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Short Communication

Nutritional composition of the farmed edible bird's nest (*Collocalia fuciphaga*) in Thailand

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ABSTRACT

This work investigated the chemical and mineral compositions of a farmed edible bird's nest (EBN) of *Collocalia fuciphaga* collected from different regions of Thailand: the Trat province in the east, the Phetchaburi province in the west and the Nakhon Si Thammarat, Satun and Narathiwat provinces in the south. The chemical composition was determined according to official AOAC methods and an inductively coupled plasma-based technique used to analyse the minerals. The results revealed that all of the EBNs examined mainly consisted of protein (61.0–66.9%) with 15.9–31.6 mg/g protein of essential amino acids and carbohydrates (25.4–31.4%). Sulfur-containing essential amino acids (methionine and cysteine) and glutamine were the main amino acid constituents. Major mineral elements detected were sodium (Na), calcium (Ca), magnesium (Mg) and potassium (K). All EBNs appeared to be good sources of Ca and Mg according to the adult dietary reference intake (DRI). The farmed EBNs collected from the Nakhon Si Thammarat and Trat provinces in particular contained sulfur essential amino acids which met the requirement of the reference pattern recommended by FAO/WHO/UNU.

1. Introduction

Edible bird's nest (EBN) is a nest made of salivary secretions from a swiftlet's two sublingual salivary glands (Sankaran, 2001). It has long been used in traditional Chinese medicine and is often regarded as a luxury food item (Oda et al., 1998). People have consumed these bird's nests, made of salivary secretions, for a very long time in China and Southeast Asia. Bird's nests have a cup shape with a white, yellow or red colour. The soup made from bird's nests has a gelatinous texture when dissolved in water. The most commercially exploited EBNs are from the White-nest swiftlet (*Collocalia fuciphaga*, *C. germani*) and the Black-nest swiftlet (*Collocalia maxima*, *C. unicolor*). These birds commonly live in sea caves on the islands and along the coastline of Southeast Asian countries such as Thailand, Indonesia, Malaysia, Vietnam and the Philippines (Lau and Melville, 1994). The large decline in EBN cave yields from overharvesting (Sankaran, 2001), and the continuous increase of the demand and value in recent years, have led to the establishment of EBN farming in many countries (Nugroho and Whendrato, 1996). In Thailand, the price of white EBN being sold by swiftlet farmers has been reported to reach 65,000 Baht (~2170 US$) per kilogram with its total export value at around 126 million Baht (~4.2 million US$) a year (Jory and Saengthong, 2007).

Usually located near the shore, swiflets are raised and bred in a house-like structure which can simulate the conditions of a cave with only small holes to enter and exit. Vents and windows are boarded up. The first harvest begins before the swiftlets lay eggs. Subsequently the birds will construct a new nest within 4–5 weeks. After this nest is harvested, another 3 months will be allowed to pass before the third nests are ready for harvesting for the last time that year (Kang et al., 1991).

In contrast to the rapid growth of the EBN's demand and value, scientific investigation on the medicinal and nutritional properties EBN is still limited, especially given the fact that these properties appear to vary with the time of the harvest and the location (Norhayati et al., 2010). This has opened up the opportunity for an adulteration of EBNs during processing with less expensive materials such as karaya gum, red seaweed and *Tremella* fungus (Marcone, 2005). Medicinally, an extract of EBN was reported to inhibit an influenza virus infection (Guo et al., 2006) and enhance the epidermal growth factor (Kong et al., 1987). In addition, estradiol hormones have been reported to be found in EBNs (Ma and Liu, 2012). These hormones are beneficial for women because low oestrogen levels lead to an elevated rate of menstrual dysfunctions such as amenorrhea and irregular menstruation (Bergemann et al., 2005).

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The composition of EBNs collected from some areas in Malaysia and Indonesia has already been reported (Marcone, 2005; Norhayati et al., 2010). Because the EBN nutrient composition may be affected by breeding sites, climate and bird food intake (Norhayati et al., 2010), this paper intends to investigate the chemical and mineral compositions of the farmed EBNs collected from various locations in Thailand.

