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Determination of Nutritional Composition of *Encosternum delegorguei* Caught in Nerumedzo Community of Bikita, Zimbabwe

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Abstract

Three forms of *Encosternum delegorguei* consumed in Nerumedzo community, Bikita, Zimbabwe were analysed for their nutritional composition. Protein, fat, ash and mineral content were determined for the preprocessed, well prepared and spoiled bugs. The proximate composition and minerals of the insects were determined using standard methods. One Way Analysis of Variance (ANOVA) was used in analyzing data. They were found to contain 30-36% protein; 51-53% fat and 1-1.5% ash respectively. Spoiled bugs contained the lowest protein content of 30.76±0.98% and highest amount of magnesium of 120±2.2 mg/100g while the preprocessed and well processed contained 110±2.5 mg/100g and 112±2.4 mg/100g respectively. Phosphorous was the most abundant in all forms with a value of 570-575 mg/100g. Calcium levels for all the three forms showed an overall mean of 85-89 mg/100g. Among the trace elements, iron was the most abundant (19-22 mg/100g). Roasting increased the protein, ash and magnesium content. The findings suggest the consumption of *E. delegorguei* is not only based on its cultural and medical roles claimed by the community, but also on the nutrients present.

Keywords: nutritional composition, *Encosternum delegorguei*, edible insect, roasting

1. Introduction

The consumption of insects (entomophagy) has been common in tropical and subtropical countries. Insects have been consumed at different growth stages either as delicacies or important components of a daily diet.Insects have been reported to have high protein, fat, mineral and vitamin contents (van Huis, 2003; Food Agriculture Organisation [FAO], 2010a, 2010b). The alternative provision of nutritional, economic and ecological benefits by insects has improved livelihoods of rural communities (FAO, 2008; Srivastava, Babu, & Pandey, 2009). In Africa, the consumption of insects is a cultural and traditional way by which economically marginalized communities supplement the meager protein and mineral content of their high carbohydrate diet (Bukkens, 2005; Christensen et al., 2006; Aiyesanmi & Adedire 1999; Kinyuru, Kenji, Muhoho, & Ayieko, 2012; Ekpo & Onigbinde, 2005). Against this background, there is need to determine the nutritional composition of insects to exploit such new sources for nutrient supplementation.

In Zimbabwe, caterpillars, termites, locusts, edible stink bugs and ants are among the favourites and mostly consumed insects (Chavhunduka, 1975; Phelps, Struthers, & Moyo, 1975). *Encosternum delegorguei* Spinola (Hemiptera Tessatomidae)/edible stinkbug is distributed widely in subtropical, open wood land and bushveld of southern regions of Zimbabwe and Northern Provinces of South Africa. A full grown *E. delegorguei* has a body which is approximately 25 mm in length and is harvested during winter. *E. delegorguei* feeds on plant juices of trees mostly *Combretum imberbe*, *Combretum molle* and *Peltophorum africanum* and to a lesser extent on *Dodonaea viscosa* and the grass *Pennisetum* (Picker, Griffiths, & Weaving, 2000; Dzerefos & Witkowitz, 2009; Dube, Dlamini, Mafunga, Mukai, & Dhlamini, 2013). Traditional leadership has allowed the conservation of *E. delegorguei* by designing a harvesting process that is managed solely by the chief. This system has allowed sustainable harvesting by limiting the loss of the host plants and collection of only mature edible stink bugs (Maredza, 1987; 'O'Flaherty, 2003; Mawere, 2012).

In central Zimbabwe, Bikita district (approximately 20°1'23.22"S, 31°41'17.65"E), *E. delegorguei* has been part of the Nerumedzo community's food culture and is locally known as *harugwa/harurwa*. In Nerumedzo, 85 % of

the population collect *E. delegorguei* not only as a traditional delicacy and dietary supplement, but also as an income generator (Newsday, 2010). During the winter season, *harurwa* generates income for the harvesters and retailers in both Zimbabwe and South Africa where the insect is known as *thongolifha* (Chavhunduka, 1975; Defoliart, 1995; Kwashirai, 2007; Mawere, 2012).

