

Palatability level, analysis of types and phytochemical content of feed on long-tailed monkeys (*Macaca fascicularis* Raffles, 1821) in the Kaliurang nature tourism forest, Yogyakarta

Elsa Lisanti^{1*}, Alza Kirana Thaharah¹, Azura Ameira¹,
Khadijah Lathifia Abidah¹, and M. Farhan Adyn¹

¹Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Negeri Jakarta, Campus A, Hasyim Asj'arie Building, 6th Floor, Jl. Rawamangun Muka, East Jakarta, 13220, Indonesia.

Abstract. The forest area on the slopes of Mount Merapi, located in the northern part of Yogyakarta, has a lot of flora and fauna. One of the fauna that lives in the area is a long-tailed monkey (*Macaca fascicularis* Raffles 1821). Long-tailed monkeys eat lots of fruit and are grouped into frugivorous animals. However, long-tailed monkeys, such as leaves and flowers, will have more abundant food in their habitat. Therefore, this study analyzed long-tailed monkey feed to see the percentage of long-tailed monkeys who chose feed. In addition, phytochemical content analysis was conducted as supplementary data to determine the feeding preferences of long-tailed monkeys. The data obtained were analyzed descriptively. The results showed that the plant species selected by the long-tailed monkeys in the Tlogo Muncar and Tlogo Nirmolo areas were *Cinchona pubescens* Vahl, *Leucaena leucocephala* (Lam.) de Wit, *Melastoma polyanthum* Burm. f, *Carex flaca* and Sp 1. The plant parts that long-tailed monkeys ate were almost entirely leaves. Phytochemical tests on samples consisted of steroid, flavonoid, phenol, saponin, and triterpenoid tests.

1 Introduction

The long-tailed monkey (*Macaca fascicularis*) is one of the primates of the genus *Macaca* and also a member of the subfamily *Cercopithecinae*. The distribution of long-tailed monkeys is the most extensive, covering most of the population in the Asian region [1]. Long-tailed monkeys live in various habitats, such as lowland, highland, and coastal mangrove forests. They can even survive in environments with high human activity [2]. Different habitat types lead to other food sources for long-tailed monkeys, affecting the variation in the diet of each population [3]. *Macaca*'s dietary variation reflects ecological plasticity in coping with differences in both food availability and abundance. Longtail

* Corresponding author: elsalisanti@unj.ac.id ; elsalisanti@gmail.com

monkey plastic takes all kinds of food in their home range. Their diet may vary across seasons and altitudes[3]. Generally, *macaca* consume both leaves and fruits, but their ability to balance their diet is influenced by seasonal variations and the availability of key food sources [4], [5], [6]. Since leaves are typically distributed more evenly, folivores tend to spend less time foraging. Also, leaves are richer in fiber, which has a lower energy content and takes longer to digest than fruits [7], [8]. The palatability of food plays a significant role in influencing foraging behavior in primates, including Tonkean macaques [9].

Kaliurang Nature Tourism Forest is one of the tailed monkeys' habitats. As a habitat for long-tailed monkeys, the natural tourism forest of Kaliurang becomes the primary determinant of the feed available to the animal. Food availability in the natural tourism forest of Kaliurang causes long-tailed monkeys to choose the type of feed [10]. The investigation of animal nutrition ecology focuses on the chemical basis of food selection and improves understanding of their feeding biology. Therefore, this research was conducted to determine the type of feed and its phytochemical content in long-tail monkey feed. This study aims to assess the kind of long-tailed monkey feed and the phytochemical content of long-tailed monkey feed.

2 Materials and methods

2.1 Materials

The materials used include samples of *Macaca fascicularis* forage plants, methanol, chloroform-ammonia, diethyl ether, glacial CH_3COOH , concentrated H_2SO_4 , concentrated HCl, Meyer's reagent, and Dragendorff's reagent. The tools used in this research are a blender, rotary evaporator, tube reaction, filter paper, and stainless steel blade.

2.2 Methods

2.2.1 Data collection

Daily behavior observations were conducted for eight hours (08.00-16.00) using a focal animal sampling technique and a five-minute interval. The plant species that became the food source of *Macaca fascicularis* were identified, and samples were taken to test the phytochemical content by taking the leaves from the tree species that became the food source of *Macaca fascicularis*.

2.2.2 Preparation of test sample extract

The leaves samples from the *Macaca fascicularis* feed were then air-dried and cut into small pieces using a stainless knife. The sample powder was macerated with ethanol and evaporated to obtain a crude extract.

