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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

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Abstrak: Analisis proximat dua belas jenis buah-buahan yang biasa dimakan oleh kera ekor panjang seperti *Arenga pinnata, Areca catechu, Terminalia catappa, Elaies guineensis, Lagerstroemia tomentosa, Mangifera indica, Cascabela thevetia, Muntingia calabura, Musa* spp.*, Artocarpus heterophyllus, Ficus tinctonia* ssp. g*ibbosa* dan *Ficus microcarpa* telah dijalankan dengan objektif khusus untuk menentukan kandungan nutrien makanan kera ekor panjang. Hasil kajian menunjukkan susunan nutrien yang berikut; serat, protein, lemak dan abu. Berdasarkan keputusan daripada analisis kimia, peratusan tertinggi kandungan serat (52.7%), protein (9.9%), lemak (77.2%) dan abu (8.5%) terdapat dalam *A. catechu, T. catappa, E. guineensis* dan *C. thevetia*. Kandungan nutrient daripada dua belas jenis buah-buahan ini didapati berbeza antara satu sama lain (Analisis ANOVA: serat, F (11, 24) = 87.978, $p < 0.05$; fiber, F (11,24) = 28.886, $p < 0.05$; lemak, F (11,24) = 2081.396, $p < 0.05$ and abu, F (11,24) = 41.011, $p < 0.05$). Kandungan serat adalah yang paling tinggi di antara keempat-empat jenis nutrien yang dikaji. Maka, *A. catechu* mempunyai kandungan serat tertinggi di antara buah-buahan yang diuji, *E. guineensis* mempunyai kandungan lemak tertinggi, *T. catappa* mempunyai kandungan protein tertinggi dan kandungan mineral yang paling tinggi terdapat dalam *C. thevetia*.

Kata kunci: Analisis proximat, Kera Ekor Panjang, Nutrisi, Buah-buahan

Abstract: Proximate analysis of twelve species of fruits commonly consumed by long-tailed macaques (*Macaca fascicularis*), i.e., *Arenga pinnata*, *Areca catechu*, *Terminalia catappa*, *Elaeis guineensis*, *Lagerstroemia tomentosa*, *Mangifera indica*, *Cascabela thevetia*, *Muntingia calabura*, *Musa* sp., *Artocarpus heterophyllus*, *Ficus tinctoria* ssp. *gibbosa* and *Ficus microcarpa*, was conducted with the specific objective to determine the nutritional composition of the foodstuffs 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 of these twelve fruit species was found to differ (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 studied. Here, *A. catechu* had the highest relative fibre content of all tested fruits, *E. guineensis* had the highest fat content, *T. catappa* had the highest protein content, and the total mineral content was highest in *C. thevetia*.

*Corresponding author: kamarul@umk.edu.my

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 as a least concern species by the International Union for Conservation of Nature (IUCN) Red List due to its wide distribution, presumed large population, broad range of habitats and occurrence in a number of protected areas (Ong & 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 is predominantly found 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). This species lives in various habitats, such as lowland forests, secondary forests, shrublands, riverine areas, and coastal mangrove forests (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 the year when fruit is unavailable, such as 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). When they forage in mangroves, long-tailed macaques spend time consuming crabs and have also been seen eating frogs, shrimp and octopuses (Sussman & Tattersall 1986; Son 2003). Their food sources may vary across seasons and altitudes, and the feeding ecology of long-tailed macaques has been reported mostly for lowland areas (Ungar 1996; Nila *et al.* 2014). In addition, long-tailed macaques have an established hierarchy in their group in which higher-ranking individuals gain prior access to preferred food items. Aggressive interactions between group members are greatest while feeding on fruit, indicating strong competition for this valuable food resource (van Schaik & 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 & Tattersall 1981). Long-tailed macaques use a variety of feeding strategies including picking fruits by hand or plucking them with their teeth, turning over rocks, snatching insects from the air and storing food in their cheek pouches (Sussman & Tattersall, 1981; Lucas & Corlett 1998).

Most plant fibre is found in the soluble form, which binds with cholesterol and is then eliminated in the stool (Edelstein 2014). Soluble fibres have benefits for serum lipids, while insoluble fibres are linked to laxation benefits (Slavin 2013). Fats serve as fuel for energy production and are 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 aid in the motion and locomotion of cells (Nix 2009). The seeds of many plants store nutrient protein required for the growth of the embryonic plant and function in storing amino acids as nutrients (Chopra & Panesar 2010). Plant proteins can be obtained from cereals, oil seeds and leaves. Minerals are elements that are widely distributed in foods and are a diverse group of nutrients that have many essential functions (Nix 2009; Robbins 1993). Minerals are used in building tissue for activating, regulating, and controlling metabolic processes and for transmitting neurological messages (Nix, 2009). The amount of minerals required by different individuals varies with age, sex, species, season and reproductive condition (Robbins 1993). Minerals are essential nutrients that play important roles in the metabolic processes of the body, and the absence of minerals can cause deficiency symptoms in animals (Gafar & Itodo 2011).