Traditional processing and preparation for consumption of *E. delegorguei* has been described elsewhere (Teffo, Toms, & Eloff, 2007; Musundire, Zvidzai, & Chidewe, 2014). The traditional processing method employed by the community should be followed accurately in order to obtain a well- prepared or unspoiled bug which imparts desirable flavour and colour. *E. delegorguei* excretes a pungent and highly alkaline fluid which is neutralized by addition of warm water, followed by stirring (Faure, 1944; Bodenheimmer, 1951). During preparation, failure of the *E. delegorguei* to release its defensive secretion, as well as accumulation of volatile compounds on the thoracic segments, will result in a blackened stink gland bug locally known as *mafuve*. This extremely bitter spoiled bug is a result of poor processing method or picking up dead bugs during harvest. The community claims that black chest bugs play an important role in the treatment of hangovers and curing of stomach aches (Musundire et al., 2014; Dzerefos & Witkowski, 2014).These are normally separated from the golden crispy ones before consumption. However, under subsequent quality control, the black chest bug can still be consumed among the golden crispy ones.

The edible stinkbug is either consumed as a relish or snack in Zimbabwe and among the vaVenda people of South Africa. The consumption of golden crispy bug is rapidly increasing due to its acclaimed traditional values that include sensory properties and medicinal such as decreasing hypertension, cure for asthma, heart diseases and as an appetizer (Musundire et al., 2014; Dzerefos & Witkowski, 2014). In Nerumedzo, the insect is consumed in three forms. The first form is consumption of the live insect soon after harvest, followed by consumption of well-prepared bugs (golden brown crispy ones) and spoilt form (black chest) bugsafter traditional processing. Although, the consumption of the bug is increasing, consumers of *E. delegorguei* are not informed of the nutritional values of the different forms they consume. This study was aimed at getting insights into the nutritional composition of the green unprocessed bugs, processed bugs (golden crispy ones) and the spoiled (black chest) bugs. Furthermore, the study was aimed at investigating the effect of traditional processing on nutrient content.

2. Materials and Methods

2.1 Location and Sample Collection of E. delegorguei

Samples of *E. delegorguei* were collected between June and August (winter) during the morning (between 5.00-6.30 am), from Bikita (approximately 20°1'23.22"S, 31°41'17.65"E). The live insects were harvested by shaking trees and picking them up from the ground. The live insects were kept in polythene ventilated bags in cooler boxes for laboratory analyses.

2.2 Traditional Processing Method of the Insect for Proximate Determination

The bugs were killed and prepared by methods outlined by (Musundire et al., 2014; Teffo et al., 2007). The bugs (500 g) were killed by immersing in 5 litres of warm water (approximately 37°C) while stirring with a wooden stick for 5 minutes. Water was drained from dead bugs and the process was repeated twice to remove volatile compounds that are known to cause temporary blindness (Teffo et al., 2007). The bugs were roasted in claypots until they turned from green to golden crispy brown. Salt was added during roasting to enhance taste and flavor.

The preprocessed and processed bugs were dried at 60°C for 12 hours in a cobalite moisture extraction oven. The samples were ground by mortar and pestle.

2.3 Determination of Crude Protein, Fat, Ash and Minerals from Pre-Processed and Post Processed E. delegorguei

2.3.1 Crude Protein Determination

Crude protein was determined using the Kjeldahl method as described by AOAC (2000). Three forms of samples, each weighing 700 mg, were placed in a Kjeldahl digestion tube. A Kjeldhal catalyst (5 g K_2SO_4 + 0.5 g $CuSO_4$) and 25 ml concentrated sulphuric acid were added to the sample. The sample was digested for one hour. The sample was cooled and 20 ml deionized water was added to the sample. After adding 25 ml NaOH (40%), the sample was then distilled and the ammonia liberated was collected in boric acid and titrated with 0.1N hydrochloric acid. A blank was prepared and treated in the same manner except that the tube was free of sample.Protein percentage was calculated according to the formula:

$$\text{Crude protein (\%)} = \frac{(\text{sample titre} - \text{blank titre}) \times 14 \times 6.25}{\text{sample weight}} \times 100$$

Where14 is molecular weight of nitrogen and 6.25 is the nitrogen conversion factor.

2.3.2 Crude Fat Determination

Fat content determination was performed by weighing 5 grams of the dried samples then placed in thimbles and transferred into Allihan condenser soxhlet extraction apparatus. The predried boiling flasks were weighed and 250 ml petroleum ether was added as extractant in the flasks. The solvent was heated and extraction occurred at a rate of 150 drops per minute for fourteen (14) hours. The solvent was evaporated using a vacuum condenser. The boiling flask with extracted fat was dried in an oven at 100°C for 30 minutes and cooled in a desiccator and weighed. The weight gained was used to calculate the fat content.

