Forest insects as food: humans bite back

Proceedings of a workshop on Asia-Pacific resources and their potential for development

19-21 February 2008, Chiang Mai, Thailand

Edited by

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
REGIONAL OFFICE FOR ASIA AND THE PACIFIC

Bangkok, Thailand 2010
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Edible insects in Thailand: nutritional values and health concerns

Jintana Yhong-aree

Edible insects should be considered not only for their nutrient content, but also for their nostalgic value to consumers. In the past, insects were commonly eaten by people in the north and northeast of Thailand. Nowadays, they are even eaten by urban dwellers throughout the country. In general, there are three main groups of insect eaters: (1) indigenous consumers from the northern and northeastern provinces (some of whom have migrated to other parts of the country); (2) consumers in urban areas who learn about and later develop a taste for insect foods; and (3) foreign tourists attracted by different insects prepared and sold in tourist spots.

Although over 50 species of insects are reported to be commonly eaten in Thailand, not all of them have had their nutritive values determined. The Institute of Nutrition at Mahidol University has analysed the nutrient contents of only those insects that are most commonly eaten. These include groups of ants, bees, beetles, bugs, cicadas, crickets, locusts, moths and termites. Edible insects are good sources of protein, fat, calories and micronutrients. The amino acid score of silkworm pupae reaches 100, followed by bamboo caterpillars (77.3), house crickets (68.7), wasps (59.4), Bombay locusts (55.8) and scarab beetles (54.3). Insects having an optimal ratio of fatty acid are house crickets, short-tailed crickets, Bombay locusts and scarab beetles.

Methods of preparation play a part in determining the nutritional values of insects for consumers. In Thai cuisine, there are 13 techniques for cooking insects, grouped into singeing (precooking), cooking in oil (frying, sauteing) and oil-free cooking (paste, soup, curry, poaching, steaming and hot salad). Recently, insect fritters, burgers and sandwiches have become popular and in high demand among non-indigenous consumers, especially in urban and tourist centres. These new methods possibly increase the caloric intake of consumers. Excessive consumption of insects may fill the stomach with chitin and chitosan, protein and fat, which carry the risk of urinary tract stone formation and development of chronic degenerative disease.

Keywords: chitin, chitosan, cuisine, nutritive value, protein, stone diseases, traditional food

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Introduction

Insects are commonly used and consumed in a variety of ways: (1) as part of regular diets; (2) as famine or survival foods; (3) for medicinal purposes; (4) for ritual purposes; and (5) as novelties (Sutton 1995). In hunter-gatherer societies, insects are recognized as food. In modern agricultural societies, insects are generally viewed negatively. But in many cultures in Africa, Asia and Oceania and Latin America, pests such as locusts and grasshoppers are important food items (DeFoliart 1999). Eating insects is not simply the result of poverty or of protein deficiency. In many parts of the world, eating insects is a matter of preference and tradition (Jach 2003; Pemberton 1999). Worldwide, insects have formed part of the cuisine of 113 entomophagous countries, with almost 1 500 known species of edible insects being consumed by over 3 000 different ethnic groups (MacEvitty 2000). In Thailand, approximately 164 species are edible (Lewvanich et al. 2000) and over 50 species are commonly eaten (Watanabe and Satrawaha 1984).

This paper focuses on insects and their role in human nutrition. Grievetti (1997) provides four principles influencing individual food patterns. First, availability of foods, either on a seasonal or regular basis, providing a variety of food supplies to consumers. Second, humans perceive a food item to be edible and become familiar with it. However, familiarity does not necessarily correlate with nutritional quality. Third, individuals select food based upon their personal preferences as to whether they like or dislike it. These are based upon sensory evaluation of past experience with such food. If foods are tasted and liked, consumption is likely to be repeated. The body’s reaction and perception of the taste and aroma of food provide valuable indications about whether or not a specific food should be eaten. The crunchy exoskeleton of insects offers a wondrous taste and induces the consumer to eat it in considerable quantity. But not all potential items identified as fit for consumption are selected. Lastly, expectation follows from exposure, that is, taste (sweet, sour, salty, bitter), colour (hue, intensity), texture (smooth, course) and odour (pleasant vs. unpleasant). Besides the nutrient content, the nutritional values of edible insects are confounded by eating patterns and behaviours, which are complicated issues. Therefore, this paper is not limited to only nutritive value; the aforementioned principles are also applied. Information presented here was obtained from rapid assessments, observations carried out over several years and published sources.

