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Proximate, Elemental and Fatty Acid Analysis of Pre-Processed Edible Birds' Nest (*Aerodramus fuciphagus*): A Comparison Between Regions and Type of Nest

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Abstract: This study was performed with the aim to evaluate the proximate, elemental and fatty acid analysis of pre-processed edible birds' nests (*Aerodramus fuciphagus*) and their comparison between the regions and type of nests. The samples of edible birds' nests were taken from 5 regions: 4 regions in Penang, Malaysia and one region in Sumatra, Indonesia. The nest type from regions in Penang was house nest, while the one from Sumatra was the cave nest. Analysis of total dry matter content was carried out according to the certification procedures outlined by the Manual of Livestock Feed Analysis, University Putra Malaysia. Crude protein was determined according to the Kjeldahl (micro) method. The fat content of the feed was determined using the total lipid extraction procedure. The crude fibre content of the sample was determined by using an automated apparatus. The elements analyzed in this study were Na, Ca, Mg, K, P and Fe. All of the elements were detected using the Atomic Absorption Spectrophotometer, while for P, PerkinElmer Lambda 35 Spectrophotometer was used. The results showed significant differences in proximate and elemental analysis of edible birds' nests between the regions and nest types. There were no significant different in the fatty acid content of the nests both between the regions and the nests type. The results also showed that the edible bird-nest have essential components in promoting body vigour.

Key words: Proximate, elemental, fatty acid, edible birds' nests, pre-processed

INTRODUCTION

The modern medicinal research reported that the main components of edible birds' nest includes water-soluble proteins, carbohydrate, trace elements (calcium, phosphorus, iron, sodium and potassium) and amino acids which play a vital role in promoting body vigour (Wong, 2006). Swiftlets are small-sized aerial birds, ranging from 9-12 cm long with narrow wings and short thin legs with strong toes and sharp claws, while plumage generally rather drab. The two most economically important edible-nest swiftlets are the white-nest swiftlet (*Aerodramus fuciphagus*) and the black-nest swiftlet (*Aerodramus maximus*). The white-nest swiftlet are resident birds normally found on islands, however currently, they are also distributed on the mainland in large populations (Tan, 2001). In this study, all the birds' nests collected were from the *Aerodramus fuciphagus* species.

The salivary nest cement is the main ingredient of the edible birds' nest and is undoubtedly one of the most expensive food ingredients in the world. It is one of the commercially available food products highly priced for human consumption processed through an animal. Unfortunately, much is still unknown about the compositional properties of the edible birds' nests. Thus, the study was conducted with the aim to analyse and compare the proximate, elemental and fatty acid of pre-processed edible birds' nests between the different regions and types of nests. In addition, this study also investigates the claims of the high nutritive quality of the edible birds' nests.

MATERIALS AND METHODS

Samples collection and preparation: Six pre-processed edible birds' nests were collected from each four different regions in Penang, Malaysia and also from Sumatra,

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Indonesia. The 4 different sampling locations in Penang were Seberang Perai South (SPS), Seberang Perai Central (SPC), South West District (SWD) and North East District (NED). The samples collected from Penang were the house nests type while the samples from Inland North Sumatra (INS), Indonesia were the cave nests type. The samples were cleaned of dirt and the visible feathers were manually removed using forceps. The nests were finely ground using a grinder. Any debris after grinding was manually removed by using forceps. The ground samples were then kept in the airtight container, labelled according to the regions and kept at room temperature.

Proximate analysis: Analytical total dry matter content was carried out according to certification procedures outlined by the Manual of Livestock Feed Analysis, University Putra Malaysia (2005). Nitrogen Content Determination (crude protein) was determined according to the Kjeldahl (micro) method. The fat content of the feed was determined using the total lipid extraction procedure of Folch *et al*. (1957). The crude fibre content of the sample was determined by using an automated apparatus (Fibertec 2010, Hot and Cold Extractor, Sweden). The carbohydrate is contained in two fractions, the Crude Fiber (CF) and the Nitrogen-Free Extractives (NFE) (McDonald *et al*., 1995). Thus,

Carbohydrates (%) =
Crude Fibre + Nitrogen-Free Extractives

The NFE includes mostly sugars and starches and also some of the more soluble hemicelluloses and some of the more soluble lignin. Since this fraction was designed to include the more digestible carbohydrates, any lignin that may come out here will tend to distort the meaningfulness of the NFE figure as lignin essentially is indigestible. Thus,

Nitrogen-free Extract (%) =
100 – (% water + %crude protein +
%crude fat + %crude fibre + %ash)

Elemental analysis: The elements analyzed in this study were Sodium (Na), Calcium (Ca), Magnesium (Mg), Potassium (K), Phosphorus (P) and Iron (Fe). All mineral elements were detected using the Atomic Absorption Spectrophotometer (AAS machine AA800, S/N 800S4030301), except for P which was detected using the PerkinElmer Lambda 35 Spectrophotometer, UK.

