Preliminary data on the nutritional composition of the edible stink-bug, *Encosternum delegorguei* Spinola, consumed in Limpopo province, South Africa

L.S. Teffo[a], R.B. Toms[b] and J.N. Eloff[a*]

THE EDIBLE STINK-BUG, *ENCOSTERNUM* (*Haplosterna*) *delegorguei* Spinola (Heteroptera, Hemiptera), is a traditional delicacy of the Venda people in South Africa's Limpopo province. Selling the insects at Thohoyandou and other markets provides a valuable income for harvesters. In this article we report the first nutritional information on these insects. Dried bugs consist of 35% protein, 51% fat, with an energy content of 2600 kJ/100 g. Amino-acid concentrations varied from 0.82 mg/100 g (for threonine) to 1.32 mg/100 g (valine). Mineral content was 1.2 g/100 g. The stink-bugs are therefore a source of proteins, fats, amino acids, minerals and vitamins. The conservation and sustainable harvesting of these insects is highly desirable. Further investigation of their nutritional and medicinal properties is recommended, as well as research on their conservation and more efficient use as a food source.

Introduction

Food plays an important role in all societies not only for human survival but also in rituals, feasts and various ceremonies. Different cultures consume different types of foods.[1] Insects have probably been used as a food source at least since the time of our first hominid ancestors. Grigg[2] has argued that 'many social scientists believe that it is culture rather than environment and economics that determines what people eat'. Insects provide a good source of proteins, minerals, vitamins and energy, they can cost less than animal protein for poor rural communities and their consumption has averted many cases of malnutrition.[3]

In South Africa, the eating of insects is more prominent in the warmer provinces such as Mpumalanga, North West, Limpopo and Gauteng. Those most commonly consumed are grasshoppers, termites, bees, mopane worms, stink-bugs, jewel beetles and white-grubs.[4] Mopane worms, *Imbrasia belina* (Lepidoptera: Saturniidae), are widely consumed in South Africa and they are also exported to or imported from other parts of southern Africa such as Botswana, Zimbabwe and Zambia,[5–8] depending on supply and demand. Another insect consumed in South Africa is the edible stink-bug, *Encosternum* (*Haplosterna*) *delegorguei* Spinola (Heteroptera, Hemiptera), commonly known as *thongolifha* in Venda. The bugs are eaten raw, dried or with stiff porridge. Although the selling and consumption of *thongolifha* in Thohoyandou is common, its nutritional properties had not been determined. This article provides the first published nutritional information on this species.

Methods

See Appendix.

Results

The nutritional composition of insects is scarce in the published literature. The available data reveal, however, that insects contain relatively high levels of protein, energy, minerals and vitamins as well as low to high fat content.[18] *Thongolifha* has a protein content of 36% and a fat content of 51% (Table 1). The high fat content was not surprising because, when the stink-bugs were processed, fat floated on the water in the bucket in which they were initially worked. The composition of the fats is currently unknown. *Thongolifha* had a lower protein content than mopane worms (63.5%), yet the stink-bug still provides a relatively good source of protein. The energy value was calculated to be 2600 kJ/100 g, which is higher than that of other edible insects (such as mopane worm at 2172 kJ/100 g). Carbohydrate content was 7.63 g/100 g (Table 1). A high energy content based on carbohydrates and fats is important in foodstuffs because it complements diet and assists in the more complete utilization of protein, thereby enhancing nutritional value.

Vitamins A, B_1, and E (Table 2) were present at concentrations of 0.23, 0.63, and 2.17 mg/100 g, respectively. Vitamin C was not detected. Important minerals such as iron, calcium, potassium, magnesium, phosphorus, sodium, zinc and selenium were also detected (Table 3), corresponding to a mineral content of 1.2 g/100 g. High values of Zn are usually obtained from high-protein foodstuff, whereas low levels are obtained from food rich in carbohydrates.

