

Insect products for high-value Western markets

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Despite widespread resistance to eating insects in Western countries, there has been a recent resurgence of interest in entomophagy and the sale of insects. This paper outlines some of the insect-based dishes being developed by restaurants in Europe and the sale of high-value insects as snack foods, novelty foods or gifts in Western markets. With continuing uptake of internet access, it is now possible for small-scale insect processors worldwide to gain direct access to retail buyers and consumers in the high-value markets of industrialized countries.

Keywords: entomophagy, edible insects, food ingredients, snack foods, novelty foods, gifts, Western markets

ENTOMOPHAGY IS WIDESPREAD IN MANY Asian, Latin American, African, Caribbean, and Pacific countries, where the processing of insects into food ingredients and snack foods is a profitable small-scale activity (Table 1). However, consumer acceptance in Western industrialized countries is more limited, owing to a widespread resistance to eating insects (although this is an acquired abhorrence as children often eat them willingly). Despite this, there are developments targeting potentially high-value Western markets through the sale of insects to consumers, either as components of meals or as snack foods, novelty foods or gifts. These products are unique or significantly different from other foods or gifts and as a result consumers are willing to pay higher prices in niche or specialist markets (e.g. high quality restaurants or novelty gift outlets).

Insect consumption has periodically been promoted in Western countries over the last 50 years and there is a current resurgence of interest. The EU is investing more than US\$4 m to research entomophagy as a human protein source (Schultz, 2012) and the FAO is proposing to create an 'International Society of Producers of Insects as Food and Feed' to develop a code of practice and standards. Special FAO meetings were held in 2012, 2013, and 2014 to plan the further development and commercialization of insect foods (FAO, 2013a,b).

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Table 1 Examples of edible insects

<i>Edible insect</i>	<i>Notes</i>
Agave worms	Larvae added to tequila and also eaten with a meal in Mexico
Bamboo worms	Larvae of the grass moth dried or fried by street vendors in Thailand and packed for international sales
Bee larvae	Sautéed, baked or deep fried in many countries. Also covered in chocolate as a gourmet item in Mexico
Centipedes	Eaten as a street food in China
Cicadas	Skewered and deep fried in the USA, Japan, Thailand, and Malaysia
Cockroaches	Toasted, fried, sautéed or boiled
Crickets	Roasted, fried, sautéed and boiled in Mexico, Thailand and Cambodia
Dragonflies and damselflies	Adults or larvae boiled in coconut milk with ginger and garlic, grilled or fried in Indonesia and China
Dung beetles	Dried and seasoned, fried in South America
Escamoles ants	Larvae known as ‘insect caviar’, served in guacamole or sautéed in Mexico
Flying ant queens	Roasted with salt and lime juice in Guatemala
Golden orb and giant wood spiders	Eaten raw, or roasted in a green bamboo tube over a fire
Grasshoppers and locusts	Eaten dried without wings and legs, roasted with chilli and lime in Mexico, ‘Nsenene’ is a fried Ugandan delicacy
June bugs	Larval and adult stages roasted as snack foods
Kanni	Caterpillars collected from shea butter trees, squeezed to retain esteemed yellow liquid, then boiled and dried. An ingredient in vegetable soup in some African countries
Leafcutter ants	Eaten toasted as ‘popcorn’ in South America
Mealworms	Larvae boiled, sautéed, roasted, or fried
Midge flies	Pressed into solid blocks and cooked into ‘Kunga cake’ in East Africa
Mopane worms	Processed commercially in southern Africa
Mosquito eggs	Dried and roasted, wrapped in a tortilla or served with lime or lemon in Mexico
Praying mantis	Eaten when young and tender, usually fried
Rhino beetle	Adults and larvae eaten fried, grilled, roasted, and stewed
Sago grubs	Larvae fried as a delicacy in Malaysia and Indonesia. Cooked in sago flour and wrapped in a sago palm leaf in Borneo and Papua New Guinea
Sapelli caterpillars	A delicacy valued for their flavour, dried and eaten in Africa
Scorpions	Skewered and fried in Thailand and China
Silk worms	Sold by street vendors in most of Asia and also canned for export
Tarantulas	Cooked with salt, oil, sugar, and garlic in Cambodia
Termites	Eaten raw in Kenya, roasted in West Africa
Wasps	Adults and larvae boiled, sautéed, roasted or fried
Water bugs	Eaten whole, steamed or fried, and an ingredient in Thai sauces
Waxworms	Larvae roasted or sautéed
Weaver ant eggs	Eaten directly. Adults are sour and mixed with rice for flavouring. Also used to make a drink in Thailand and the Philippines