2. Materials and methods

2.1. Sample collection and preparation

EBN samples were collected from June to October 2010 from five EBN farms located in the eastern, western and southern regions of Thailand (Fig. 1). A bird farm consists of several bird houses built in different locations along the seashore in each region (A–E). One bird farm, owned by a single bird farmer, is distributed at different places close to the seashore in each region. Three replications were conducted for each analysis. The sample used in each replication was from mixed portions of 5–6 bird nests collected from 3 to 5 bird houses for each bird farm in each region. For each farm, a total of 200 g of the EBN sample was collected. The EBN samples were cleaned to remove dirt and feathers by using forceps and scissors before being finely ground in the grinder (Philips, Thailand). After being ground, some leavings were manually removed using forceps. A fine powder sample of each EBN was then kept in a dry bottle, labelled according to the region and put in desiccators at room temperature for further examination.

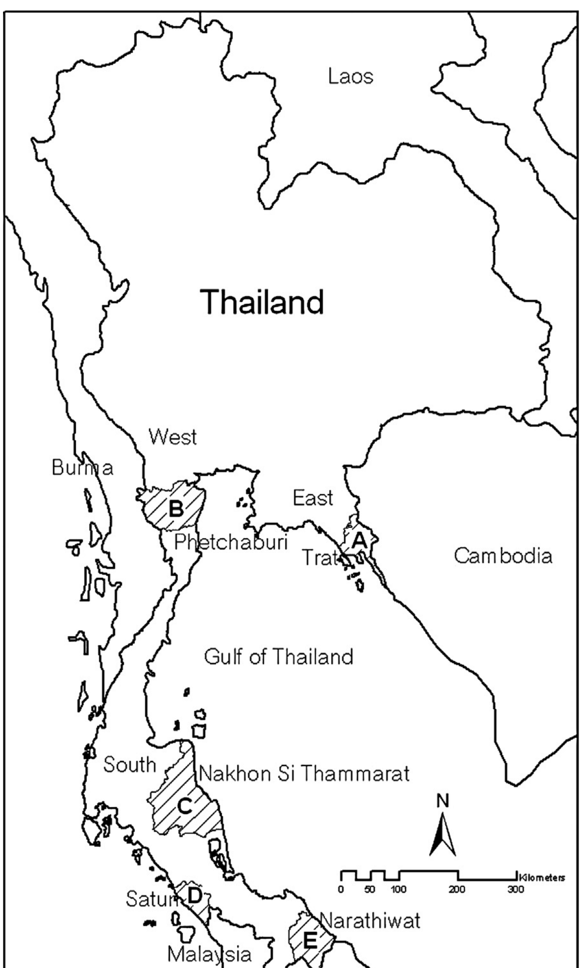

Fig. 1. The five locations in Thailand where the farmed edible bird's nests (EBN) samples were collected.

2.2. Determination of proximate composition

The official methods of the Association of Official Analytical Chemistry (AOAC, 2005) were employed to determine the moisture, protein, fibre, ash contents and fat of the ground EBN samples. Moisture content was determined by drying the EBN sample in an oven at 105 °C until a constant weight was obtained (Method 934.01). Crude protein content was determined by Kjeldahl's method, using 6.25 as a conversion factor (Method 2001.11). Fibre was determined after digesting a known weight of a fat-free sample in refluxing 1.25% sulfuric acid and 1.25% sodium hydroxide (Method 962.09). Ash contents were determined by dry ashing in a furnace at 550 °C for 18 h (Method 942.05). Crude fat content was calculated from a fraction of lipid extracted from the hydrolysed EBN sample (Wrolstad et al., 2005). The sample was first digested by hydrochloric acid (HCl) before extracting with a mixture of chloroform/methanol (1/1, v/v). Removal of the organic solvent was carried out using a rotary evaporator (Buchi, Switzerland). All EBN samples were undertaken in triplicate and the results were expressed as the percent of dried matter (DM) basis. The available carbohydrate was obtained by the difference method (subtracting the percent of crude protein, fat, fibre and ash from 100% dry matter).

