Nutritional Composition of Fruits Selected by Long-tailed Macaques (*Macaca fascicularis*) in Kuala Selangor, Malaysia

Norazila Kassim, Kamarul Hambali* and Aainaa Amir

Faculty of Earth Science, Universiti Malaysia Kelantan, Locked Bag No. 100, 17600 Jeli, Kelantan, Malaysia

*Corresponding author: kamarul@umk.edu.my

Running head: Nutritional Composition

Abstract: Proximate analysis of twelve species of fruits commonly consumed by long-tailed macaques (*Macaca fascicularis*), i.e. Arenga pinnata, Areca catechu, Terminalia catappa, Elaies guineensis, Lagerstroemia tomentosa, Mangifera indica, Cascabela thevetia, Muntingia calabura, Musa spp., Artocarpus heterophyllus, Ficus tinctoria ssp. gibbosa and Ficus microcarpa was conducted with the specific objective to determine the nutritional composition of the foodstuff of long-tailed macaques. The results showed the following order of nutrients: fibre, protein, fat and ash. Based on the results of the chemical analysis, the highest percentage of fibre content (52.7%), protein (9.9%), fat (77.2%) and ash (8.5%) were found in A. catechu, T. catappa, E. guineensis and C. thevetia respectively. The nutrient composition from these twelve fruit species were found to be different from each other (ANOVA test: crude protein, F (11,24) = 87.978, p < 0.05, crude fibre, F (11,24) = 28.886, p < 0.05, crude fat, F (11,24) = 2081.396, p < 0.05 and ash, F (11,24) = 41.011, p < 0.05). Fibre was found in the highest amount among the four types of nutrients that were studied. Here, A. catechu had the highest relative fibre content of all tested fruits, E. guineenis the highest fat content, T. catappa the highest protein content, while the total mineral content was highest in C. thevetia.

Keywords: Proximate Analysis, Long-Tailed Macaque, Nutrition, Fruits
INTRODUCTION

Long-tailed macaques (Macaca fascicularis) are primates from the Cercopithecidae family, weighing between 3 to 5 kilograms (Lucas, 1995). Macaca fascicularis is categorized under least concern species by IUCN Red List due to its wide distribution, presumed large population, a broad range of habitats and occurrence in a number of protected areas (Ong and Richardson, 2008). This species is widely distributed in Southeast Asia including Thailand, Indonesia, Singapore, Brunei, Malaysia, the Philippines, Vietnam and Laos (Brandon-Jones et al. 2004). In Peninsular Malaysia, M. fascicularis can be found nearly everywhere but predominantly in tourist areas, such as Bukit Malawati Kuala Selangor, Penang Botanical Gardens, Templer Park Kuala Lumpur and Kuala Selangor Nature Park (Hambali et al. 2014). They live in various habitats, such as lowland forests, secondary forests, shrub lands, riverine areas, and coastal forests of mangroves (Rowe, 1996; Supriatna et al. 1996).

Long-tailed macaques are frugivorous, and on Borneo in Kalimantan, 66.7% of their diet consists of ripe, fleshy fruits while macaques on Sumatra devote an even higher percentage of their diets to fruit (82%) (Yeager, 1996; Wich et al. 2002). During times of year when fruit is unavailable, the dry season into the early rainy season, long-tailed macaques focus on other food sources including insects, stems, young and mature leaves, flowers, seeds, grass, mushrooms, invertebrates, bird eggs, clay and bark (Wheatley, 1980; Yeager, 1996; Son, 2003). Where they forage in mangroves, long-tailed macaques spend time consuming crabs and have also been seen eating frogs, shrimp and octopus (Sussman and Tattersall, 1986; Son, 2003). However, when fruits are unavailable, they will turn to alternative food sources (Lucas and Corlett, 1991). Their food may vary across seasons and altitudes and the feeding ecology of long-tailed macaques has been reported mostly in lowland areas (Ungar, 1996; Nila et al. 2014). Besides, long-tailed macaques have an established hierarchy in their group where higher ranking individual gain prior access to preferred food. Aggressive interactions between group members are the highest while feeding on fruit, indicating strong competition for this valuable food resource (van Schaik and van Noordwijk, 1988). When foraging, long-tailed macaques will travel in circular routes and their routes will be modified depending on feeding locations, resting sites, water sources and protective vegetation cover (Sussman and Tattersall, 1981). Long-tailed macaques use a variety of feeding strategies including picking of fruits by hand or plucking with their teeth, turning over rocks, snatching insects from air and storing food in cheek pouches (Sussman and Tattersall, 1981; Lucas and Corlett, 1998).