The nutritional needs of long-tailed macaques are key in determining their species ecology (Moges & Balakrishnan 2014). The nutritional components of the macaque diet are important in understanding their behaviour and foraging strategies (Moges & Balakrishnan 2014). In addition, these animals must obtain adequate food to survive and breed successfully (Wiafe 2015). The main objective of this study was to determine the nutritional composition of the 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) and at the entrance of KSNP and the surrounding area, including residential areas and small town areas. These study areas were located near 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 it shelters a wide variety of habitats, such as secondary forest, mangrove forest, the estuary of the Selangor River, mudflats that open to the Straits of Malacca and a man-made 25-acre 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 along with the silvered leaf monkey (*Trachypithecus cristatus*) (MNS 2014).

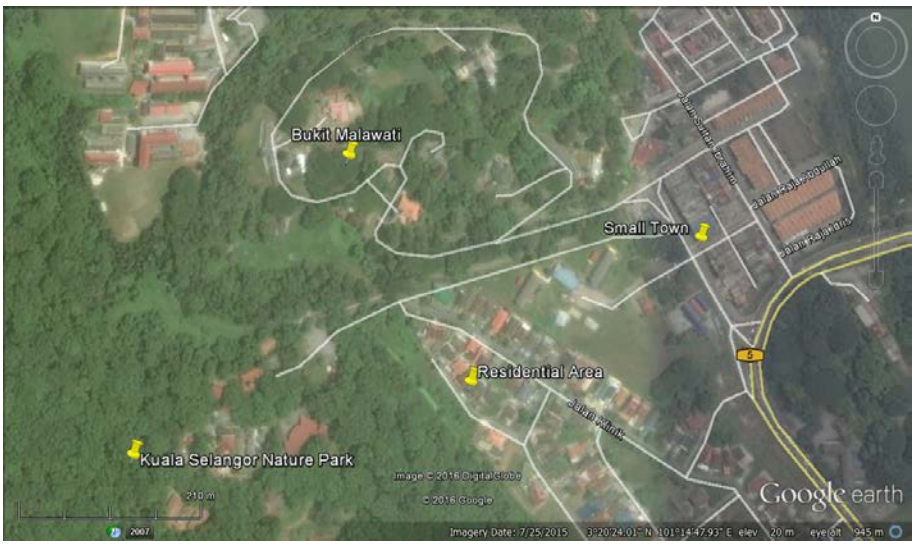

Figure 1: Map of the study area (Image sourced from Google earth, on 25 July 2015).

Methods

The nutrient contents of the fruits of twelve species consumed by *M. fascicularis*, based on a previous study by Hambali *et al.* (2014), were analysed. The species were *Arenga pinnata*, *Areca catechu*, *Terminalia catappa*, *Elaeis guineensis*, *Lagerstroemia tomentosa*, *Mangifera indica*, *Cascabela thevetia*, *Muntingia calabura*, *Musa* sp., *Artocarpus heterophyllus*, *Ficus tinctoria* ssp. *gibbosa* and *Ficus microcarpa*.

Proximate analysis was used to determine the nutritional composition of these fruits. The fruits were partitioned into four parts, which were crude protein, crude fat, crude fibre and ash. The analysis was conducted at the Nutritional Laboratory of Faculty of Veterinary and Health, Universiti Malaysia Kelantan. The crude protein contents were analysed using the Kjeldahl method (Moges & Balakrishnan 2014), the crude fibre was determined by the FibreBag System from C. Gerhardt GmbH & Co. KG (Konigswinter, Germany), the crude fat was analysed by the Soxtec extraction method, and the total mineral content was determined through the percentage of ash (Moges & Balakrishnan 2014). This study used a total of one gram per species and repeated the analyses three times.

The differences between the nutrient values in the selected fruit samples (crude fibre, crude fat, crude protein, and ash) were tested using the analysis of variance (ANOVA) test. All data were checked for normality, and because the sample size was greater than thirty, the data were assumed to be normal according to the central limit theorem. Because the data were normally distributed, the parametric statistical test one-way ANOVA was chosen. The statistical significance was set at P-value <0.05. All data analyses were

conducted using the Statistical Package for the Social Science (SPSS Inc, Chicago, IL).