2.3. Amino acid analysis

All samples were analysed, using the EZ:faast® liquid chromatography–mass spectrometry (LC/MS) amino acid kit KHO-7338 (Phenomenex, California, USA). First, the official AOAC method (Method 994.12, AOAC, 2005) was used for protein hydrolysis prior to the amino acid determination with concentrated HCl. Then, all steps of derivatisation and analysis were performed as described in the kit manual. The sample injection volume was 1 μL; all analyses were performed on the equipped LC–MS/MS (Waters alliance 2695, USA). The LC–MS/MS column used was the AAA-MS (Phenomenex) and standard analysis conditions were used as described in the manual. Separation of the amino acid derivatives was achieved by a flow of 0.25 mL/min at a column temperature of 35 °C. A Quattro Ultima triple quadrupole (Manchester, UK) mass spectrometer with electro spray ionisation (ESI) probe was employed for analyses of the amino acid enrichments. The conditions for mass spectrometer were operated with capillary voltages of 3 kV (ESI^+) and 2 kV (ESI^-). The source was kept at 120 °C and the desolvation temperature was 400 °C. Nitrogen was used as cone and desolvation gas with flow rates of 150 and 500 L h^{-1}, respectively. Argon was used as collision gas and kept at a pressure of 2.4×10^{-3} mbar. The amino acids were expressed in percent of total amino acids and in mg/100 g of dry weight. Three replications have been done for amino acid determination.

2.4. Elemental analysis

Elemental analysis method in this experiment was modified from Naozuka et al. (2011). Sample masses at about 250 ± 0.0005 mg were digested using a diluted oxidant mixture (2 mL HNO_3 + 1 mL H_2O_2 + 3 mL H_2O). The temperature was increased gradually, starting from 50 °C and increasing up to 200–220 °C. The digestion was completed in about 45–50 min as indicated by the appearance of a transparent liquid mixture. The mixtures were left to cool down and the contents of the crucibles were transferred to 50 mL volumetric flasks. The volumes of the contents were made to 50 mL with 2% HNO_3 solution. The wet digested solutions were transferred to plastic bottles which were stored in the refrigerator for mineral determination.

Sodium (Na) and potassium (K) contents were determined by using a flame atomic absorption spectrophotometer (Perkin-Elmer Analyst spectrophotometer model 300, Norwalk, CT, USA) equipped with an air–acetylene flame. A monoelemental hollow cathode lamp and the instrumental conditions (wavelength, slit and lamp intensity) recommended by the manufacturer were properly applied for the analysis of each element. Calcium (Ca), magnesium (Mg), iron (Fe), copper (Cu), zinc (Zn), manganese (Mn), and selenium (Se) were measured by using an inductively coupled plasma-optical emission spectrometry (ICP-OES, Perkin-Elmer model optima 3300 Dv, Norwalk, CT, USA). Argon, a carrier gas, was used to induce plasma.

2.5. Statistical analysis

All variables were tested for normality by applying the Kolmogorov–Smirnov test and the homogeneity of variances was assessed by using Levene's test. Data transformation was carried out where necessary. All results were expressed as mean ± standard deviation ($n = 3$). The data was statistically treated by one-way ANOVA and Duncan's post hoc test with $p < 0.05$ considered to be statistically significant. The statistical analysis was performed using Statistica software (StatSoft India Pvt. Ltd., India).

3. Results and discussion

3.1. Proximate composition

The proximate composition of the farmed EBNs collected from various regions of Thailand is shown in Table 1. In accordance with other findings (Marcone, 2005; Huda et al., 2008), the order of lowest to highest composition was found to be similar for all EBNs examined, i.e. fibre, fat, ash, moisture, carbohydrate and protein.