Some essential amino acids were also present (Table 4), and concentrations varied from 0.82 mg/ml (for threonine) to 1.32 mg/ml (valine). Other essential amino acids were present at low but measurable levels. Table 5 (see online supplement at www.sajs.co.za) compares the percentage of amino acid *thongolifha* protein with that of beef and chicken meat.[19] The percentage of methionine and lysine for *thongolifha* was low, whereas the values for phenylalanine, threonine and tryptophan were closer to those of beef and chicken. This implies that *thongolifha* protein content, on a mass basis, is not nearly as good as that of these other

Table 1. Partial chemical composition of *Encosternum delegorguei.*

Protein (%)	Fat (%)	Ash (%)	Carbohydrate (g/100 g)	Moisture (%)	Dry matter (%)	Energy (kJ/100 g)
35.2	50.5	1.7	7.63	4.9	95.1	2600

Table 2. Vitamin content (as mg/100 g) of *Encosternum delegorguei.*

Vit. A	Vit. B_1	Vit. B_2	Vit. C	Vit. E
0.23	0.63	0.86	Not detected	2.17

Table 3. Mineral content of *Encosternum delegorguei* (mg/100 g).

Cl'	Na	Cu	SO_4''	Ca	Mg	K	P	Fe	Se	Mn	Zn
85.4	55.3	4.4	66.7	91	109	275	575	20.2	0.2	0.8	46

[a]Phytomedicine Programme, Department of Paraclinical Sciences, Faculty of Veterinary Science, University of Pretoria, Private Bag X04, Onderstepoort 0110, South Africa.
[b]Transvaal Museum, Northern Flagship Institution, P.O. Box 413, Pretoria 0001, South Africa.
*Author for correspondence.
E-mail: kobus.eloff@up.ac.za

Table 4. Essential amino acid profile of *Encosternum delegorguei* and daily requirements.

Amino acid	Amino acid content (mg/100 g)	Daily minimum requirement (mg)	Minimum mass (g) of insects required for daily minimum
Isoleucine	830	450–700	54
Leucine	1050	620–1100	59
Methionine	400	550–1100	137
Phenylalanine	810	220–1100	27
Threonine	820	310–500	37
Tryptophan	160	160–250	100
Valine	1320	650–800	49
Lysine	850	500–800	58

sources and therefore consumption of the insects will only partially provide essential amino acids.

Discussion

Our data confirm that consumption of the *thongolifha* is not just a traditional delicacy of the Venda people but provides them with a source of protein, various minerals and essential amino acids. However, the number of insects that have to be consumed to provide the daily required minimum for essential amino acids varies from 680 for phenylalanine to 3400 for methionine (Table 4). Thus, other foods are needed as complementary sources of essential amino acids.

Edible insects have a higher protein content, on a mass basis, than other animal and plant foods such as beef, chicken, fish, soybeans, and maize. For example, mopane worms, which are widely consumed in southern Africa, have protein levels of 64%,[6] which is higher than for meat and fish. Ramos-Elorduy *et al.*[20] have reported on the nutritional value of 78 species of edible insects in Mexico, whose protein values ranged from 15–81% whereas the calorie content ranged from 293–762 kcal/100 g. *Thongolifha* is comparable with the insect, *Acantocephala declivis*, which has a protein content of 35% and 45% (fat).[20] Insects such as termites, grasshoppers, and caterpillars are better sources of protein than beef, chicken, pork or lamb on a mass basis. However, more research needs to be done on the bioavailability of the nutritional components. If the insect is ground to powder, much of the available nutrients may potentially be digested, but if the bug is just chewed, much of the material in the cuticle will simply pass through the gastrointestinal tract without being absorbed.

The chemical composition of the scent glands of adults and nymphs of the Indian stink-bug *Tessaratoma javanica* was analysed by Janaiah *et al.*,[23] who found *trans* hex-2-enal, *trans* hex-2-enyl acetate and *n*-tridecane in the adult scent, while *trans* oct-2-enal and *n*-tridecane were detected in the abdominal scent glands of nymphs. The scents had a lethal effect on small red ants and black ants (species unreported).