Fatty acid analysis: The total fatty acids were extracted from samples using the chloroform-methanol 2:1 ($v\ v^{-1}$) solvent system according to the method of Folch as described by Rajion (1985). The absolute amounts of fatty acids were calculated based on the concentration of the internal standard of heneicosanoic acid added with the aid of a personal computer.

Statistical analysis: The proximate, elemental and fatty acid values were analyzed using the one way Analysis Variance (ANOVA) procedure to compare the means between the different regions. Significantly different means were then differentiated using the Duncan Multiple Range Test. The results obtained from the proximate, elemental and fatty acid analyses were then compared between the cave nests (from Indonesia) and the house nests (from Penang). The values were analyzed using Independent T-Test. All statistical analysis was performed using SPSS® 12.0 for Windows (SPSS Inc., Chicago, USA) at 95% confidence interval.

RESULTS

Proximate analysis of pre-processed edible birds' nests according to regions: The result for proximate analysis is showed in Table 1. The highest component found in the nests in all the regions was the crude protein (24-49%), except in SPC, where the carbohydrate value was the highest (58.2%), while the crude fat remained the lowest value in all the regions. However, the crude protein value did not differ significantly ($p>0.05$) between the region except for the SPC where the crude protein was significantly lower ($p<0.05$) than other regions.

The carbohydrate values were the second highest component in the nests, ranging from 28-58%. The nests from SPC have significantly higher ($p<0.05$) carbohydrates compared to the other regions. The values of moisture, ash, crude protein and carbohydrate differ significantly ($p<0.05$) between regions.

Elemental analysis of pre-processed edible birds' nests according to regions: In the elemental analysis, the order of composition (from highest to lowest) was found to be identical in all the regions i.e., Na, Ca, Mg, K, Fe and P. Table 1 demonstrates the values of all the elements tested which was significantly different ($p<0.05$) among the regions except for Na. Sodium remained the highest values (1.3-2.0%) of all the elements tested among the regions with no significant difference between the regions. The standard deviations among all the elements tested in all the regions were small. The Fe values were found to be much higher (0.003-0.005%) than the phosphorus values (0.0003-0.0006%) in all the regions.

Table 1: Proximate and elemental analysis of pre-processed edible birds' nests according to regions

	Seberang Perai West (SPW)	Seberang Perai Central (SPC)	South West District (SWD)	North East District (NED)	Inland North Sumatra (IND)
Proximate analysis (%)					
Fat	0.5223^{a}	0.4708^{a}	1.9976^{b}	0.5349^{a}	0.4986^{a}
Ash	5.3438^{b}	2.7500^{a}	5.4034^{b}	5.7376^{b}	7.5274^{c}
Moisture	15.3454^{b}	13.7692^{a}	20.2030^{c}	15.7866^{b}	15.6692^{b}
Carbohydrate	28.7674^{a}	58.2078^{b}	33.2650^{a}	27.5662^{a}	29.3960^{a}
Crude protein	49.0472^{b}	24.3638^{a}	37.7590^{b}	49.2990^{b}	45.5092^{b}
Elemental analysis (%)					
Sodium (Na)	1.5085^{a}	1.3074^{a}	1.5886^{a}	1.7326^{a}	2.0640^{a}
Calcium (Ca)	0.7462^{b}	0.6445^{a}	0.6654^{ab}	0.7482^{b}	1.0204^{c}
Magnesium (Mg)	0.1313^{c}	0.1084^{a}	0.1172^{ab}	0.1234^{bc}	0.1087^{a}
Potassium (K)	0.0254^{ab}	0.0256^{ab}	0.0208^{a}	0.0398^{c}	0.0363^{bc}
Iron (Fe)	0.0046^{bc}	0.0054^{c}	0.0024^{a}	0.0043^{abc}	0.0031^{ab}
Phosphorus (P)	0.0003^{a}	0.0003^{a}	0.0005^{ab}	0.0006^{b}	0.0004^{a}

^{abc} Values with different superscripts within row differed significantly at $p<0.05$