Fibre, the smallest constituent, was found to be significantly different among the EBNs from the five locations examined with values about 0.1%. The contents of crude fat (0.4–1.3%) and ash (5.9–7.4%) were within similar ranges as those of the EBNs collected in Penang, Malaysia and Sumatra, Indonesia which were reported to be 0.2–2.5% and 2.3–9.0%, respectively (Marcone, 2005; Huda et al., 2008). Moisture content of the EBNs from the three regions (east, west and south) was also significantly different. The EBNs from the east and the west were the highest (24.3%) and lowest (17.8%), respectively. There were no significant differences in the moisture content (with an average value of 19.0%) of the EBNs collected from the three locations in the south observed. Moisture content of the EBN from the west was closer to that of the south than that of the east.

Carbohydrate contents of the EBNs collected from one location in the west and the three locations in the south were not significantly different with an average value of 30.7%. This carbohydrate content was significantly higher than that of the east (25.4%). Unlike carbohydrate content, the crude protein content (the most abundant component) of the EBN collected from the east (66.9%) was significantly higher than that from samples from the west and south, which did not show significant differences among the four locations collected, and with an average value of 61.5%. Variations in carbohydrate and crude protein content of farmed EBNs collected from the east, west and south of Thailand (25.4–31.4% and 60.9–66.9%, respectively) were smaller than those of the EBNs collected in Malaysia and Indonesia (27–58% and 24–67%, respectively) reported by Huda et al. (2008), Marcone (2005), and Norhayati et al. (2010). Protein in EBN was reported to contain glycoprotein (Kathan and Weeks, 1969), which inhibits the influenza virus haemagglutination (Biddle and Belyavin, 1963) and promotes cell division in the immune system (Aswir and Wan Nazaimoon, 2011; Kong et al., 1987). A protein epidermal growth factor (EGF), similar to the physical properties of EGFs isolated from the mouse and the shrew, was also detected and partially purified from the EBN extract (Kong et al., 1987). This salivary EGF protein provides protection from injurious factors such as gastric acid, bile acids, pepsin, and trypsin and to physical, chemical and bacterial agents (Venturi and Venturi, 2009).

3.2. Amino acid composition

The amino acid composition of protein in the EBNs collected from different locations in Thailand is presented in Table 2. Sums of essential amino acids ranged between 15.9 and 31.6 mg/g protein. EBNs collected from Nakhon Si Thammarat in the south (C) and Trat in the east (A) contained greater amounts of essential amino acids (31.6 mg/g protein and 27.6 mg/g protein, respectively) than those from other provinces (15.9–17.71 mg/g protein). Sulfur-containing amino acids, methionine and cysteine, were major essential amino acids found in all of the EBNs examined (10.7–26.2 mg/g protein). The sulfur-containing amino acids contribute substantially to the maintenance and integrity of cellular systems by influencing cellular redox state and cellular capacity to detoxify toxic compounds, free radicals and reactive oxygen species (Townsend et al., 2004). According to the FAO/WHO/UNU expert consultation reference profile of protein for human consumption, methionine and cysteine are the most limiting amino acids in the whole diet (FAO/WHO/UNU Expert Consultation, 2007). The amounts of methionine and cysteine of EBNs collected both from Nakhon Si Thammarat (26.2 mg/g protein) and Trat (22.6 mg/g protein) were greater than those of the FAO/WHO/UNU requirement (22 mg/g protein). The farmed EBNs in Thailand are therefore a good source of sulfur-containing amino acids.

The predominant amino acid among the nonessential amino acids found in the EBNs was glutamine. EBNs collected from Satun in the south (D) and Phetchaburi in the west (B) contained glutamine (20.0 and 15.6 mg/g protein, respectively) in higher amounts than those from other locations which contained glutamine at 12.4 mg/g protein on average. Glutamine has traditionally been thought of as a nonessential amino acid, but

Table 1
Proximate composition of different samples of the farmed edible bird's nests (EBN) collected from various locations in Thailand (A from Trat province, B from Phetchaburi province, C from Nakhon Si Thammarat province, D from Satun province, and E from Narathiwat province).