Source: adapted from FAO, 2013a; Martin, 2013; and Deane, 2013

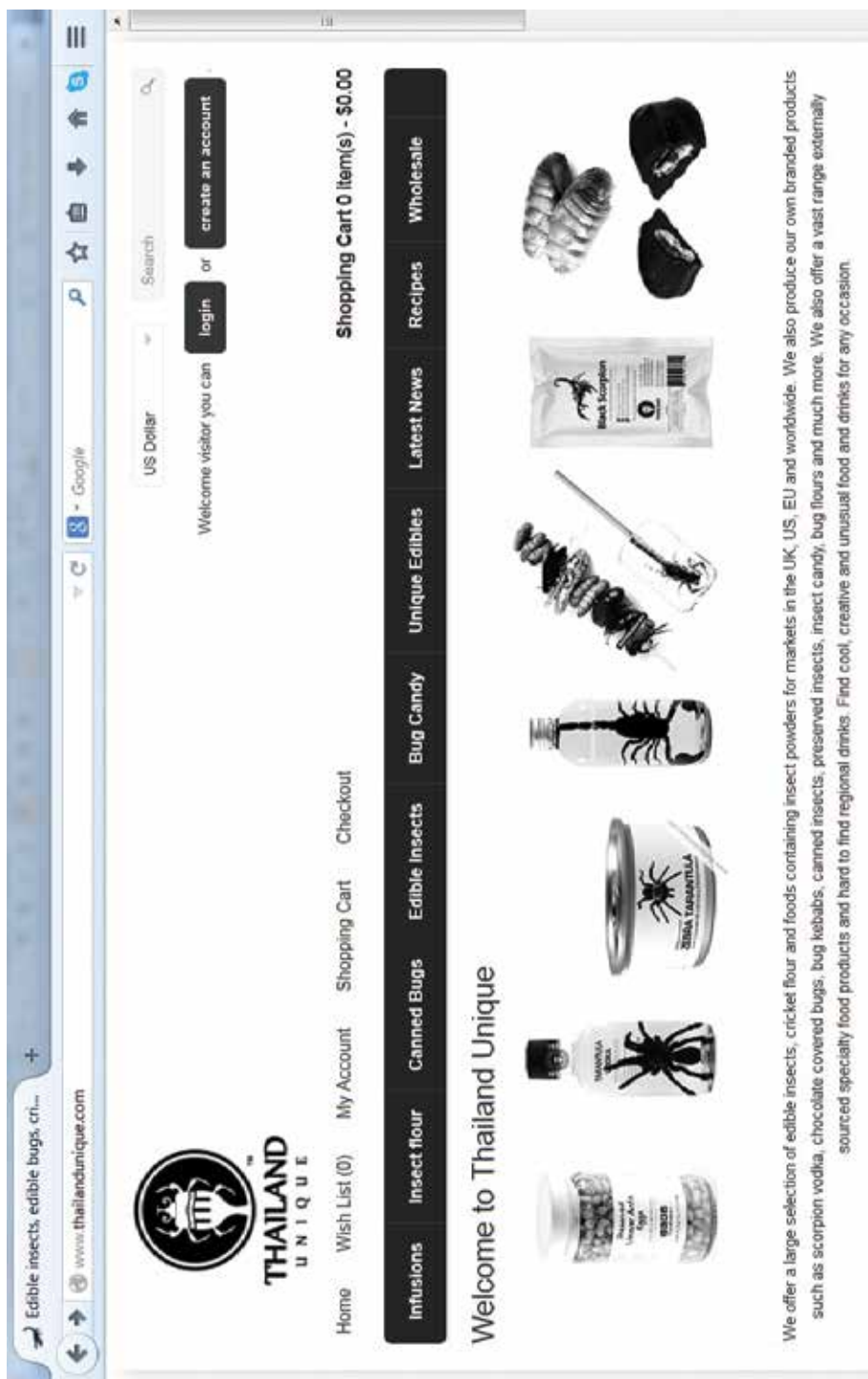


Figure 1 Screen-grab of website selling insect products

Source: Thailand Unique website

With the increasingly widespread uptake of internet access, it is now possible for small-scale processors in all countries to gain direct access to the highest value market of retail buyers and consumers in industrialized countries and a number of insect producers are already benefiting from internet promotion and sales (e.g. Figure 1, novelty insect products from Thailand). The expansion of training and education in computing and information technology by universities in many developing countries could lead to a rapid increase in the numbers of small-scale insect processors who can use the internet to access international markets.