Edible insects: a contribution to economic empowerment

On average, the monthly household income of a Thai farmer is approximately 9 639 Thai baht National Statistics Office 2007). Selling insects could improve the economic status of poor farmers. Unlike other agricultural or food products, there are no national data collected on the contribution of insects to the economic status of Thai farmers. As an income source, bamboo caterpillars and silkworm pupae are popular and are normally expensive. A few decades ago, Watanabe and Satrawaha (1984) reported that silkworm pupae sold for 25 baht per kilogram in rural markets. Nowadays, their market price has increased to 200 to 250 baht per kilogram for bamboo caterpillars and 120 to 150 per kilogram for silkworm pupae.

1 US$1.00 = 33 Thai baht October 2009.)

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As a primary occupation, selling edible insects can be attractive. One of the pioneers of edible insect selling, Mr Nuss T., who has been in this business for 16 years, related that selling edible insects is a job that can be handled singly. It does not need many labourers. Purchasing insects wholesale requires an investment of about 4,000 baht per day for 13 species. Net profit is approximately 1,200 baht per day (or 30 percent). Mr Nuss T. reported that he sells 70 to 80 tonnes of insects per year, and he estimates that the country’s demand may be 2,000 tonnes (Department of Industrial Promotion 2004).

Because of the remarkable increase in demand, supplies of edible insects are even being brought into Thailand from neighbouring countries. For instance, Cambodian farmers collect locusts and trade them at Rong Khlaub Market, a large market on the Thai-Cambodian border. The price is 40 baht per kilogram (Hutsaithong 1996). It has been observed that the quantities of edible insects being imported through this market have increased. Intermediaries trade the insects from that point to other outlets including Bangkok and Phitsanulok. Bangkok is reportedly the largest market.

Availability of edible insects

In Thailand, insect eaters can be found in all regions of the country. In the past, indigenous insect eaters were known to reside mostly in the north and northeast. These people were attuned to the climate and geographical situation. In these regions, insects can be collected from paddy fields, upland and forested areas, natural ponds and streams; some kinds of edible insects are available all year round (Youang-see and Wipatpanich 2005). However, there may be variations of species and volume. Grootaert and Kiatsomthorn (2003) reported that from April to June (peaking in May), ants, termites and beetles are abundant. In this period insects feed on decayed wood and litter. In years of abundant rainfall, the surplus of insects collected from nature adds to the family income of the collectors. Edible insects are commonly found also in urban areas. For instance, Sarapee (2004) listed six Orders, 13 Families and 21 species of edible insects available in urban areas of Surin Province from June 2002 to May 2003. Currently, large quantities, representing 10 to 15 species, are sold in large food outlets such as Klong Tuey and Dhevaj markets in Bangkok.

Edible insects are now increasingly being domesticated. This has been accomplished in a number of countries. In Guangdong, China, water beetles sold in the local markets are hatched locally in special nurseries (Jach 2003). In Thailand, commonly farmed species are crickets and locusts. To promote school nutrition, children are encouraged to raise red ants and giant water bugs. Among the few insects being domesticated, mulberry silkworms and crickets are the most successful (Defoliart 1995), whereas red ants and giant water bugs were unsuccessful for commercial-scale production (Chamjanya et al. 2008).

Consumption of edible insects

The consumption of insects has evolved over the past decades. Worasunwatt et al. (1975) published an account of species of insects used in various local recipes in Northeast Thailand. Nutrition researchers consider these consumed insects as an important source of protein for the native people whose nutritional status is poor (Sirischartkwal and Sungprapag

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1982). Sungprapai and Puwastein (1983) analysed their nutritive values and documented them as an unconventional protein source because they are consumed by native dwellers only, and are not accepted by the Thai people in general. Due to their palatability and status as a delicacy, edible insects have been marketed progressively in public places. More than 200 species were reported to be eaten in the northeastern region (Watanabe and Satrawa 1984).