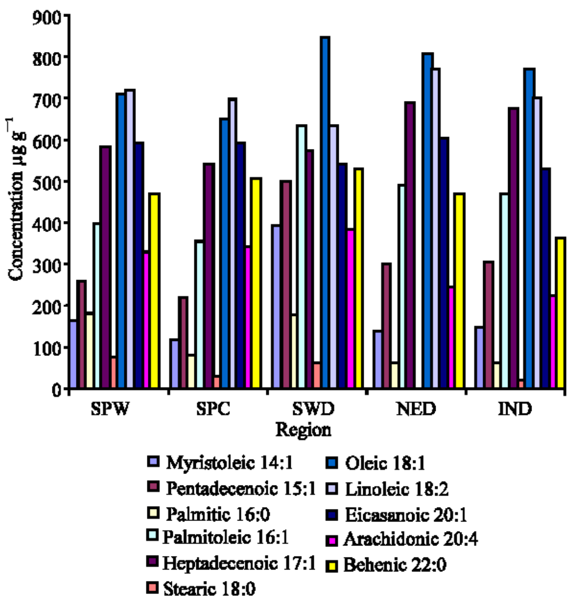

Fig. 1: Means of fatty acid analysis according to regions

Fatty acids analysis of pre-processed edible birds' nests according to regions: This study revealed that there are eleven fatty acids found in pre-processed edible birds' nests as demonstrated in Fig. 1. The fatty acids found were myristoleic acid (14:1), pentadecenoic acid (15:1), palmitic acid (16:0), palmitoleic acid (16:1), heptadecenoic acid (17:1), stearic acid (18:0), cis oleic acid (18:1), linoleic acid (18:2), eicosanoic acid (20:1), arachidonic acid (20:4) and behenic acid (22:0). The fatty acid analysis showed no significant differences among the regions as demonstrated in Fig. 2. The graph patterns were fairly consistent in all the regions, except in SWD, where palmitoleic and oleic acid values were higher but not significantly different among all the regions. All the fatty acids found except myristoleic acid were not significantly different ($p<0.05$) among the regions.

Out of the 11 fatty acids found, 3 were Saturated Fatty Acids (SFA), while the others were Unsaturated Fatty Acids (UFA). The saturated fatty acids found in pre-processed edible birds' nests were palmitic acid (16:0), stearic acid (18:0) and behenic acid (22:0). The unsaturated fatty acids found were myristoleic acid (14:1), pentadecenoic acid (15:1), palmitoleic acid (16:1), heptadecenoic acid (17:1), cis oleic acid (18:1), linoleic acid (18:2), eicosanoic acid (20:1) and arachidonic acid (20:4). The mean of saturated and unsaturated fatty acids also showed no significant difference among the regions (Fig. 2).

Proximate, elemental and fatty acid analysis of pre-processed edible birds' nests according to nest types: The results of the proximate, elemental and fatty acid analyses were compared between the cave nests (from Indonesia) and house nests (from Penang) and are demonstrated in Fig. 3, 4 and 5, respectively. The order of composition (from lowest to highest) was found to be identical in the different types of nests, which are fat, ash, moisture, carbohydrate and protein (Fig. 3). Crude protein remained the most abundant composition found (40-45%). The graph pattern for all the analyses were fairly consistent in comparing between the different types of nests. The proximate analysis showed significant difference ($p<0.05$) between ash and carbohydrate of the house and cave nests. Crude fat values remained the lowest when comparing between the cave and house nests (0.5-1.0%).

Comparing the elements, the order of composition (from highest to lowest) was found to be identical among the types of nests, which are Na, Ca, Mg, K, Fe and P as showed in Fig. 4. Ca and Fe values differ significantly ($p<0.05$) between the house and cave nests. Na levels in cave nests are higher but not significantly different ($p>0.05$) when compared to house nests. Generally, the cave nests have higher levels of Na and Ca.

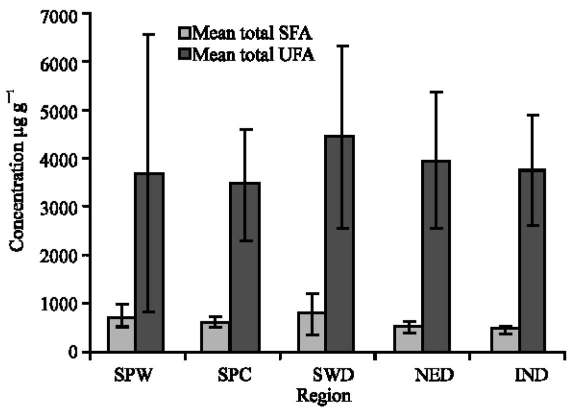

Fig. 2: Mean total of Saturated Fatty Acids (SFA) and Unsaturated Fatty Acids (UFA) according to regions