Most of the plant fibre is found in the soluble form, which binds with cholesterol that is then eliminated in the stool (Edelstein, 2014). Soluble fibres have benefits on serum lipids while insoluble fibres are linked with laxation benefits (Slavin, 2013). Fats serve as fuel for energy production and essential body nutrients (Nix, 2009). Fat also supplies important tissue requirements as a structural material for cell membranes, protective...
padding for vital organs and insulation to maintain body temperature (Nix, 2009). Proteins help in motion and locomotion of cells (Nix, 2009). The seeds of many plants store nutrient protein required for the growth of the embryonic plant and serve the function of storing amino acids as nutrients (Chopra and Panesar, 2010). Plant proteins can be obtained from cereals, oil seeds and leaves. Minerals are elements that are widely distributed in foods and a diverse group of nutrients that have many essential functions (Nix, 2009; Robbins, 2001). Minerals are used in building tissue for activating, regulating, controlling metabolic processes and transmitting neurologic message (Nix, 2009). The amount of minerals required by different individuals vary with age, sex, species, season and reproductive condition (Robbins, 2011). Minerals are essential nutrients that play important role in metabolic processes of the body and the absence of minerals can cause deficiency symptoms in animals (Gafar and Itodo, 2011).

Nutritional needs of long-tailed macaques are the key to determine species ecology (Moges and Balakrishnan, 2014). Nutritional components of the macaques’ diet is important in order to understand their behaviour and foraging strategies (Moges and Balakrishnan, 2014). Besides that, the animal must obtain adequate food in order to survive and breed successfully (Wiafe, 2015). The main objective of this research was to determine the nutritional composition of preferred fruits consumed by long-tailed macaques at a site in Peninsular Malaysia.

MATERIALS AND METHODS

Study Area

This study was conducted in Kuala Selangor Nature Park (KSNP), at the entrance of KSNP and the surrounding area, including residential areas and small town areas. These study area was located near to the Bukit Malawati, Kuala Selangor (Figure 1).

Kuala Selangor Nature Park was established in 1987 by the Malaysian Nature Society and the Selangor State Government (MNS, 2014). The size of the park is 732.4 acres and shelters a wide variety of habitats, such as secondary forest, mangrove forest, the estuary of the Selangor River, mudflats, which open to the Straits of Malacca and a man-made 25 acres brackish water lake system (MNS, 2014). The long-tailed macaque is one of the primate species that can be found in the secondary forest of KSNP other than Silver-leaf Monkey (Trachypithecus cristatus) (MNS, 2014).
Methods

Nutrient contents of twelve species of fruits consumed by M. fascicularis based on previous study by Hambali et al. (2014) were analyzed. They were Arenga pinnata, Areca catechu, Terminalia catappa, Elaies guineensis, Lagerstroemia tomentosa, Mangifera indica, Cascabela thevetia, Muntingia calabura, Musa spp., Artocarpus heterophyllus, Ficus tinctoria ssp. gibbosa and Ficus microcarpa.

The proximate analysis was used to determine the nutritional composition these fruits. The fruits were partitioned into four parts, which were crude protein, crude fat, crude fibre and ash. The analysis was conducted at Nutritional Laboratory of Faculty of Veterinary and Health, Universiti Malaysia Kelantan. The crude protein contents was analyzed by using the Kjedahl method (Moges and Balakrishnan, 2014), crude fibre was determined by FibreBags System of Gerhardt, crude fat was analyzed by Soctex Extraction method, and the total mineral content was determined through the percentage of ash (Moges and Balakrishnan, 2014). This study used a total of one gram per species and repeated in three times.