Because of socio-economic developments, rural people are increasingly migrating to urban areas and bringing their food habits along. Not surprisingly, edible insects have been included. Furthermore, the migrants gradually introduce edible insects as delicacies to people in the new setting. As can be observed, the edible insect is accepted and becomes popular, especially in poor urban communities where insect-eating migrants reside. As a result, Young-see et al. (1997) propose that edible insects should no longer be considered unconventional.

Currently, Young-see and Viwatsanich (2005) divide insect eaters into three groups: (1) indigenous insect eaters, who may reside either in their native areas or have migrated to new locations. (The latter are observed to be deeply attached to insect dishes, considering them to be nostalgic food; (2) the new insect eaters – people who belong to families of insect-eating migrants and have been introduced to insect-eating customs by their parents or relatives (It was observed that young family members more easily accept insect dishes prepared by frying and frittering because they are more delicious;); and (3) many migrants from neighboring countries and tourists scattered around various parts of the country. The former are known to be indigenous insect eaters and the latter are traditional insect eaters as well as new consumers.

Cooking methods and recipes

Collected insects die and spoil quickly and are therefore generally prepared live. Preparation and cooking methods vary with the cultural group (Sutton 1995). In traditional Thai cuisine, indigenous knowledge relates that edible insects should be prepared without using oil. Especially in the northern and northeastern regions, people eat sticky rice as a staple food. In this instance, oil-free dishes are prepared because they are most compatible with their standard meal. Traditionally, oil-free insect recipes include roasting, smoking (or baking), steaming (or homok), poaching, with chili paste, as a hot salad (half cooked) and uncooked/ raw. Typically, among the rural poor, insects are incorporated into a ragout or vegetable dish as well as an ingredient in plain or spicy soups (Young-see et al. 1997).

Oil-cooking of insects, including frying, sautéing and frittering, is considered to be modern Thai insect cuisine, because these cooking techniques have been recently introduced. In addition, they have been disseminated to non-indigenous insect eaters through markets. The oil-based recipes make insect dishes tastier resulting in their becoming more popular in urban areas and tourist destinations. These cooking methods are also commonly used in other cultures as well (Ramons-Ellorduy et al. 1997).

Culinary efforts in the preparation of new insect recipes are directed toward modifications to overcome prejudices against insects. Frittering is a new form of cooking in Thailand and creates a pleasant aroma. Among younger generations of Thai insect eaters, frittering helps to
banish the queasy feeling of the consumer. Flavour is one of the essential determinants by which insects are considered most edible (MacEvilly 2000). Fried and grated insects are further improved by sauces that enhance their delicacy and palatability, especially when they go well with beverages like beer or wine. In addition, edible insects are being prepared in the form of sandwiches, burgers and pizza in order to serve westerners who are familiar with and appreciate these styles of cooking.

It is evident that insect dishes available in Thailand are not only prepared using traditional but also western styles. However, traditional styles such as soup, paste, steaming, etc. are still used for main meals. The western style of preparing edible insects is directed more towards their being consumed as snacks.

**Nutritional values of edible insects**

Data on the nutritive values of insects are important, for they inform consumers about the quality and quantity of their intake. For international comparison, a common yardstick to assess the nutritional value of food is the weight of food, along with its nutrient content (Grigg 1995). Because food analysis is costly, the available data on the nutritive values of edible insects in Thailand have focused on those species which are most commonly eaten.

Nutritive values of insects vary depending upon species, habitats, the growth stage of the insects and methods of cooking. Characteristics of consumers such as gender and food habits contribute to their preferences. Many publications state that edible insects are rich in protein, fat and calories, as well as being good sources of minerals such as iron, calcium and vitamins A, B, B1 and D. Ramses-Ellordy et al. (1997) conducted protein analysis of 78 species of edible insects. On a dry weight basis, protein content was determined to be 15 to 81 percent. Protein digestibility varied from 76 to 98 percent. Wasp had the highest protein content.

Jongjaiath et al (2008) collected samples of seven common edible insects sold in various public markets in Bangkok (Klong Tuse and Dhevej), Khon Kaen and Sakiew (Rongkhao). These markets are well-known as large insect outlets. The results showed high protein content in bamboo caterpillars, silkworm pupae and wasps (Table 1).