2.2.3 Phytochemical content test

Phytochemicals are substances plants generate from their primary and secondary metabolic processes. Phytochemical content testing is based on the method [11]. The tests carried out are as follows:

- Alkaloid test. Four grams of crude extract were mixed with 10 mL of chloroform ammonia and filtered into a test tube. A few drops of 2 M H₂SO₄ were added to the filtrate, which was then shaken to form two layers. The supernatant was transferred to a new test tube, where Meyer's reagent and Dragendorff's reagent were added. The presence of alkaloids was confirmed by forming a white precipitate with Meyer's reagent and an orange-to-red-brown precipitate with Dragendorff's reagent.
- Triterpenoid and steroid tests. Four grams of crude extract were treated with diethyl ether, and the soluble fraction was separated in diethyl ether. Glacial CH₃COOH and concentrated H₂SO₄ were added to the soluble fraction. The mixture was gently shaken and left to stand for a few minutes. Steroids produce a blue or green color, while triterpenoids yield a red or violet color.
- Flavonoid test. Four grams of crude extract were mixed with hot water, boiled for 5 minutes, and filtered. A small amount of Mg powder and 1 mL of concentrated HCl were added to the filtrate, and the mixture was shaken. The formation of a red, yellow, or orange color indicates a positive test.
- Phenol test. Four grams of crude extract were mixed with hot water, followed by a few drops of 1% FeCl₃ reagent. The appearance of a green, blue, or purple color indicates a positive test.
- Saponin test. Four grams of crude extract were mixed with hot water, followed by a few drops of concentrated HCl. The formation of stable foam after approximately 15 minutes indicates a positive test.

2.2.4 Data analysis

The data on the plants consumed by long-tailed monkeys were analyzed descriptively. The analysis of the secondary metabolites in the test sample was recorded as either positive (indicating the presence of a compound) or negative (indicating the absence of a compound). These results were further examined.

3 Results and discussion

3.1 Long-tailed monkey feed

Research on the diet of long-tailed monkeys was carried out in Tlogo Muncar and Tlogo Nirmolo, Kaliurang. There are five types of long-tailed monkey feed in both. The exact observation location was consumed, namely *quinine* (*Cinchona pubescens* Vahl), *Leucaena leucocephala* (Lam.) de Wit, and *Melastoma polyanthum* Burm. F, *Blue zinger* (*Carex flaca*), and one species not identified (Table 2). Most consumed feed preferences based on age and sex, i.e., adult male (31%), adult female (*Leucaena leucocephala* 33%),

juvenile males (*Melastoma polyanthum* 24%), juvenile females (*Sp1* 23%) and children (*Carex flaca* 15%) (Figure 1).

Table 1. Types of feed consumed by long-tailed monkeys in Tlogo Muncar and Nirmolo Logo

Latin name	Family	The part eaten			
		L	Fw	Fr	S
<i>Cinchona pubescens</i> Vahl	Rubiaceae	1	1	0	0
<i>Leucaena leucocephala</i> (Lam.) de Wit	Leguminosae	1	0	1	0
<i>Melastoma polyanthum</i> Burm. f	Melastomaceae	1	0	1	1
<i>Carex flaca</i>	Cyperaceae	1	0	0	0
<i>Sp1</i>	Malvaceae	1	1	0	0

Description: (1 = present; 0 = not present) (L = Leaf; Fw = Flower; Fr = Fruit; S = Stem)

The age structure of long-tailed monkeys in Tlogo Muncar and Nirmolo Logo consisted of five categories: adult male (AM), adult female (AF), juvenile male (JM), juvenile female (JF), and infant (C). According to Bolter and Zihlman [12], the age classes in vervet monkeys (*Cercopithecus aethiops*) are classified as adult males at approximately 6–7 years, adult females at about 4–5 years, juvenile males from 5 to 48 months, juvenile females from 5 to 36 months, and infants from about 4–5 to 18 months.

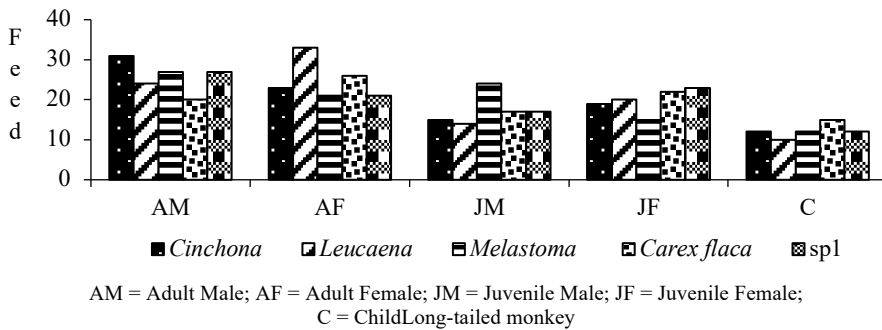


Fig. 1. Percentage of feed frequency consistency based on the group composition of long-tailed monkeys in Tlogo Muncar and Tlogo Nirmolo.