The differences between the nutrient values in selected fruits sample (crude fiber, crude fat, crude protein, and ash) were tested by using Analysis of Variance (ANOVA) test. All data were checked for normality and due to the sample size was greater than thirty, the data was assumed to be normal according to Central Limit Theorem. As the data were normally distributed, the parametric statistical test, One-Way ANOVA was chosen. Statistical significance was set at P-value <0.05. All data analysis was done by using the Statistical Package for the Social Science (SPSS). The ethics of non-human primate research in Malaysia was followed.

RESULTS AND DISCUSSION

Nutrient Contents in Twelve Fruits Species Consumed by Long-tailed Macaques

Table 1 provides the details of the means of three replicates of nutrients contents of A. pinnata, A. catechu, T. catappa, E. guineensis, L. tomentosa, M. indica, C. thevetia, M. calabura, Musa spp., A. heterophyllus, F. microcarpa, and F. tinctoria ssp. gibbosa. There was a significant difference between the amount of crude protein (ANOVA, F (11,24) = 87.978, p < 0.05), crude fibre (ANOVA, F (11,24) = 28.886, p < 0.05), crude fat (ANOVA, F (11,24) = 2081.396, p < 0.05), and ash (ANOVA, F (11,24) = 41.011, p < 0.05) between the twelve fruit species, suggesting that nutrient contents of these twelve species may be different from one another.

The results of the proximate analysis indicated that the mean relative amount of crude protein was highest in T. catappa (9.86%; SD = 0.2), F. tinctoria ssp. gibbosa (8.27%; SD = 0.25) and F. microcarpa (6.67%; SD = 0.68), while it was lowest in A. catechu (3.29%; SD = 0.2) and E. guineensis (2.5%; SD = 0).
The mean relative amount of crude fibre was highest in A. catechu (52.73%; SD = 3.39) and L. tomentosa (36.34%; SD = 16.05) and lowest in A. heterophyllus (3.62%; SD = 1.29) and Musa spp. (2.79%; SD = 2.83). E. guineensis (77.2%; SD = 1.77) and M. calabura (10.47%; SD = 0.49) were highest in their relative mean crude fat content, while Musa spp. (0.36%; SD = 0.21) had the lowest crude fat content. Amount of ash was highest in C. thevetia (8.53%; SD = 0.6) and A. pinnata (7.84%; SD = 0.33), while lowest in M. indica (3.05%; SD = 0.59) and E. guineensis (1.7%; SD = 0.1).

Here, A. catechu had the highest relative fibre content of all tested fruits, E. guineensis the highest fat content, T. catappa the highest protein content, while the total mineral content was highest in C. thevetia. There are few important roles in each nutrient studied.

**Nutritional Characteristics of the Diet of Long-tailed Macaques**

Many primate species are frugivorous and represent the primary consumers of plants (Wiafe, 2015). According to Curtin (2002), the greater part of food consumed by Roloway monkeys (Cercopithecus Diana roloway) from the Cercopithecidae family in Bia National Park, Ghana is made up of fruits and the pulp of mature fruits were found to be the most important food category for this species. Bourliere et al. (1970) also found that Lowe’s monkeys (Cercopithecus campbelli lowei) from the Cercopithecidae family in Ivory Coast consumed more fruits compared to flowers, leaves and insects.

Macaques are omnivorous-frugivorous primates, i.e., they eat fruits, but also leaves, flowers, shoots, roots, invertebrates, and small animals in variable quantities (Maruhashi, 1980; Caldecott, 1986; Kurup and Kumar, 1993; Krishnamani, 1994; O’Brien and Kinnaird, 1997; Su and Lee, 2001; Rowe and Myers, 2011; Schülke et al. 2011). The percentage of fruit in the diet, usually higher than other food items, depends on the particular macaque species — from relatively low (10–32% in M. fuscata; Agetsuma and Nakagawa, 1998) to very high (85% in M. nigrescens; Rowe and Myers, 2011) — but may also show intra-specific variations, depending on habitat and provisioning (e.g., in M. fuscata: 15% in provisioned troops [Son, 2003] and 88% in unprovisioned ones [Wheatley, 1980]), and seasonal variations (Hanya et al. 2003). The number of fruit species included in the macaques’ diet is species-specific but often higher than for other sympatric frugivores (Corlett, 1998).