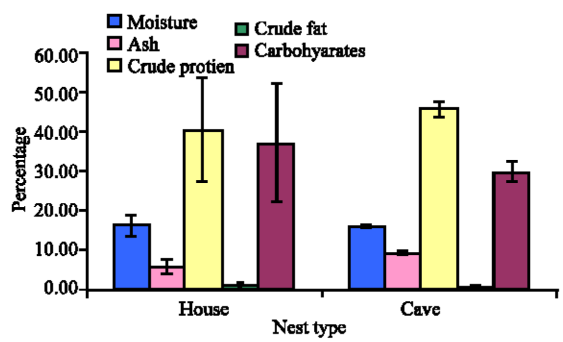

Fig. 3: Means of proximate analysis according to nest types

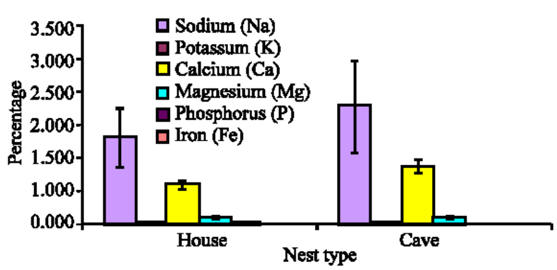

Fig. 4: Means of elemental analysis according to nest types

The fatty acids found in cave nests and house nests were similar. Eleven fatty acids were found, in which three of them were Saturated Fatty Acids (SFA) and the remaining were Unsaturated Fatty Acids (UFA). Figure 5 demonstrated similar graph pattern among the types of nests. No significant difference ($p<0.05$) were detected in the fatty acid analysis between the house and cave nests.

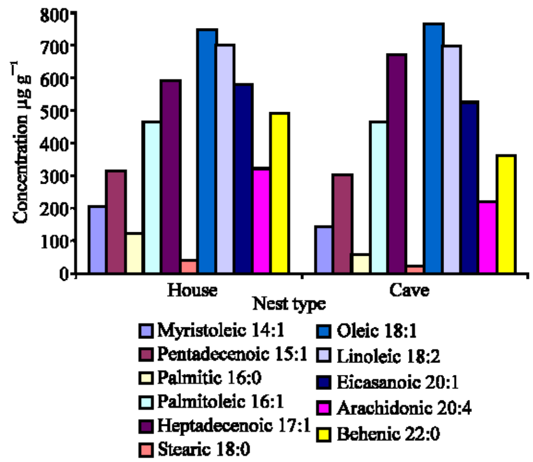

Fig. 5: Means of fatty acid analysis according to nest types

DISCUSSION

It is very important to understand or at least know the fundamental correlation between food source and reproduction energetic of the swiftlets. This has a direct impact on the growth of the swiftlets colony in a bird house or the population in a region (Lim, 2006). In general, the results show that the proximate and elemental analyses of the pre-processed birds' nests were directly related to the locations (regions) where the sampling were made as well as the type of nests. This might be due to the condition of surrounding habitats, availability and abundance of food source as demonstrated by Che Awang (2001).

In proximate analysis, it is evident that the proximate and elemental analysis values were affected by the regions where the birds' nests were sampled. By far the most abundant component in the birds' nests is crude protein (Marcone, 2005). The crude protein values in SPC, NED and INS were significantly higher than the other regions. It is probably as a result of good feeding environment and abundance of feed in the area. The areas mentioned above have high rainfall and near water bodies, which provide a good environment for insects to proliferate, which in turn, provides the swiftlets' diets. When comparing house nests and cave nests, the cave nests have a slightly higher but not significantly different ($p>0.05$) in the level of crude protein. This again, may be the result of good feeding environment and location of the bird houses in Penang, resulting in abundance of food. The swiftlet population and size are controlled by the carrying capacity of the natural environment. Thus, the levels of crude protein in cave nests might be an indication of a decreasing sustainable environment for the swiftlets to proliferate.

In this study, the carbohydrate values were obtained by adding the values of crude fibre and the nitrogen-free extractives, as indicated by McDonald *et al.* (1995). Among all the regions, only the SPC have significantly high level ($p<0.05$) of carbohydrate. They also have the lowest crude protein value. This may be an indication that there is decreasing food supply in the area. It is also possible that the crude fibre consist of fibrous protein. This fibrous protein is not detected in the crude protein values, but they are included in the crude fibre values. Examples of fibrous proteins include collagen, elastin and keratin. The digestibility of food is closely related to its chemical composition. The fibre fraction of a food has the greatest influence on its digestibility and both the amount and chemical composition of the fibers are important (McDonald *et al.*, 1995).