RESULTS AND DISCUSSION

Nutrient Contents in Twelve Fruit Species Consumed by Long-Tailed Macaques

Table 1 provides the details of the means of three replicates for the nutrient contents of *A. pinnata, A. catechu, T. catappa, E. guineensis, L. tomentosa, M. indica, C. thevetia, M. calabura, Musa* sp., *A. heterophyllus, F. microcarpa*, and *F. tinctoria* ssp. *gibbosa*. There was a significant difference in 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, $p < 0.05$) among the twelve fruit species, suggesting that the 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* sp. (2.79%; SD = 2.83). The relative mean crude fat content was highest in *E. guineensis* (77.2%; SD = 1.77) and *M. calabura* (10.47%; SD = 0.49), while *Musa* sp. (0.36%; SD = 0.21) had the lowest crude fat content. The amount of ash was highest in *C. thevetia* (8.53%; SD = 0.6) and *A. pinnata* (7.84%; SD = 0.33), while the was 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* had the highest fat content, *T. catappa* had the highest protein content, and the total mineral content was highest in *C. thevetia*. Each studied nutrient has a few important roles.

Table 1: Nutrient contents in twelve fruits consumed by long-tailed macaques in Kuala Selangor.

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

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 proportion of the food consumed by roloway monkeys (*Cercopithecus diana roloway*), from the Cercopithecidae family, in Bia National Park, Ghana, is composed of fruits, and the pulp of mature fruits was 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 and also leaves, flowers, shoots, roots, invertebrates, and small animals in variable quantities (Maruhashi 1980; Caldecott 1986; Kurup & Kumar 1993; Krishnamani 1994; O'Brien & Kinnaird 1997; Su & Lee 2001; Rowe & Myers 2011; Schülke *et al.* 2011). The percentage of fruit in the diet is usually higher than that of other food items and depends on the particular macaque species — from relatively low (10–32% in *M. fuscata*; Agetsuma & Nakagawa 1998) to very high (85% in *M. nigrescens*; Rowe & Myers 2011) — and may also show intra-specific variation, depending on the habitat and provisioning (e.g., in *M. fuscata*: 15% in provisioned troops [Son 2003] and 88% in unprovisioned ones [Wheatley 1980]) and seasonal variation (Hanya *et al.* 2003). The number of fruit species included in the macaque diet is species-specific but is often higher than that in the diets of other sympatric frugivores (Corlett 1998).

The 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, in contrast to other mammals tending to avoid dehiscent fruits that are preferred by birds (Lucas & 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).

Frugivores may select their food from a large diversity of fruits that differ in colour, shape, and ease of harvest, which often corresponds with their nutritional content (Leighton 1993). These fruit characteristics must relate to the preference of the primates regarding which species to exploit according to their ability to manipulate and digest the fruits based on their nutritional requirements (McConkey *et al.* 2002). Most primates select fruits that are yellow in colour with a rind-like skin, sweet juicy pulp and well-protected seeds (Julliot 1996). In this study, in addition to having preferred fruit features such as being sweet, juicy and large in size, the fruit of *M. indica* also has high fibre content. Thus, this is the reason long-tailed macaques choose *M. indica* as one of their preferred foods (Hambali *et al.* 2014).

According to the previous study by Hambali *et al.* (2014), the five most abundant tree species found in Kuala Selangor are *M. indica*, *F. microcarpa*, *F. tinctoria* ssp. *gibbosa*, *A. catechu*, and *T. catappa*. In this study, the nutrient contents of these five tree species the highest in fibre, as shown in Table 1. In addition, in the study by Hambali *et al.* (2014), *M. fascicularis* in Kuala Selangor were found to prefer fig fruits as a staple food, and a study by Riley (2007) also showed that fig fruits are a staple food of 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 availability by fruiting throughout the year (MacKinnon *et al.* 1996). In this study, the fig species included *F. microcarpa* and *F. tinctoria* 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 content, except for *E. guineensis*. *M. fascicularis* chose *E. guineensis* as one of their preferred foods, which may be due to the nutritional needs of this species in

Kuala Selangor. Proteins are essential components of the diet that are necessary for the survival of primates (Pugalenthi *et al.* 2004).

CONCLUSION AND RECOMMENDATIONS

From the results of the chemical analysis, the highest percentages of fibre (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 of these twelve fruit species was found to differ. Fibre was found in the highest amount among the four types of nutrients that were studied. The highest relative fibre content of all tested fruits was found in *A. catechu*, *E. guineensis* had the highest fat content, *T. catappa* had the highest protein content, and the total mineral content was highest in *C. thevetia*. The number of studies on the nutritional composition of fruits selected by long-tailed macaques is low in Malaysia; therefore, this study is important to record data and add to our knowledge regarding the nutritional composition of foods selected and prioritized by this species. Further laboratory analysis of other nutrient contents of primate foods including carbohydrates, mineral elements and neutral detergent fibre should be conducted. In addition, analyses of other parts of food plants, including leaves, flowers and seeds, should be carried out to further determine the nutrient contents in the diet of the long-tailed macaque.

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