Insects as components of meals

Insects are used as novelty dishes in some high-quality Western restaurants (e.g. The Archipelago, London) (Schofield, 2013; AFP, 2013), including mealworm faux caviar, pan-fried locusts and crickets, and locusts that are baked until they are crisp and mixed with chilli and garlic or ginger. Restaurant chefs report crisp insects to be more acceptable than 'anything that is soft and squidgy', which customers tend to be squeamish about (Smithers, 2011). Many dishes therefore do not resemble their insect source (e.g. sushi-style cubes, minced crickets, caterpillar croquettes, dried grasshopper paste) (Eddy, 2012). There has been some success in commercializing processed insects for human consumption in the Netherlands, including three insect species: yellow mealworm larvae, lesser mealworm larvae, and locusts. Dutch insect breeders who previously supplied insects for pet foods have seen a new market opportunity and, with government backing, have founded a trade organization to promote the concept. It intends to prepare legislation governing insect farms, health and safety standards, and marketing through retail outlets.

'Ento' resulted from a postgraduate project at the Royal College of Art and Imperial College London, UK, on the issues surrounding the introduction of insects into Western diets (Dasan et al., 2012). The research found that most people could accept dishes in which the insect parts were not identifiable, such as biscuits made from insect flour. Even a layer of breadcrumbs was sufficient for many people to find whole insects acceptable. Adding insects to existing recipes, such as cricket falafel or insect sushi, produced mixed responses. The team modified a food pairing database (Foodpairing website) and substituted insects for close flavour matches (e.g. baked waxworms taste like roasted pistachio nuts). Using this method they produced more than 70 insect ingredients that could be used to create new recipes. The **Nordic Food Lab** was established by the founders of Restaurant Noma in Copenhagen and has specialized in insect cuisine, working with entomologists to find creative ways of making insects not only acceptable to Western tastes but also celebrated for their gastronomic value (Nordic Food Lab website). The increased interest in entomophagy has also spawned a series of cookbooks with recipes that use insect ingredients (e.g. Ramos-Elorduy, 1998; George Gordon, 2013; van Huis et al., 2014; Lang, 2013).

Snack foods and novelty gifts

There are traditional seasonal markets for insect snack foods in many countries (Table 1). Insects are often fried or roasted and sold by street food sellers or in local marketplaces. A well-known example is the mopane (or mopani) worm (Figure 2). The ‘worms’ are large edible caterpillars of the emperor moth (*Goniimbrasia* (or *Imbrasia*) *belina*) that feed on mopane trees (*Colophospermum mopane*) in southern Africa. They are collected from the wild and the picker pinches the tail end to rupture the innards and then squeezes the worm to expel the gut contents (Mukwazhi, 2013). During the harvest season, from November to January, hundreds of people are employed to hand-pick caterpillars from the trees. In some areas the lack of a sustainable approach to commercial worm farming has led to over-harvesting, and captive breeding projects (e.g. at the University of Pretoria) aim to ensure the preservation of wild stocks (DFID, 2005). Farming mopane worms is low-cost, low-maintenance, and produces a profitable harvest, with 3 kilograms of mopane leaves yielding 1 kilogram of worms (Toms et al., 2002).

Traditionally they are preserved by sun-drying or by smoking to produce additional flavours. Demand is very high and the dried worms are eaten as a crisp snack, or soaked to rehydrate them before frying them until they are crunchy. The worms are also processed at a larger-scale, canning them in brine, in tomato sauce or chilli sauce to enhance the flavour. The harvesting and sale of mopane worms is a multi-million dollar industry in southern Africa (*The Hindu*, 2013); the main producing countries are Botswana, Namibia, South Africa, and Zimbabwe. It is estimated that South Africa alone trades 1.6 million kg of mopane worms annually (Banda, 2012). The canned product is distributed to supermarkets, shops, hotels, and restaurants and dried products are also exported and sold via the internet for a retail price of ≈£15.95 per pack of 40 g (equivalent to ≈\$600/kg) (see Harvey Nichols and Firebox websites).