2.3.3 Ash Determination

Total ash content was determined as total inorganic matter by incineration of a sample at 550°C (AOAC, 2000). 1g of each of the samples was weighed into a pre-weighed porcelain crucible and incinerated overnight in a muffle furnace at 550°C until a white ash free of carbon was obtained.The crucible was removed from the muffle furnace, cooled in a desiccator and weighed.Ash content was calculated according to the following formula:

$$\text{Ash (\%)} = (\text{ash weight} / \text{sample weight}) \times 100$$

2.4 Mineral Profile

2.4.1 Preparation of sample for Mineral Analysis

An ash sample of 0.5 g was digested by the wet digestion method. It was first digested with 10 ml HNO_3 at a gentle temperature (60-70°C) for 20 min. Then the sample was digested with $HClO_4$, at high temperature (190°C) till the solution became clear. The digested sample was transferred to 250 ml volumetric flask and volume was made with distilled water and then filtered (Duhan et al., 2002; AOAC, 2000).

2.4.2 Determination of Fe^{2+}, K^{+}, Zn^{2+}, Ca^{2+} and Mg^{2+} in *E. delegorguei*

The filtered samples were loaded into the atomic absorption spectrophotometer/AAS (Varian AA 240, Victoria, Australia) for the determination of Fe^{2+}, Zn^{2+}, Ca^{2+} and Mg^{2+}. The standard curve for each mineral was prepared by running samples of known strength. The mineral contents of the samples were estimated by using the respective standard curve prepared for each element.

2.4.3 Determination of Phosphorus in *E. delegorguei*

Phosphorous was determined as phosphate by the Vanadomolybdate colorimetric method (Pearson, 1976). The standard phosphate stock solution was prepared by dissolving 2.1935 g of pure potassium dihydrogen phosphate in 500 ml of water, diluted and co-analyzed with the sample extract. The digested sample of 35 ml containing 1.0 mg P per ml was pipettted into 50 ml volumetric flask. Vanadate –molybdate reagent (10 ml) was added, diluted to mark with distilled water. The solution was shaken and allowed to stand for 10 minutes to develop colour. At the same time, a blank was prepared in which 35 ml distilled water was substituted for the sample to set the zero absorbance at 420 nm.The absorbance was measured using SHIMADZU Bio spec-1601 UV-Visible spectrophotometer.

2.5 Statistical Analysis

Each proximate and mineral determination was carried out on three separate samples and analyzed in triplicate on dry weight basis. The nutrient content was based on means values ± standard deviation. Data were assessed by the analysis of variance at 5% significant levels (Snedecor and Cochran, 1987).The results were presented in tables.

3. Results and Discussion

The well prepared form of *E. delegorguei* had higher quantities of protein and fat compared to raw and spoiled bug (Table 1). Following traditional processing, roasting of *E. delegorguei* was noted to significantly increase protein and ash content. Roasting significantly reduced the protein content of the spoiled bug.

The high crude protein of the insect of more than 30% (Table 1) is suggestive of the potential of the insect specie in combating protein deficiency. The high protein content of *E. delegorguei* has been obtained by other workers (Ramos–Elorduy et al., 1997; X. Cheng, Feng, & Z. Cheng 2010; Bango, Lawal, & Songonuga, 2006; Omotoso & Adedire, 2007; Bukkens, 1997; Teffo et al., 2007;Kinyuru et al., 2012; Melo et al., 2012; Mariod, Siddig, & Nooraini, 2011). During roasting, there is also a considerable colour development through maillard reaction (Potter & Hotchkiss, 1995; Vaclavik & Christian, 2008). Through the maillard reaction, the *E. delegorguei* turns from green to yellow. Due to heat application, protein digestibility is gradually enhanced by polypeptide chains unfolding thus allowing the protein to beliable to protease digestive enzymes resulting in improved protein content in *E. delegorguei* (Opstveldt et al., 2003). In this study, the spoiled bug had a lower protein content. This might be due to poor processing resulting in theactivation of protease inhibitors and increase in other bioactive compounds

such as cyanogens (Musundire et al., 2014). However, further research can be done to elucidate the link between bioactive compounds and protein content. The three forms of *E. delegorguei* had a higher protein content than other conventional foods such as fish, beef, milk and pork (Premalatha, 2011; Ghaly, 2009).