Qualitatively, the protein of insects such as silkworm pupae has been analysed and found to be safe for human consumption (Zhou and Han 2006). The contribution of protein to overall human intake varies with the stage of it. insect eaten and the time period of its availability. In the palm weevil, the mature stage has higher protein content than when it is immature (Omotoso and Adedire 2007). In the northwest Amazon, insects provide approximately 5 to 7 percent of total protein intake during the year. Their contribution increases to 12 to 26 percent during May to June when availability peaks (Dufour 1987). This period coincides with the mature stage of insects. Sutton (1995) studied gender differences in insect consumption and found that men consumed more insects than women, contributing to more than three times the protein intake (men: 69 percent, women: 31 percent).

In relation to protein quality, the amino acid profile of edible insects is relevant. Some species may contain enough amino acid to provide the requirements of an adult, such as Mexican
<table>
<thead>
<tr>
<th>Vernacular name</th>
<th>English name</th>
<th>Scientific name</th>
<th>Cal</th>
<th>Prot</th>
<th>Fat</th>
<th>Cal</th>
<th>Prot</th>
<th>Fat</th>
<th>Cal</th>
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<th>Fat</th>
<th>Cal</th>
<th>Prot</th>
<th>Fat</th>
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<td>Mang sub-tao</td>
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<td>Cybister limbatus F.</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Mang ki-nun</td>
<td>Scarab beetles</td>
<td>Heodoliphia sp.</td>
<td>98</td>
<td>18.1</td>
<td>1.8</td>
<td>98</td>
<td>13.4</td>
<td>1.4</td>
<td>215</td>
<td>13.5</td>
<td>12.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jing-need</td>
<td>House crickets</td>
<td>Achatia testaceola Waiter</td>
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<td></td>
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<td></td>
<td></td>
<td>133</td>
<td>18.6</td>
<td>6.0</td>
<td>134</td>
<td>12.9</td>
<td>5.5</td>
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<td>Ji konke</td>
<td>Short-tailed crickets</td>
<td>Brachybruchus portentorius Licht</td>
<td>188</td>
<td>17.5</td>
<td>12.0</td>
<td>126</td>
<td>12.8</td>
<td>5.7</td>
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<td>Mang-kachon</td>
<td>Mole crickets</td>
<td>Gryllotetops efficus Baurini</td>
<td>136</td>
<td>15.5</td>
<td>9.3</td>
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<td></td>
<td></td>
<td>101</td>
<td>11.7</td>
<td>4.3</td>
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<tr>
<td>Mang-silina</td>
<td>Giant water bugs</td>
<td>Lethocerus indicus</td>
<td>182</td>
<td>19.8</td>
<td>8.3</td>
<td>303</td>
<td>22.9</td>
<td>18.8</td>
<td>90</td>
<td>4.3</td>
<td>1.3</td>
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<td>Patunkka</td>
<td>Bombay locusts</td>
<td>Puanga succincta L.</td>
<td>157</td>
<td>27.6</td>
<td>4.7</td>
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<td>20.8</td>
<td>6.1</td>
<td>221</td>
<td>16.6</td>
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<td>Spur-throated grasshoppers</td>
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<td>105</td>
<td>14.3</td>
<td>3.3</td>
<td>290</td>
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<td>Rod-duan</td>
<td>Bamboo caterpillars</td>
<td>Omphisa fuscolenta</td>
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<td>20.4</td>
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<td>25.5</td>
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<td>231</td>
<td>16.1</td>
<td>15.3</td>
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<tr>
<td>Non-nhlay</td>
<td>Silkworm pupae</td>
<td>Bombyx mori L.</td>
<td>152</td>
<td>14.7</td>
<td>8.3</td>
<td>127</td>
<td>12.2</td>
<td>7.0</td>
<td>241</td>
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</tr>
<tr>
<td>Thob</td>
<td>Hornet grubbe</td>
<td>Vespa sp.</td>
<td>140</td>
<td>14.8</td>
<td>6.9</td>
<td>140</td>
<td>14.6</td>
<td>6.8</td>
<td>108</td>
<td>12.1</td>
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</tbody>
</table>