Samples	Proximate composition (% dry matter; $n = 3$)*					
	Moisture	Ash	Crude protein	Crude fat	Fibre	Carbohydrate
A	24.3 ± 0.3 a	6.8 ± 0.0 b	66.9 ± 1.6 a	0.8 ± 0.1 ab	0.1 ± 0.0 d	25.4 ± 1.6 b
B	17.8 ± 0.1 c	6.7 ± 0.1 b	61.0 ± 0.1 b	1.1 ± 0.1 a	0.1 ± 0.0 b	31.0 ± 0.2 a
C	19.2 ± 0.5 b	7.4 ± 0.0 a	60.9 ± 0.9 b	1.3 ± 0.5 a	0.1 ± 0.0 c	30.4 ± 1.1 a
D	19.0 ± 0.1 b	5.9 ± 0.2 c	61.5 ± 1.6 b	1.2 ± 0.2 a	0.1 ± 0.0 e	31.4 ± 1.7 a
E	18.8 ± 0.1 b	6.8 ± 0.2 b	62.6 ± 0.1 b	0.4 ± 0.1 b	0.1 ± 0.0 a	30.1 ± 0.3 a

* Means ± SD ($n = 3$).
a–e: means ($n = 3$) in category column with the same letter are not significantly different ($p > 0.05$).

Table 2
Amino acid composition (mg amino acid/g protein) of farmed edible bird's nests ($n=3$) collected from various locations in Thailand (A from Trat province, B from Petchaburi province, C from Nakhon Si Thammarat province, D from Satun province, and E from Narathiwat province).

Amino acid	Provinces					FAO/WHO/UNU (2007) adults
	A	B	C	D	E	
	(mg amino acid/g protein; $n=3$)					
Threonine	1.3	1.2	1.1	1.5	1.1	23.0
Valine	1.0	1.1	1.0	1.2	1.11	39.0
Isoleucine	1.0	1.1	1.1	1.3	1.01	30.0
Lysine	0.8	0.8	0.9	0.8	0.8	45.0
Tryptophan	0.0	0.0	0.0	0.0	0.0	6.0
Phenylalanine + tyrosine	1.0	1.0	1.3	1.2	0.8	38.0
Methionine + cysteine	22.6	10.7	26.2	11.8	12.2	22.0
ΣEssential	27.6	15.9	31.6	17.7	17.1	203.0
Glutamine	12.0	15.6	12.5	20.0	12.7	
Asparagine	3.5	5.4	3.8	4.2	3.4	
Serine	1.9	1.7	1.8	2.5	1.5	
Glycine	1.7	1.4	1.5	1.8	1.2	
Aspartic acid	1.2	1.3	1.2	1.3	1.3	
Glutamic acid	1.0	1.1	1.1	1.1	1.2	
Proline	0.9	0.9	1.0	1.1	1.0	
Alanine	0.8	0.8	1.1	1.1	0.8	
Cystine	0.3	0.4	0.3	0.4	0.3	
Histidine	0.1	0.1	0.0	0.2	0.0	15.00

Table 3
Elemental composition of the edible bird's nests (A from Trat province, B from Phetchaburi province, C from Nakhon Si Thammarat province, D from Satun province, and E from Narathiwat province) at 100 g and the average intake of each element per portion and the recommended daily dietary reference intakes (DRI).