Aerodramus fuciphagus are known to survive over a wide range of habitat from sea level to highlands up to 2.800 m (Siti Hawa, 2001). The humidity of these natural habitats varies and may affect the moisture content of the birds' nests. Furthermore, the microclimate of the bird houses also plays a role in determining the humidity, temperature and light intensity of the house. In order to obtain the best quality birds' nest in swiftlet farming, the humidity levels must be within range of 80-85% of the environment (Fadzilah A'ini, 2004). In dry caves above sea level, air with relatively low humidity (<70%) may cause many nests to fall from the walls (Phach and Voisin, 2001).

Crude fat levels and ash levels remained the lowest in the proximate analysis, whether comparing between regions or nest types. This may be due to the composition of the birds' nests which is made exclusively out of the saliva and is highly digestible (Marcone, 2005). The diets of the swiftlets are exclusively insects according to the study conducted by Langham (1980) and these insects may contain low levels of fat composition in their bodies.

In the elemental analysis, the order of composition (from highest to lowest) was also found to be identical in all the regions and the nest types sampled, i.e., Na, Ca, Mg, K, Fe and P. These results were also in accordance to the study conducted by Marcone (2005), except in this study, the P values, a macro-mineral were much lower than the values of Fe, a micro-mineral. According to the National Research Council, the standard units for macro-mineral are in percent (%) and the standard of micro-mineral are in parts per million (ppm). But, in this study the values of Fe are also demonstrated in percent for ease and convenience of discussion.

Although, mineral elements constitute a relatively small amount of total body tissues, they are essential to many vital processes (Ishak, 1970). The minerals found in the edible birds' nests are essential to promote body vigour. Na was found to be the highest level of element found in this study, whether comparing between regions or nest types. However, these values were not in accordance to any studies such as conducted by Marcone (2005) or reported by Wong (2006). This may be due to experimental error or other unknown factors. Na strongly affects distribution of water through osmosis. It plays a vital function in reduction of nerve and muscle action of human beings (Tortora and Grabowski, 2003).

The Ca levels of the edible birds' nests are among the highest among all the elements tested. This is true when comparing between regions and nest types. It is also significantly different when comparing between house nests and cave nests. The cave nests have significantly higher levels ($p<0.05$) of Ca compared to house nests. In human, the most important functions of Ca include tooth formation, functions in the heart, muscles and nerves, as well as blood coagulation in the permeability of the membranes and lactation (Ishak, 1970).

Magnesium is the fourth most abundant cation in the body and the second most plentiful intra-cellularly. Magnesium is indispensable in the diet (Ishak, 1970) and required for normal functioning of muscle and nervous tissue as well as participates in bone formation (Tortora and Grabowski, 2003). The Mg level in this study was the third highest among all the elements studied and in accordance to the study conducted by Marcone (2005).

The P values were not in accordance to any studies such as conducted by Marcone (2005) or reported by Wong (2006). This may be due to different experimental work out or other unknown factors. The cave nests have significantly higher ($p<0.05$) levels of Fe compared to the house nests. This may be due to the natural environment of the cave which promotes some form of nutrient absorption into the birds' nest. The availability of elements found in this study could be linked to the surrounding habitats, availability and abundance of food source (Lim, 2006).

All the fatty acids found in the samples were Omega-6 fatty acids. No Omega-3 fatty acids were detected in all samples. This is because these types of fatty acids are usually found if the animal has a meat based diet. Swiftlets feed exclusively on insects, therefore, they have no access to sources of Omega-3 fatty acids (Rudin and Felix, 1996). Swiftlets are insectivorous birds which feed on winged ants, fig wasps, bees, flies and other wing-borne insects (Langham, 1980). These insects feed on mainly plants, which are sources of Omega-6 fatty acids. Most of the fatty acids are unsaturated fatty acids except for palmitic acid, stearic acid and behenic acid, which are saturated fatty acids. Saturated fatty acids are the components of normal animal fats, while unsaturated fatty acids are components of plant oils (Blood and Studdert, 2003). This proves that the fatty acids in the birds' nests are based on the diets the swiftlets consume.

In all the regions, the fatty acid values are within the same range except in SWD where the values of oleic acid and linoleic acid are slightly higher but not significantly different ($p>0.05$) from the other regions. This again may be due to the diet and availability of the food for the swiftlets. The highest amounts of fatty acids found in the house and cave nests were also oleic and linoleic acid. All these fatty acids were not significantly different among the types of nests.

CONCLUSION

Based on the results, it can be concluded that the edible birds' nests contain high protein and low fat content, high in macro-minerals such as Ca, K and Na, as well as the unsaturated fatty acids and high levels of Omega-6 fatty acids. All these components are essential in promoting body vigour. Thus, the claim of the high nutritive quality of the edible bird-nest is proven.

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