(2) Institute of Nutrition, Mahidol University, Food Composition Database for BMTCAL Program, 2002.
(3) Yongs-anr and Vichitpanich (2003)
<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Amino Acid Content (mg/g)</th>
<th>Essential Amino Acid Content (mg/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acacia bees</td>
<td>Acacia repens</td>
<td>32.1</td>
<td>55.8</td>
</tr>
<tr>
<td>Bombay moths</td>
<td>Platypteryx odorata</td>
<td>21.2</td>
<td>20.2</td>
</tr>
<tr>
<td>Bombay moths</td>
<td>Parafibula divaricata</td>
<td>23.7</td>
<td>26.5</td>
</tr>
<tr>
<td>Buri moths</td>
<td>Crambus orbiculatus</td>
<td>19.3</td>
<td>15.6</td>
</tr>
<tr>
<td>Cutworms</td>
<td>Spodoptera litura</td>
<td>29.2</td>
<td>31.2</td>
</tr>
<tr>
<td>Grasshoppers</td>
<td>Chorthippus parallelus</td>
<td>29.2</td>
<td>31.2</td>
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<tr>
<td>House crickets</td>
<td>Acheta domesticus</td>
<td>30.0</td>
<td>31.0</td>
</tr>
<tr>
<td>Malacosoma</td>
<td>Malacosoma neustria</td>
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<td>30.0</td>
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<tr>
<td>Silkworms</td>
<td>Bombyx mori</td>
<td>22.0</td>
<td>21.0</td>
</tr>
<tr>
<td>Spiders</td>
<td>Steatoda proxima</td>
<td>32.0</td>
<td>33.0</td>
</tr>
<tr>
<td>Scorpions</td>
<td>Heterometrus tergarius</td>
<td>32.0</td>
<td>33.0</td>
</tr>
</tbody>
</table>

Source: For details, see the references provided in the original document.
Edible insects (Ladron de Guerra et al. 1995). Jongjaiithet et al. (2008) published amino acid profiles of six common species of insects eaten in Thailand. Table 2 shows that different species of insects have different profiles of both essential and non-essential amino acids. Among the essential amino acids, leucine is relatively high in all species (50.0–78.5 mg/gram protein). Silkworm pupae contained the most lysine. According to WHO (1985), the amino acid score of silkworm pupae reached 100, followed by bamboo caterpillars (77.5), house crickets (68.7), wasps (53.4), Bombay locusts (55.8) and scarab beetles (34.2).

Fat content: Fat components (crude fat, cholesterol and fatty acids) in edible insects show a similar pattern to protein. Not all edible species of insects are high in fat. Ramos-Elorduy et al. (1997) reported on fat in 78 species of insects and found it ranged from 4.0 to 77.2 percent. Ekpo and Onigbinde (2007) documented unsaturated fatty acid in termites (Macrotermes bellicosus) at 51.02 percent. Jongjaiithet et al. (2008) determined the fat content of seven sample insect species (Tables 1, 3). Bamboo caterpillars and short-tailed crickets are high in fat, followed by silkworm pupae and wasps. As far as nutrition is concerned, fat intake is interpreted based on the optimal ratio among saturated and unsaturated fatty acids. In principle, the optimal ratio of saturated fatty acid to monounsaturated fatty acid and polyunsaturated fatty acid informs the appropriate fat intake. It is recommended that this ratio should be 1:1:1 for these respective components (Whitney and Rolfes 1999). As such, the study shows that fatty acids in house crickets, short-tailed crickets, Bombay locusts and scarab beetles meet the optimal ratio. Apart from fatty acids, cholesterol was analysed. Cholesterol per 100 gram sample is high in house crickets (105 milligrams), followed by Bombay locusts (66 milligrams), scarab beetles (56 milligrams) and bamboo caterpillars (34 milligrams).