Fruit species eaten are not restricted to the so-called ‘primate fruits’, those with large seeds, orange-brown colour, and a protective rind (Corlett, 1998). Macaques eat various fruit types, including dehiscent and indehiscent fruits, protected or not, and of every colour, contrary to other mammals tending to avoid dehiscent fruits that are preferred by birds (Lucas and Corlett, 1998; Kitamura et al. 2002), unprotected fruits preferred by other frugivores (Corlett, 1998), and yellow fruits preferred by other mammals (Kitamura et al. 2002).
Frugivorous may select their food from a large diversity of fruits that differ in colour, shape, and ease for harvest, which often corresponds with their nutritional content (Leighton, 1993). These fruit characteristics must relate to the preference of the primates of which species to exploit, according to their ability to manipulate and digest the fruits according to their nutritional requirements (McConkey, 2002). Most of the primates may select for fruits that are yellow in colour with a rind-like skin, sweet juicy pulp and a well-protected seeds (Julliots, 1996). In this study, instead of having great features of the fruit such as sweet juicy and large size, M. indica also contained high fibre contains. Thus, this is the reason the long-tailed macaques choose M. indica as one of their preference food (Hambali et al. 2014).

According to the previous study by Hambali et al. (2014), the five most abundance tree species that are found in Kuala Selangor are M. indica, F. microcarpa, F. tinctonia ssp. gibbosa, A. catechu, and T. catappa. In this study, the nutrient contents of these five tree species were higher in fibre as shown in Table 1. Besides, the study by Hambali et al. (2014), M. fascicularis in Kuala Selangor were prefer fig fruits as a staple food and the study by Riley (2007) also state that fig fruits are staple food for Tonkean macaques (Macaca tonkeana) in Lore Lindu National Park, Sulawesi, Indonesia. Figs act as a keystone resource, providing food for many animals such as monkeys, arboreal mammals, squirrels, civets, and birds. The high diversity of fig trees in the rain forest assures food during fruiting throughout the year (MacKinnon et al. 1996). In this study, the fig species included F. microcarpa and F. tinctonia ssp. gibbosa, which were higher in fibre content compared to other nutrients.

Most of the fruits consumed by M. fascicularis had low levels of fat contents, except for E. guineensis. M. fascicularis chose the E. guineensis as one of their preference diet maybe due to nutritional needs of this species in Kuala Selangor. Proteins are essential components of the diet needed for the survival of primates (Pugalenthi et al. 2014).

CONCLUSION AND RECOMMENDATION

From the results of chemical analysis, the highest percentage of fibre content (52.7%), protein (9.9%), fat (77.2%) and ash (8.5%) were found in A. catechu, T. catappa, E. guineensis and C. thevetia respectively. The nutrient composition from these twelve fruit species were found to be different from each other. Fibre was found in the highest amount among the four types of nutrients that were studied. A. catechu had the highest relative fibre content of all tested fruits, E. guineensis the highest fat content, T. catappa the highest protein content, while the total mineral content was highest in C. thevetia. This research on the nutritional composition of fruits selected by the long-tailed macaques was less in Malaysia, therefore this study is important to record
the data and add our knowledge on the nutritional composition selected and to be a priority by this species. Further laboratory analysis for other nutrient contents of primate foods includes carbohydrate, mineral element and neutral detergent fiber should be conducted. Besides, the other part of food-plants includes leaves, flowers and seeds should be carried out to analyses the nutrient contents in long-tailed macaque’s food.