The defensive secretion released by the live stink-bugs has yet to be analysed and its effects on human eyes are not known but appear to be significant. One of us (R.B.T.) reports that it is advisable to close your eyes or use goggles when handling the insects. The black bugs used for the treatment of hangovers have also not been closely studied and their medicinal properties have yet to be properly investigated. Insects prepared in different ways and those from different regions or seasons have still to be analysed and compared.

The sale of stink-bugs and mopane worms provides a valuable source of income for many families in Limpopo province. Quin[21] reported that the sale of beef is adversely affected during the mopane worm season. Mopane worms and *thongolifha* were usually sold at R5 per cup in 2004 in South Africa, and harvesters could earn up to R1000 a month. In 2007, after some difficult seasons affected by drought and possibly over-harvesting, the price increased to R10 per cup (M. Thagwana, pers. comm.).

In general, insects can be a relatively cheap source of protein and therefore poor people should be encouraged to consider insects as an acceptable food item. Some of the insects that are regarded as food are available in abundance and are seen as pests by farmers. Widespread harvesting and consumption might serve as a form of biological control of these pests to protect their crops. Harvesters, and the community at large, should be taught to look after the forests and the host plants which support the insects, in order to preserve them.

Some insects are toxic and may create allergy problems.[22] The traditional preparation of insects is capable of improvement, to avoid contamination and wastage. Mpuchane *et al.*[24] reported on the deterioration of the mopane worm's nutritional quality by bacteria, fungi and insects during storage.

Conclusion

Thongolifha is not just a traditional food but contains reasonable levels of protein, vitamins, some amino acids and minerals. We therefore recommend it as a food source. Sustainable harvesting is advocated in order to ensure the availability of stink-bugs because some harvesters from Venda travel as far as Modjadji village to collect this traditional delicacy, and the demand already exceeds the local supply.

Stink-bugs are also an economic resource and several families rely on the sale of the insects as an important part of their income, so that sustainable harvesting and preservation is required. Further research is needed to elucidate the variation in the composition of these edible insects in terms of habitat, host plants, season of the year and preparation procedures.

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1. Caplna P. (1992). Feast, fasts and famine: food for thought. In *Berg Occasional Papers in Anthropology: Food, Health and Identity.* Routledge, London.
2. Grigg D. (1995). The geography of food consumption: a review. *Prog. Hum. Geog.* **19**(3), 338–354.
3. Chavunduka D.M. (1975). Insects as a source of food to the African. *Rhod. Sci. News* **9**, 217–220.
4. Toms R.B. and Nonaka K. (2005). Harvesting of insects in South Africa and Japan—Indigenous knowledge in the classroom. Online: www.scienceinafrica.co.za/
5. DeFoliart G.R. (1995). Edible insects as minilivestock. *Biodiv. Conserv.* **4**, 306–321.
6. Dreyer J.J. and Wehmeyer A.S. (1982). On the nutritive value of mopane worms. *S. Afr. J. Sci.* **78**, 33–35.
7. Greyling M. and Potgieter M. (2004). Mopane worms as a key woodland resource. In *Indigenous Forests and Woodlands in South Africa*, eds M.J. Lawes, H.A.C. Eeley, C.M. Shackleton and B.G.S. Geach, pp. 575–589. University of KwaZulu-Natal Press, Pietermaritzburg.
8. Moruakgomo M.B.W. (1996). Commercial utilization of Botswana's veld products the economics of phane: The dimensions of phane trade. In *Proc. First Multidisciplinary Symposium on Phane, Botswana*, eds B.A. Gashe, K. Leggett, and S.F. Mpuchane, pp. 23–31. Department of Biological Sciences, University of Botswana, and the Kalahari Conservation Society, Gaborone.
9. Dzerefos C.M. (2006). Stinkbessie op die spyskaart. In a nutshell. South African Macadamia Growers Association, Nov/Dec. pp. 4, Tzaneen.
10. Harris L.E. (1970). *Nutrition Research Techniques for Domestic and Wild Animals*, vol. 1, 16th edn (1995). Association of Official Analytical Chemists, Gaithersburg, MD.
11. Einarsson S., Josefsson B. and Lagerkvist S. (1983). Determination of amino acids with 9-fluorenylmethyl chloroformate and reversed-phase high-performance liquid chromatography. *J. Chromatogr.* **282**, 609-618.
12. Smit L.E. and Nel M.M. (1987). Vergelyking tussen