Caloric content: As a result of the protein, fat and carbohydrate contents, caloric values can be determined either by calculation or by direct assessment of insect samples. Insects high in fat provide more calories. This was also demonstrated by Ramos-Elorduy et al. (1997) from 78 species of edible insects analysed with caloric content ranging from 293 to 762 Kcal/100 grams. The same patterns were confirmed by Jongjaiithet et al. (2008). The cooking method plays a role in increasing the caloric content of cooked insects. As noted by Basjong et al. (2002), frying insects adds fat to the cooked products, amounting to approximately 13 to 17 gram per 100 grams of insects. Table 1 (columns 2 and 3) shows the remarkable increases of calories in fried insects. It is noted that cooking insects as paste does not contain as many calories because insects are but one of the ingredients is a spicy mix.
<table>
<thead>
<tr>
<th>Common name</th>
<th>Scientific name</th>
<th>Saturated fatty acid (% fatty acid)</th>
<th>Unsaturated fatty acid (% fatty acid)</th>
<th>Cholesterol (mg)</th>
<th>MUFA</th>
<th>PUFA</th>
</tr>
</thead>
<tbody>
<tr>
<td>House crickets</td>
<td>Acheta domestica</td>
<td>36.5</td>
<td>30.1</td>
<td>31.1</td>
<td>105</td>
<td></td>
</tr>
<tr>
<td>Short-tailed crickets</td>
<td>Brachyrupes portentosus</td>
<td>35.8</td>
<td>32.3</td>
<td>29.6</td>
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<tr>
<td>Scarab beetle</td>
<td>Holotrichia sp.</td>
<td>34.3</td>
<td>30.0</td>
<td>32.4</td>
<td>56</td>
<td></td>
</tr>
</tbody>
</table>

MUFA: Monounsaturated fatty acid  
PUFA: Polyunsaturated fatty acid  
NA: Not analysed  
http://www.kku.ac.th/ret_kku/Abstract/AbstractView.aspx?Qld=04458900  

Microelements: Insects are also rich in vitamins A, B, C and minerals such as calcium, iron, phosphorus, potassium, sodium, and magnesium. In the Thailand Food Database (Institute of Nutrition, Mahidol University, 2002), when compared to pork and chicken, the groups of beetles, crickets and locusts have comparable levels of protein, minerals, iron, calcium and vitamins A and B. However, the level of these macroelements varies with the insect species.

Advantages and disadvantages of insect consumption

Despite a positive perception of edible insects as delicacies, and scientific evidence of their nutritional value, edible insects need to be considered in terms of the potential negative consequences of their consumption. In this regard, issues related to the chitin, protein and fat content of edible insects are important.

Chitin is a naturally abundant mucopolysaccharide found in the supporting exoskeletal material of crustaceans, insects, etc. Chitosan is the N-deacetylated derivative of chitin. Chitin and chitosan have a wide range of applications (Majeti and Kumar 2000). Chitin is digested by chitinase. There are two chitinases: acidic mammalian chitinase (AMCase) and chitinase isozymes (chit). Chit is a hydrolytic enzyme produced by microorganisms. In tropical populations with a higher rate of protein malnutrition, AMCase activity is high and could confer increasing resistance against parasitic infection (Padgett et al. 2007). Chitin and chitosan also have a protective effect on candida, an infection caused by yeast (Koide 1998). Chitin and chitosan can bind dietary lipids, resulting in the reduction of plasma cholesterol and triglycerides. Consequently, the intestinal absorption of lipids is reduced (Koide 1998). Majeti and Kumar (2000) also confirm that chitin is a fat trap in the stomach, thereby preventing the trapped fat from absorption. In contrast, chitinase forms gel and traps lipids and other nutrients including fat-soluble vitamins and minerals. As for long-term effects,
chitosan may interfere with and lead to calcium reduction. As a result, bone metabolism and possibly vitamin D absorption may be impair... risk.

There is hesary among medical practitioners working in hospitals in Northeast Thailand that urinary tract stone diseases may be associated with the consumption of edible insects. The mechanism of urinary stone formation is unclear. At the beginning of the twentieth century the percentage of bladder stones was as high as 90 percent in countries such as China and Thailand. In the last few decades the frequency of bladder stones occurrence has sharply decreased (Hesse and Siener 1997). However, health professionals working in насоматоые provinces observe that urinary stone diseases have persisted, for example in Northeast Thailand.

Urinary stone diseases are a painful and costly medical condition to treat (Cohan et al. 1996). About 40 percent of urinary stone sufferers need in-patient treatment, with a relatively high rate of surgery (12.2 percent). Of all urinary tract stones, more than 76 percent consist of calcium oxalate (Hesse and Siener 1997). Most of all, calcium oxalate stones have gained increased importance. Halstead and Valyasevi (1967) reported the urinary stone situation in Ubon Ratchathani Province (the lower northeast) where insects have been eaten commonly. In a sample population of 20,860, 3.8 percent, at one time in their lives, had active urinary stone disease, and 2.6 percent had one or more symptoms suggestive of the disease. The prevalence of urinary stones in urban areas in Ubon Ratchathani was 4.7 per 1,000. Sriviboonlue (1992) documented the prevalence of urinary tract stones in an administrative subdivision of Khon Kaen Province (the upper northeast) as 3.76 per 1,000. The lower rate does not correspond to an improvement of nutrition in this region.