A Netherlands company has introduced insect foods for retail sale, including chocolate pieces containing ground mealworms and cricket snack foods, an Asian vegetable dish with mixed crickets, and nuggets that contain 80 per cent ground chicken and 20 per cent ground mealworms (Tagliabue, 2011). ‘Buqadilla’ is an innovative spicy Mexican snack food made of



Figure 2 Retail packs of dried mopane worms
Source: Edible website, product information

chickpeas and lesser mealworms that is under development for the Dutch market. It was well received in several restaurants where it was tested (van Huis et al., 2014). 'Crikizz' are spicy, popped snacks based on 10–20 per cent mealworms and cassava, developed by Ynsect and French students (FAO, 2013a). According to focus groups, the taste is pleasant and the texture is as crunchy as other snack foods. 'Larvets' are farm-raised larvae, available in BBQ, Cheddar cheese or Mexican spice flavours and 'Crick-ettes' are seasoned crickets available in salt and vinegar, bacon and Cheddar cheese or sour cream and onion flavours (Figure 3).



Figure 4 Insects as gifts: cricket lolly
Source: Hotlix website



Figure 3 'Larvets' insect snack food
Source: Hotlix website

In the USA and Europe, eating insects has increased as a curiosity niche food sector. These insects are marketed as high-value novelty foods and gifts (Table 2). For example, specialist suppliers (e.g. Edible) sell a range of delicacies including Thai curry crickets, oven-baked tarantula, scorpion or cricket lollies (Figure 4), dried crickets, and BBQ worm crisps that are sold via the internet and also stocked by large retailers (e.g. Selfridges and Harvey Nichols). An increasing number of customers are willing to try new products and sales are strong, having grown by 20 per cent in 2012 (Smithers, 2011).

Table 2 Retail prices for different types of insect snack foods, novelty foods, and gifts

<i>Product</i>	<i>Retail price</i>	<i>Price (US\$ per unit)</i>
Mopane worms	£15.95/40 g	598.12/kg
Amber scorpion candy	£4.25 each	6.37 each
Banana-flavoured lollipop with a real scorpion	£3.39 each	5.08 each
Freeze-dried grasshoppers	£54.82/100 g	822.30/kg
Tarantula in resin	£33.90 each	50.85 each
Frozen waxmoths	€30.86/500 g	80.24/kg
Frozen crickets	€9.24/200 g	60.06/kg
Freeze-dried mealworms	€5.65/50 g	149.90/kg
Freeze-dried crickets	€9.45/50 g	245.70/kg
5 assorted bugs (sago worm, silk worm, big cricket, grasshopper, and weaver ant)	\$5.60/10 g	560.00/kg
Chocolate-covered silkworm pupae	\$4.80 each	4.80 each
Giant water scorpions	\$5.90/ 20 g (1 or 2 scorpions)	295.00/kg
Rhino beetles	\$5.60/20 g (2 or 3 beetles)	280.00/kg
Water scorpion chilli dipping paste	\$2.57/ ≈175 g	14.68/kg
Bamboo worm vodka	\$8.99 /75 ml	119.86/l
Winged flying termites	\$5.60/20 g	280.00/kg
Scorpion-infused vodka	\$9.99/70 ml	142.70/l
Chinese armour tail scorpions	\$7.99 (for 3 scorpions ≈20 g)	399.50/kg

Note: Retail prices at March 2013. Currency conversions: £1 = US\$1.5, €1 = US\$1.3

Source: Harvey Nichols, Trau-dich, Kreca, and Thailand Unique websites; Fellows and Axtell (in press)

Quality and safety standards

Because of their long history of consumption, it is generally believed that edible insects do not pose a significant health risk and are safe to eat. At present, there are few quality standards or legal issues surrounding the sale of insects. Fresh insects, like other foods, are rich in nutrients and moisture that allow microbial growth and they require processing by boiling, drying, roasting or frying to preserve them. Insects can also become contaminated during processing and handling and strict hygienic practices are required (Amadi et al., 2005; Giaccone, 2005). Safe products are produced by applying quality assurance and HACCP (hazard analysis and critical control point) methods in the same way as other types of food processing. To ensure good microbiological quality, insects should be processed quickly after harvesting and stored in a cool, dry place. Rapid processing and packaging also reduces the risk of post-harvest microbial contamination, and hygienic handling throughout

the process is important to prevent re-contamination and cross-contamination (Klunder et al., 2012). Removing a large proportion of the water in insects by drying, roasting or frying limits the growth of most microorganisms but in humid areas dried insects are susceptible to moisture pick-up, which can then result in bacterial or mould growth. The packaging materials should therefore have a sufficiently high moisture barrier. Because of its commercial importance, the mopane worm has been studied in more detail than other insects. Caterpillars were found to be contaminated with moulds and mycotoxins (Mpuchane et al., 1996), and it was concluded that frequent consumption of infected foods over long periods was likely to pose health risks. However, it is likely that contamination was caused by poor quality water, flies, and soil.