die standaardkoperreduksie, chloramien T-metodes en 'n gewysigde hoÿdrukvloeistofchromatografiese metode vir die bepaling van lactose in melk- en melkprodukte. *S. Afr. J. Dairy Sci.* **19**(2), 62–64.
13. Zasoski R.J. and Burau R.G. (1977). A rapid nitric acid digestion method for multi-element tissue analysis. *Commun. Soil Sci. Plant Anal.* **8**(5), 425–436.
14. Antanasopoulos N.A. (1982). *Flame Methods Manual for Atomic Absorption*. GBC Scientific Equipment, Victoria, Australia.
15. Wimalasiri P. and Wills R.B.H. (1985). Simultaneous analysis of thiamine and riboflavin in foods by high-performance liquid chromatography. *J. Chromatogr.* **318**, 412–416.
16. Dodson R.Y., Young E.R. and Soliman A.M. (1992). Determination of total vitamin C in various food matrixes by liquid chromatography and fluorescence detection. *J. AOAC Int.* **75**(5), 887–891.
17. Manz U. and Philipp K. (1981). A method for the routine determination of tocopherols in animal feed and human foodstuffs with the aid of high-performance liquid chromatography. *Int. J. Vitam. Nutr. Res.* **51**, 342–348.
18. DeFoliart G.R. (1999). Insects as food: Why the western attitude is important. *Ann. Rev. Entomol.* **44**, 21–50.
19. Beach E.F., Munks B. and Robinson A. (1943). The amino acid composition of animal tissue protein. *J. Biol. Chem.* **1**, 431–439.
20. Ramos-Elorduy J., Moreno J.M.P., Prado E.E., Perez M.A., Otero J.L. and de Guevara O.L. (1997). Nutritional value of edible insects from the State of Oaxaca, Mexico. *J. Food Compost. Anal.* **10**, 142–157.
21. Quin P.J. (1959). *Foods and Feeding Habits of the Pedi.* Witwatersrand University Press, Johannesburg.
22. Gullan P.J. and Cranston P.S. (1986). In *The Insects: an Outline of Entomology,* 3rd edn, chap. 1, pp. 1–19. Blackwell, California.
23. Janaiah C., Rao P.S., Chari N and Reddy P.V. (1979). Chemical composition of the scent glands of adults and nymphs of the bug *Tessaratoma javanica* Thunberg. *Indian J. Exp. Biol.* **17**, 1233–1235.
24. Mpuchane S., Gashe B.A., Allotey J., Siame B., Teferra G. and Dithlogo M. (2000). Quality deterioration of phane, the edible caterpillar of an emperor moth *Imbrasia belina. Food Contr.* **11**, 453–458.

This article is accompanied by a supplementary table online at www.sajs.co.za

Appendix

We analysed dried bugs purchased at Thohoyandou from harvesters who collected them in the mountains around Modjadji village in Limpopo province during winter (May–August 2004) at dawn or dusk, when it is cold and the animals' metabolic rates are low. Our results therefore reflect the composition of the market material. The bugs were kept in a freezer until needed for analysis. It is necessary to record the traditional method of preparing the insects for eating, as this influences the nutritional results.