Halstead and Valyasevi (1967) also determined factors associated with urinary tract stone diseases. As far as nutrition is concerned, symptoms of bladder stones occur at a greater rate in water-deprived villages than in villages with ample year-round water supply (20 per 1,000 and 12.3 per 1,000, respectively). A positive correlation also was found between the abundance of fish and the prevalence of bladder stones. The authors note that the problem was inversely related to economic status. In the better-off villages, the rate of bladder stones is higher than in moderate or poor villages (20.4 per 1,000, 10.4 per 1,000 and 8.6 per 1,000, respectively). Halstead and Valyasevi (1967) also observed that the people in the areas studied ate large quantities of vegetables, which may be rich in oxalate, such as wild spinach (pak korne), pak kodone, pak kiew and the leaves of the naturalized leucaina.

In normal individuals, only small amounts of ingested oxalate (about 6 to 14 percent) are absorbed (Hesse et al. 1999). Thus, ingestion of vegetables of high oxalate content in combination with a misbalancing of other nutrients might contribute to the occurrence of the stone diseases. Halstead and Valyasevi (1967), however, do not highlight the quantity of insect intake which has been commonly eaten in the region studied. Not all species of edible insects are high in calcium. Thus, increased dietary oxalate intake (from indigenous vegetables) coupled with low calcium intake leads to a high risk of kidney stone formation (Holmes and Assimos 2004). Moreover, if a person consumes high calcium-containing species, chitosan does not reduce intestinal oxalate absorption (Wolf et al. 2006). Cohan et al. (1993) ascertained that a high calcium diet is associated with a decreased risk of kidney stone formation. The role of dietary oxalate in calcium oxalate kidney stone formation remains unclear.

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The influence of animal protein on the risk of calcium kidney stone formation is uncertain. Robertson et al. (1979) report the overall relative probability of forming urinary stones markedly increased throughout the period of high animal protein ingestion. Curhan et al. (1993) show a positive association between animal protein intake and kidney stones. Hesse and Siener (1997) report that ingesting high levels of animal protein led to the increased metabolism of phenylalanine, tyrosine, cryptophan and hydroxyproline. Consequently, oxalate excretion was observed to increase. Age and gender may contribute to urinary stone formation. Taylor et al. (2004) found a positive association between animal protein intake and kidney stones in men of 40 to 59; however, no association was found in men over 60. Young women are noted to have a low risk of kidney stones (Curhan et al. 2004).

Consuming edible insects that are rich in fat and calories may imply a risk of urinary stone diseases. Overconsumption of fat calories and fat intake leads to obesity, which brings with it the risk of gallstones (Pikley and Mann 1988). Among women, the risk was more than 75 percent greater for those in the highest BMI (Body Mass Index) categories (≥ 32 kg/m²) (Curhan et al. 1998a). Thins et al. (1990) reported that hyperlipidemia is related to gallstones through an elevated triglyceride and cholesterol level. Haffner et al. (1990) showed that diabetes carries a risk of gallstones, even if an individual is not obese.

Publications concerning risk of stone formation due to the effects of vitamins are rarely available. Only Curhan et al. (1999) published a study that supports the theory that the risk of stone formation rises with increasing vitamin C intake.

To date, urinary stone disease has gained increasing significance due to the changes in living conditions, that is, industrialization and malnutrition (Hesse and Siener 1997). However, an industrialized society does not necessarily influence the lifestyle of people in a negative manner. Curhan et al. (1998a) showed that the risk of urinary tract stone formation decreased with the intake of each 240 millilitre serving of beer, wine, coffee, or tea. In contrast, an increase in risk was seen for each 240 millilitre daily serving of grapefruit juice. Taylor et al. (2004) discovered that a low risk of kidney stone formation was found in men younger than 60. This group is assumed to be active alcohol drinkers. As observed, fried and frinteed insects are commonly eaten with beer or wine. Optimistically, perhaps this food and beverage consumption pattern contributes positively to lower the chance of stone formation. Overall, the genesis of stone diseases is a complex process. No single factor explains an evident apparent cause. Another warning of concern from MacEvilly (2000) relates to insects causing allergies; his study suggested that insects should not be eaten with nuts or shellfish as both have been shown to trigger allergic responses in hypersensitive individuals.