Table 1. % Proximate composition of pre processed and post processed *E. delegorguei*

Proximate Analyte	Pre processed	Post Processed	
	Raw	Spoiled Bug	Well – Prepared
Protein (%)	34.34±0.31[a]	30.76±0.98[b]	36.06±0.49[c]
Fat (%)	51.28±0.82[a]	51.39±0.80[a]	52.94±0.85[a]
Ash (%)	1.13±0.03[a]	1.45±0.08[b]	1.17±0.05[c]

*All values are expressed as means ± standard deviation.Values in the same row followed by the same letter are not significantly different at (p=0.05 ANOVA analysis).

The results show that the insect is a good source of fat because the values are greater than 50%. This is consistent with other published studies (Ramos Elorduy et al., 1997; Teffo et al., 2007; Cmelik, 1969; Adesina, 2012; Omotoso & Adedire, 2007; Siulapwa, Mwambungu, Lungu, & Sichilima, 2014). During the killing and toxin removal process, fat globules will be seen floating on water despite roasting without oil which is evident that *E. delegorguei* is high in fat. The high fat content is also responsible for the palatability and flavor of *E. delegorguei*. According to Bukkens (2005), the plants on which the insect feeds greatly contributes to its fat and fatty acid content.In this study,the insect was found to feed on sap of various trees hence the plant juices they suck may be responsible for their high fat content.

This study reveals that *E. delegorguei* has significant amounts of minerals.The results indicated an ash value that is supported by other authors (Phelps, Struthers, & Moyo, 1975; Oyarzun, Graham, & Eduardo, 1996; Kinyuru et al., 2009; Melo, Horaico, Hector, & Concepcion, 2011; Omotoso, 2006; Omotoso & Adedire, 2007). It was noted that subjecting the insect to heat processing by roasting significantly increased ash content.This increase might be attributed to continuous increase in the minerals present (Shadung, Maboko, & Mashel, 2012; Omotoso & Adedire, 2007).

There were higher quantities of phosphorous in all the three forms studied. Roasting significantly changed the magnesium content and the spoiled bug recorded the highest value (Table 2). The values of phosphorus, calcium, iron, zinc and potassium were not significantly different from preprocessed and post processed *E. delegorguei* forms.

Table 2. Mineral Content of *E. delegorguei*

Minerals mg/100g	**Pre processed**	**Post Processed**	
	Raw	Spoiled	Well prepared
Phosphorus	570±1.1[a]	572±1.2[a]	573±1.11[a]
Magnesium	110±2.5[a]	120±2.2[b]	112±2.4[c]
Calcium	85.5±0.01[a]	85.0±0.00[a]	89.36±0.02[a]
Iron	21.5±0.18[a]	19.5±0.20[a]	20.8±0.18[a]
Zinc	3.95±0.00[a]	4.00±0.01[a]	3.98±0.01[a]
Potassium	279±0.5[a]	280±0.45[a]	278±1.0[a]

*All values are expressed as means ± standard deviation.Values in the same row followed by the same letter are not significantly different at (p=0.05) ANOVA analysis).

A number of studies revealed that insects have significant amounts of minerals such as phosphorus, magnesium, calcium, iron, zinc and potassium which were observed in the present study (Teffo et al., 2007; Shen & Ren, 1999; Mariod et al., 2011; Feng et al., 2000a, 200b; Igwe, Ujowundu, Nwaogu, & Okwu, 2011; Christensen et al., 2006; Siulapwa et al., 2014; Rumpold & Schulter, 2013). Roasting increased magnesium content, indeed the ash content depicts mineral content through heat application. Insect diet greatly influences micronutrient content (Rumpold & Schulter, 2013), thus the sap sucked by *E. delegorguei* is responsible for its mineral consitituents.From a nutritional

perspective, the insect can be used as a new source of mineral supplementation. Zinc and iron deficiency is common in women diets in Africa (Orr, 1986), therefore the consumption of the insect should be encouraged to increase amount of the mineral content in high carbohydrate diets. This study observed that *E. delegorguei* has significant concentrations of minerals which are comparable to animal sources (van Huis, 2003; Williams, 2007).

4. Conclusion

E. delegorguei has significant amounts of protein, fat, ash and minerals (phosphorous, magnesium, zinc, calcium and iron) which may be expoited to alleviate malnutrition in the marginalised poor communites. The traditional processing method (roasting), increased the availability of protein, ash and magnesium content.Further research need to be done on amino acid and fatty acid profiling of the three forms.

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