Indigenous technology in insect preparation. The insects are inedible without pre-treatment. The first step in preparing as food was to separate all dead stink-bugs, leaves and debris from the live insects. The live animals were placed in a bucket with a small amount of warm water and stirred with a wooden spoon. During the stirring, the bugs release a defensive secretion with a strong odour. This has an offensive smell and irritates human eyes, so the collectors close their eyes for protection. The bugs were rinsed with warm water and the process was repeated about three times, although some people shorten the procedure. When the smell (defensive secretion) has been removed, the insects are blanched briefly in hot water and dried in the sun. The dead stink-bugs collected were not processed in this way, as they are unable to release the defensive secretions and are therefore prepared differently or used for different purposes. In an alternative procedure for the dead insects, the heads were removed and the thorax and abdomen squeezed between thumb and index finger. The translucent pale green gland was exuded through the neck of the dead animal and wiped off on a stone. After the bugs were sun-dried, the original dead insects, which were missed in the first sorting, are easily identifiable during subsequent quality control; their surface and contents are blackened, probably by the effusion of the stink glands. They were therefore rejected for human consumption in the normal way, but, according to some, may be used as a cure for hangovers.[9] The dried bugs are ready to be eaten either raw or cooked.

Nutritional analysis of insects. The traditionally prepared *thongolifha* were ground and 100 g material was analysed using standard procedures for the assessment of the nutritional qualities of food at the Analytical Services laboratory of the Agricultural Research Council at Irene, which forms part of the South African National Accreditation System. The following tests were conducted and procedures followed as indicated briefly below.

Determination of macronutrients and amino acids. The method of Harris[10] was used to determine the ash content of the insects. Organic matter was removed by heating at 550°C overnight and the remaining residue was the ash. An Allihan Condenser Soxhlet extraction apparatus was used to determine fat content with ether as extractant. The ether was evaporated and the fat was left inside the beaker. The weight gained was used to calculate the fat content.

The analysis of amino acids after acid hydrolysis extraction, pre-column derivatization, separation by HPLC and detection by fluorescence was employed to determine the composition of proteins and peptides.[11] Protein in the stink-bug material was extracted and further precipitated with tungstate; the concentration of the different carbohydrates in the filtrate was determined by HPLC in terms of refractive index.[12] A factor of 6.25 was used to convert nitrogen content to protein.

Determination of minerals. Edible stink-bug (1 g) was digested with 7 ml concentrated nitric acid and 3 ml perchloric acid at temperatures up to 200°C and made up to volume in a 100-ml volumetric flask.[13] For potassium and sodium, an aliquot of the digested solution was subjected to flame emission spectroscopy in a liquid petroleum gas–air flame using lithium as an internal standard. To determine iron and zinc minerals, the digest solution was subjected to atomic absorption spectrometry using an air–acetylene flame at wavelengths of 248.3 and 213.9 nm, respectively. For calcium, an aliquot of the solution was subjected to atomic absorption spectrometry in a nitrous oxide–acetylene flame, using a wavelength of 422.7 nm.[14]

Determination of vitamins: Thiamine (vitamin B_1) and riboflavin (vitamin B_2) were determined by HPLC.[15] Vitamin C was sought using acetic acid and meta-phosphoric acid, followed by determination with HPLC using fluorescence.[16] Alkaline saponification of the test material involved elimination of fats, liberation of natural retinol in the cells and hydrolysis of added vitamin A. Unsaponifiable matter was extracted with ether, and vitamin A was determined by HPLC and detected using UV and fluorescence, respectively.[17]

Supplementary material to:

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Table 5. Percentage of protein of different essential amino acids of *Encosternum delegorguei* compared to that of beef and chicken.

Essential amino acids	Methionine	Phenylalanine	Threonine	Tryptophan	Lysine
E. delegorguei	1.1	2.3	2.3	0.4	2.4
Beef*	3.1	4.9	4.5	1.4	8.1
Chicken*	3.2	3.8	4.6	1.3	8.4

*From ref. 19.