In summary, edible insects are generally viewed as good sources of protein, fat, calories, vitamins and minerals. These nutrients, along with chitin, may imply an influence on urinary tract stone diseases directly or indirectly. Although the mechanism is unclear, metabolic disorders as well as malnutrition could be major contributory factors of urinary tract stone formation.
Conclusion

Eating insects has both advantages and disadvantages. Insects are often incorporated in and cooked with other ingredients. If the recipes are properly prepared, they will increase their total nutritional value. For instance, beans can be part of a balanced diet. While edible insects are perceived as an excellent source of protein, fat and vitamins and minerals, many insect eaters today may regard them as a source of these nutrients. Rather, they enjoy edible insects to satisfy the preferences of their palates and as a social function. Many are no longer personally squamish about eating insects when more modern cooking methods (frittering, frying, etc.) are used to add to their taste. The eating behaviour of individuals is influenced by background, cultural traditions and social values. As a result, in general, insect eaters balance the quality of their diet. Well-balanced nutrition is the ideal to strive for. In particular, the nutritional value obtained from insect consumption depends on the species, environmental factors (season, habitat, climate), culture and socio-economics. Unbalanced intake of edible insects possibly brings about obesity, chronic degenerative diseases and urinary stone disease.

In developing countries, agro-ecosystems change rapidly in response to the farmers' perceptions of opportunities and constraints. In most cases, the result of changes leads to apparent vulnerability for environmental abuse. In the past, the insect fauna in Thailand were rich in certain areas such as Na Haew (Grootaert and Kiatsoothorn 2003), an area of high biodiversity. This was due to the people's indigenous knowledge derived from their local culture to value the environment. They realized that insects could provide not only daily food, but simultaneously aid in maintaining diversity of habitats for other life forms. In return, this helps native people survive and sustain their local environment. In remote areas, insects have considerable potential for alleviating nutritional inadequacies. Moreover, some local people can make use of them to generate income.

Criticisms have been leveled about edible insects playing a somewhat mutually exclusive role in both ecosystems and as human food. The fact is that Thailand imports edible insects from neighbouring countries to satisfy domestic demand and consumption. The edible insect scenario presents one of demand exceeding supply. To a degree, the explanation of the combined issues includes the following: (1) As forests provide shade and habitats to organisms, any reduction of the forest cover poses a threat to the insect fauna. So when forestry areas are destroyed, a normal ecosystem becomes unbalanced. As a consequence, the insect fauna are negatively impacted and their availability is diminished. (2) Overharvesting of insects for economic purposes in order to close gaps brought about by urban demand. (3) In certain more remote forest areas, insects may be abundant; however, there may be a lack of insect collectors because many have migrated to the city.

Edible insect consumption is a good example of the interaction between human nutrition and biodiversity. There will be ongoing future use of insects for human nutrition. The question is: How can we ensure supplies, perhaps through development of economically feasible methods of mass rearing edible insects, in combination with efficient and sustainable harvesting of wild insects? The maintenance of biodiversity is important to human health and nutrition (Wahid et al. 1998). As proposed by Toledo and Burlingame (2006), nutrition and biodiversity initiatives provide the very foundation for reducing by half the
proportion of people suffering from hunger by 2015 as envisaged in the Millennium Development Goals.

Literature cited


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244-251.


Today, most edible insects are harvested in the wild and it is only recently that farming of insects for direct human consumption has begun, mainly in Thailand, Laos and Vietnam. Farmed insects can also be found in the USA and the Netherlands, but mainly for purposes other than human consumption. If insects are to become a profitable commodity in Western countries, there is a need for development of safe and efficient mass-rearing systems. Standard methods for determination of nutritional value. Mass-rearing techniques. Trade and value chains. Ethical issues (animal welfare). Entomophagy—the practice of eating insects.