ACKNOWLEDGMENT

We thank the Faculty of Earth Science for giving us an opportunity to conduct this study and the laboratory assistant of Nutritional Laboratory of Faculty of Veterinary and Health, Universiti Malaysia Kelantan for guiding us in completing the nutritional analysis.

REFERENCES


Figure 1: Map of the study area (Source: Google Earth, 2016).
Table 1: Nutrient contents in twelve fruits consumed by long-tailed macaques in Kuala Selangor.

<table>
<thead>
<tr>
<th>Fruits</th>
<th>Common name / English name</th>
<th>% Crude Protein</th>
<th>% Crude Fibre</th>
<th>% Crude Fat</th>
<th>% Ash</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arenga pinnata</td>
<td>Sugar palm, Arenga palm, Aren palm, Black-fiber palm, Gomuti palm, Aren, Enau, Irok, Kaong</td>
<td>3.83 0.10</td>
<td>25.95 3.03</td>
<td>1.67 1.37</td>
<td>7.84 0.33</td>
</tr>
<tr>
<td>Areca catechu</td>
<td>Areca palm, arecanut palm, betel palm, Indian nut, Pinang palm</td>
<td>3.29 0.20</td>
<td>52.73 3.39</td>
<td>1.40 0.48</td>
<td>3.76 0.18</td>
</tr>
<tr>
<td>Terminalia catappa</td>
<td>Bengal almond, Country almond, Indian almond, Malabar almond, Sea almond, Tropical almond</td>
<td>9.86 0.20</td>
<td>22.76 2.69</td>
<td>0.97 0.77</td>
<td>5.83 0.12</td>
</tr>
<tr>
<td>Elaeis guineensis</td>
<td>Oil palm</td>
<td>2.50 0.00</td>
<td>9.07 0.36</td>
<td>77.2 1.77</td>
<td>1.7 0.10</td>
</tr>
<tr>
<td>Lagerstroemia tomentosa</td>
<td>Queen flower/White grape myrtle, Leza</td>
<td>4.15 0.08</td>
<td>36.34 16.05</td>
<td>1.07 0.66</td>
<td>3.86 0.66</td>
</tr>
<tr>
<td>Mangifera indica</td>
<td>Mango</td>
<td>3.42 0.40</td>
<td>8.97 1.65</td>
<td>1.61 0.51</td>
<td>3.05 0.59</td>
</tr>
<tr>
<td>Cascabela thevetia</td>
<td>Yellow oleander, Lucky nut</td>
<td>5.44 0.06</td>
<td>9.61 0.89</td>
<td>3.13 0.55</td>
<td>8.53 0.60</td>
</tr>
<tr>
<td>Muntingia calabura</td>
<td>Jamaican cherry, Panama berry, Singapore cherry, Strawberry tree</td>
<td>6.52 1.07</td>
<td>18.43 2.50</td>
<td>10.47 0.49</td>
<td>5.18 0.55</td>
</tr>
<tr>
<td>Musa spp.</td>
<td>Banana</td>
<td>4.42 0.29</td>
<td>2.79 2.83</td>
<td>0.36 0.21</td>
<td>3.48 0.50</td>
</tr>
<tr>
<td>Artocarpus heterophyllus</td>
<td>Jack tree, Jackfruit</td>
<td>3.73 0.13</td>
<td>3.62 1.29</td>
<td>0.65 0.61</td>
<td>3.57 1.18</td>
</tr>
<tr>
<td>Ficus tindoria ssp. gibbosa</td>
<td>Dye fig, Humped fig, Strangler fig</td>
<td>8.27 0.25</td>
<td>34.48 0.88</td>
<td>2.68 0.70</td>
<td>7.14 0.80</td>
</tr>
<tr>
<td>Ficus microcarpa</td>
<td>Chinese Banyan, Malayan Banyan, Taiwan Banyan, Indian Laurel, Curtain fig, Gajumaru</td>
<td>6.67 0.68</td>
<td>36.24 2.55</td>
<td>2.68 0.47</td>
<td>6.46 0.30</td>
</tr>
</tbody>
</table>