Where insects are consumed whole, this usually includes their gut microflora. Little is known about the gut microorganisms in insects and the possible presence of pathogens, viruses, and toxins that could pose a danger when eaten. However, in general, insect pathogens have been found to differ from vertebrate pathogens and are regarded as harmless to humans.

Processing and eating insects might also cause allergic reactions in people who are sensitive to specific proteins and the allergenicity of insects should therefore be tested. The application of pesticides to kill wild insects is an issue that should be considered when these are collected for food. Many countries do not have policies controlling the use of agri-chemicals in areas where people collect edible insects and collection takes place with little knowledge of the consequences of eating chemically treated insects (Ayieko et al., 2012). Insect farming allows greater control over hygienic practices and the use of safe feeds, which reduces potential toxicological and microbiological hazards. Management strategies are needed to prevent insect diseases from occurring and risk guidelines and sanitary standards need to be established for each species. When using waste materials as feed, their safety from pathogens, contaminants, and heavy metals needs to be assured. Regulations and quality control guidelines for insect-based feeds and foods are yet to be developed.

References

- AFP (2013) 'Chefs from famous Danish restaurant cook giant cockroach', Daily News [online] <www.nydailynews.com/life-style/eats/chefs-famous-danish-restaurant-cook-cockroach-article-1.1313714> [accessed 3 June 2014].
- Amadi, E.N., Ogbalu, O.K., Barimalaa, I.S. and Pius, M. (2005) 'Microbiology and nutritional composition of an edible larva (*Bunaea alcinoe* Stoll) of the Niger Delta', *Journal of Food Safety* 25: 193–7 <<http://dx.doi.org/10.1111/j.1745-4565.2005.00577.x>>.
- AP (2013) 'Mopane worm, crunchy and yummy!', *The Hindu*, 26 January 2013 [online] <www.thehindu.com/todays-paper/tp-in-school/mopane-worm-crunchy-and-yummy/article4346177.ece> [accessed 3 June 2014].
- Ayieko, M.A., Kinyuru, J.N., Ndong'a, M.F. and Kenji, G.M. (2012) 'Nutritional value and consumption of black ants (*Carebara vidua* Smith) from the Lake Victoria region in Kenya', *Advance Journal of Food Science and Technology* 4(1): 39–45.