Elements	Content of elements (mg/100 g dry matter; $n=3$)					DRI (mg/day)
	A	B	C	D	E	
Sodium	1987.6 ± 175.0 a	1508.9 ± 116.8 b	1418.5 ± 45.8 bc	1233.8 ± 80.3 c	1494.3 ± 71.9 b	1500
Calcium	674.2 ± 62.6 b	628.1 ± 49.2 b	696.7 ± 27.2 ab	814.4 ± 31.7 a	749.0 ± 127.0 ab	1000
Magnesium	142.1 ± 5.9 a	143.8 ± 3.3 a	148.1 ± 4.5 a	143.8 ± 1.7 a	147.3 ± 1.3 a	310–420
Potassium	38.2 ± 2.0 b	23.1 ± 0.6 d	27.2 ± 1.2 c	42.8 ± 3.0 a	21.1 ± 2.5 d	4700
Iron	0.8 ± 0.2 ab	0.5 ± 0.1 b	0.6 ± 0.1 b	1.2 ± 0.3 a	0.7 ± 0.2 b	8–18
Selenium	0.4 ± 0.1 a	0.5 ± 0.1 a	0.4 ± 0.1 a	0.4 ± 0.1 a	0.5 ± 0.1 a	55 μg
Copper	0.3 ± 0.0 bc	0.2 ± 0.0 c	0.4 ± 0.0 a	0.3 ± 0.0 b	0.3 ± 0.0 c	900 μg
Manganese	0.0 ± 0.0 b	0.0 ± 0.0 b	0.0 ± 0.0 b	0.1 ± 0.0 b	0.3 ± 0.2 a	1.8–2.3

a–c: means ± SD ($n=3$) in category row with the same letter are not significantly different ($p > 0.05$).

laboratory and clinical data suggests that it may be essential during certain inflammatory conditions, such as infections and injuries (Conejero et al., 2002; Wilmore and Shabert, 1998).

3.3. Mineral content

Table 3 shows the mineral levels detected in the EBNs. The results expressed in mg/100 g of EBN on dry basis are presented in the decreasing order of concentration. Sodium (Na) was the most abundant mineral in the EBNs, followed by calcium (Ca), magnesium (Mg) and potassium (K). The presence of iron (Fe), selenium (Se), copper (Cu) and manganese (Mn) was little. Major minerals found in the EBNs were similar to those of seawater (Castro and Huber, 2005; Bardi, 2010). A bird food such as an insect that lives near the seashore may contain high content of Na, Ca, Mg and K according to their plant feed (Lee et al., 2007).

The values of the average intake of essential elements were compared with the daily dietary reference intake (DRI) of adult females and males aged between 19 and 50 years old set by the Institute of Medicine (IOM) in 2004. EBNs are a good source of Ca and Mg. DRI values have been established for Ca and Mg, with the daily adequate Ca intake for adults at 1000 mg/day and Mg at 310–420 mg/day, respectively (IOM, 2004). All of the EBNs (100 g) from different regions of Thailand can supply 70% of the DRI for Ca and 40% of the DRI for Mg. However, consumption of the EBN (100 g) would meet approximately 70–100% of the DRI for Na (Table 3). High Na content may be not beneficial to consumers who prefer lower sodium products.

In Thailand, EBN is normally consumed in the form of the bird's nest soup. The soup usually contains 33 g of EBN per litre of water (Thai-Indo swiftlet supply, 2013). Edible bird nest soup is available at various prices in the Thai market. Price varies from 21 Baht (0.72 US$) per 150 mL for the soup made for a local market (Thai Tambon, 2013) to 88 Baht (~2.94 US$) per 42 mL for the superior soup made for high-end supermarket (Brands, 2013). Therefore consumers could consider eating the soup to make a partial contribution to daily intake according to their backgrounds.

4. Conclusions

Based on the results of this study, farmed EBNs collected in Thailand are significant sources of protein and carbohydrates. EBN's nutritional composition appeared to vary with locations. Sulfur-containing essential amino acids were the main essential amino acids found in the EBNs. The contents of these amino acids in the EBNs collected from Nakhon Si Thammarat in the south and Trat in the east were higher than other regions and were comparable to those of the FAO/WHO/UNU requirements. Sodium (Na) was the most abundant EBN mineral, followed by calcium (Ca), magnesium (Mg) and potassium (K), respectively. The EBN was considered to be a good source of Ca and Mg according to the adult dietary reference intake (DRI).

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