added that the level of reduction could be higher than 86%. All these contradict the increased results obtained from this work. However, the values obtained in processed variegated grasshopper lower than the lethal dose of 200-500mg/100g reported by Pearson (1973) [18]. The highest value obtained was close to what was reported by Ekop *et al.,* (2004) [6] for total oxalate in *Z variegatus* of 26.40.

The increase in the values of these anti- nutrients with processing when compared to their values bin the raw grasshopper showed that processing methods have great effect on them. This result contradicts earlier reports that processing methods reduce the levels of these nutrients in plants (Yakubu *et al.,* 2010). It was also reported that these organic compounds can be synthesized by animal's body where they can bind with other minerals but the reasons for the increase of values with processing cannot be determined in this work. It may be due to reasons beyond the scope of this work.

Table 1: Proximate Analysis of processed grasshopper

Sample	Moisture	Protein	Fat	Fibre	Ash	CHO
Roasted	45.13b	41.54 [d]	3.77 [a]	8.38 [b]	1.17 [a]	0.01 [a]
Fried	26.35 [a]	25.77 [c]	37.11[b]	6.23 [ab]	1.11 [a]	3.43 [b]
Boiled	74.01 [d]	18.12 [a]	1.59 [a]	5.22 [a]	0.54 [a]	0.52 [a]
Raw	70.35 [c]	22.63 [b]	1.80 [a]	5.04 [a]	0.82 [a]	0.00 [a]

Mean values followed by different superscript within the same column are significantly different (P<0.05)

Table 2: Mineral Profiles of the processed grasshopper

	Raw	Fried	Boiled	Roasted	Control
Sodium	1541.99±10.00[d]	1608.56±8.00[c]	1804.85±4.00[a]	1706.12±6.12[b]	1497.64±2.04[e]
Potassium	5278.46±8.00[b]	6684.98±4.00[a]	5376.10±6.00[c]	4156.16±6.00[d]	4699.53±9.00[d]
Magnesium	4995.16±5.00[b]	5403.62±3.00[a]	4998.07±8.00[b]	5157.31±7.00[a]	5520.98±10.00[a]
Calcium	3706.27±6.00[b]	4115.21±15.00[a]	2264.12±16.96[d]	3014.14±4.00[c]	4231.07±10.00[a]
Manganese	103.10±3.10[c]	106.97±0.90[c]	122.92±0.92[a]	103.63±0.63[c]	113.84±0.84[b]
Ferric	305.99±0.90[d]	290.02±2.02[d]	361.52±1.02[b]	327.58±2.08[c]	499.42±9.42[a]
Copper	7.64±0.04[a]	8.03±0.03[a]	7.45±0.45[a]	6.86±0.06[a]	6.92±0.92[a]
Zinc	57.83±2.03[a]	58.84±0.84[a]	59.14±0.14[a]	56.13±0.13[a]	59.34±0.34[a]
Phosphorus	6241.41±10.00[a]	6500.95±7.00[a]	6655.29±5.00	6365.06±5.06[a]	6403.81±3.01[a]

Mean values followed by different superscript within the same column are significantly different (P<0.05)

Table 3: Vitamin Profile of Processed Grasshopper

Sample	vit A	vit E	vit B2	vit B12	vit B6
Fried	0.2426[a]	0.1335 [a]	0.0145 [a]	0.8213 [a]	0.7908 [b]
Roasted	0.4547 [c]	0.4817 [c]	0.0134 [a]	2.6254 [d]	0.9865 [c]
Boiled	0.2101 [a]	0.1918 [a]	0.0380 [a]	1.1461 [b]	0.8373 [b]
Raw	0.3252 [b]	0.2758 [b]	0.0530 [a]	1.2615 [c]	0.6718 [a]

Mean values followed by different superscript within the same column are significantly different (P<0.05)

Table 4: Anti-Nutrient Properties of Processed Grasshopper

Sample	Tanin	Total Phenol	Alkaloid	Oxalate
Fried	4.52[d]	5.55[d]	8.15[c]	22.41[c]
Roasted	2.40[b]	3.94[b]	2.56[b]	29.54[d]
Boiled	2.77[c]	4.26[c]	9.76[d]	15.53[b]
Raw	1.28[a]	2.26[a]	0.65[a]	8.05[a]

Mean values followed by different superscript within the same column are significantly different (P<0.05)

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