- Banda, I. (2012) 'Zimbabwe's mopani worms disappearing from rural diets', Inter-Press Service News Agency [online] <www.ipsnews.net/2012/03/zimbabwersquos-mopani-worms-disappearing-from-rural-diets/> [accessed 3 June 2014].
- Dasan, A., Chung, J., Aguirre-Bielschowsky, J. and Fraser, J. (2012) 'Case study: Ento, the art of eating insects' [online], Core77 <www.core77.com/blog/case_study/case_study_ento_the_art_of_eating_insects_21841.asp> [accessed 3 June 2014].
- Deane, G. (2013) 'Bug-a-boo's or grubs up' [online], Eat the Weeds <www.eattheweeds.com/bug-a-boos-or-grubs-up/> [accessed 3 June 2014].
- DFID (2005) 'Mopane woodlands and the Mopane worm: enhancing rural livelihoods and resource sustainability' [online], London: DFID <<http://r4d.dfid.gov.uk/Project/2943/>> [accessed 3 June 2014].
- Eddy, M. (2012) 'These insect-based foods actually look pretty good' [online], The Mary Sue <www.geekosystem.com/ento-is-food-from-bugs> [accessed 3 June 2014].
- FAO (2013a) 'Insects for food and feed' [online] <www.fao.org/forestry/edibleinsects/65425/en/> [accessed 3 June 2014].
- FAO (2013b) 'Processing edible insects for food and feed', in *Edible Insects: Future Prospects for Food and Feed Security*, FAO Forestry Paper 171, Chapter 9 [pdf], Rome: FAO <www.fao.org/docrep/018/i3253e/i3253e00.htm> [accessed 3 June 2014].
- Fellows, P.J. and Axtell, B.L. (in press) *Opportunities in Food Processing: A Handbook for Setting Up and Running a Small-Scale Business Producing High-Value Foods*, Wageningen, The Netherlands: CTA.
- George Gordon, D., (2013) *The Eat-a-Bug Cookbook, Revised: 40 Ways to Cook Crickets, Grasshoppers, Ants, Water Bugs, Spiders, Centipedes, and their Kin*, New York: Ten Speed Press.
- Giaccone, V. (2005) 'Hygiene and health features of "minilivestock"', in M.G. Paoletti (ed.), *Ecological Implications of Minilivestock: Role of Rodents, Frogs, Snails, and Insects for Sustainable Development*, pp. 579–98, New Hampshire: Science Publishers.
- Klunder, H.C., Wolkers-Rooijackers, J., Korpela, J.M. and Nout, M.J.R. (2012) 'Microbiological aspects of processing and storage of edible insects', *Food Control* 26(2): 628–31 <<http://dx.doi.org/10.1016/j.foodcont.2012.02.013>>.
- Lang, E. (2013) *Eating Insects as Food*, New York: IBM Publishing.
- Martin, D. (2013) 'Girl meets bug. Edible insects: the eco-logical alternative' [online], <<http://edibug.wordpress.com/list-of-edible-insects/>> [accessed 3 June 2014].
- Mpuchane, S., Taligoola, H.K. and Gashe, B.A. (1996) 'Fungi associates with *Imbrasia belina*, an edible grasshopper', *Botswana Notes and Records* 28: 193–7.
- Mukwazhi, T. (2013) 'Worms! A look at Zimbabwe's favorite snack: mopane worms', *New York Daily News*, 25 January 2013 [online] <www.nydailynews.com/life-style/eats/zimbabwe-favorite-snack-mopane-worms-article-1.1247669> [accessed 3 June 2014].
- Ramos-Elorduy, J. (1998) *Creepy Crawly Cuisine: The Gourmet Guide to Edible Insects*, South Paris, ME: Park Street Press.
- Schofield, H. (2013) 'Insect eating creeps on to Paris menus', *BBC News Magazine*, 20 November 2013 [online] <www.bbc.co.uk/news/magazine-24912602> [accessed 3 June 2014].
- Schultz, T. (2012) 'Time For a "bug mac"? The Dutch aim to make insects more palatable', *The Salt*, 11 April 2012 [online] <www.npr.org/blogs/thesalt/2012/04/11/150354933> [accessed 3 June 2014].

Smithers, R. (2011) 'Insects will be important part of UK diet by 2020, says scientist', the Guardian.com, Thursday 31 March [online] <www.theguardian.com/environment/2011/mar/31/insects-uk-diet-2020> [accessed 3 June 2014].

Tagliabue, J. (2011) 'Insects as food? Trying to change "ick" to "yum"', *New York Times*, 14 March 2011 [online] <www.nytimes.com/2011/03/15/world/europe/15bugs.html?pagewanted=all&_r=0> [accessed 3 June 2014].

Toms, R.B., Thagwana, M.P. and Lithole, K.D. (2002) 'The mopane worm: indigenous knowledge in the classroom', *Science in Africa* [online] <www.sciencein africa.co.za/2003/june/mopane.htm> [accessed 1 November 2013].

van Huis, A., van Gurp, H. and Dicke, M. (2014) *The Insect Cookbook: Food for a Sustainable Planet (Arts and Traditions of the Table: Perspectives on Culinary History)*, New York: Columbia University Press.

Websites

'Edible', product information <www.harveynichols.com/brand/edible-/> [accessed 3 June 2014].

Firebox, edible mopani worms, company information <www.firebox.com/product/5324/Mopane-Worms> [accessed 3 June 2014].

Foodpairing, information on food pairing from Sense for Taste <www.foodpairing.com> [accessed 3 June 2014].

Harvey Nichols, edible mopani worms, company information <www.harveynichols.com/search/mopani> [accessed 3 June 2014].

Hotlix, product information <www.hotlix.com/candy/> [accessed 3 June 2014].

Kreca, freeze dried insects, product information <www.kreca.eu/default.asp?pageid=35&webgroupfilter=4> [accessed 3 June 2014].

Nordic Food Lab <<http://nordicfoodlab.org/>> [accessed 4 June 2014].

Selfridges, 'Edible' product information <www.selfridges.com/en/Food-Wine/Brand-rooms/Gourmet-brands/EDIBLE/?brandname=EDIBLE&departmentId=19943> [accessed 3 June 2014].

Thailand Unique, product information <www.thailandunique.com/> [accessed 3 June 2014].

The Archipelago, <www.archipelago-restaurant.co.uk> [accessed 3 June 2014].

Trau-dich, product information <www.trau-dich-shop.com> [accessed 3 June 2014].