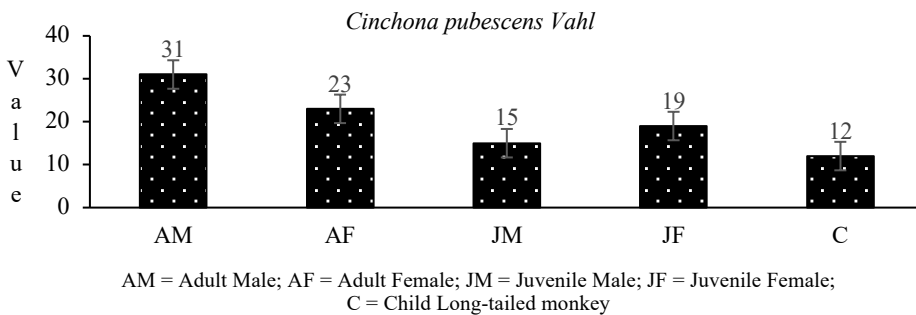


Fig. 2. The palatability level of *Quinine* as feed for long-tailed monkeys.

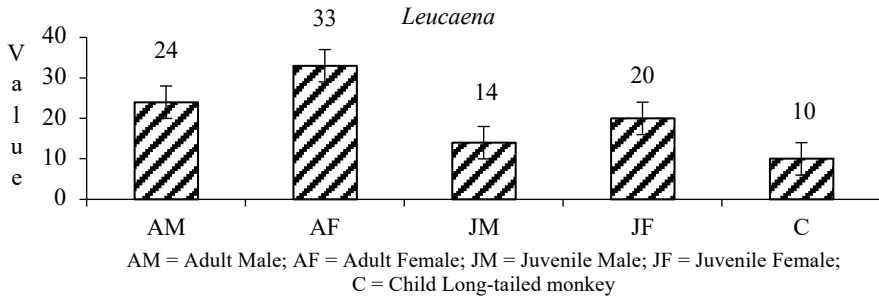


Fig. 3. The palatability level of *Leucaena* as feed for long-tailed monkeys.

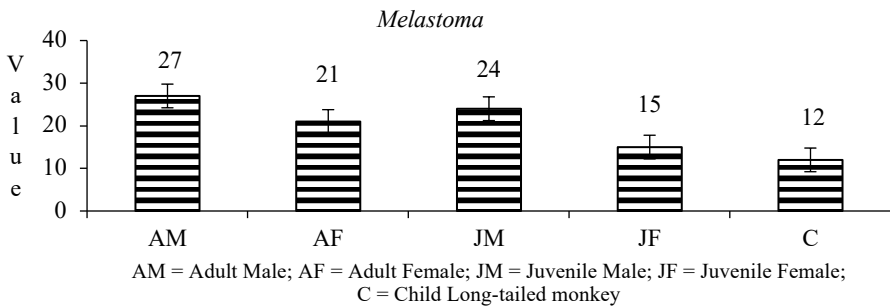


Fig. 4. The palatability level of *Melastoma* as feed for long-tailed monkeys.

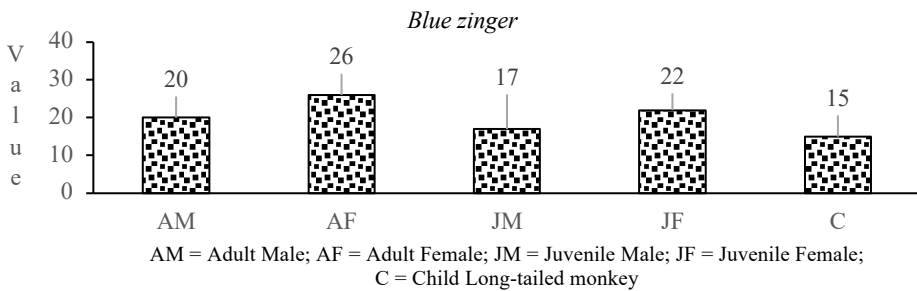


Fig. 5. The palatability level of *Blue Zinger* as feed for long-tailed monkeys.

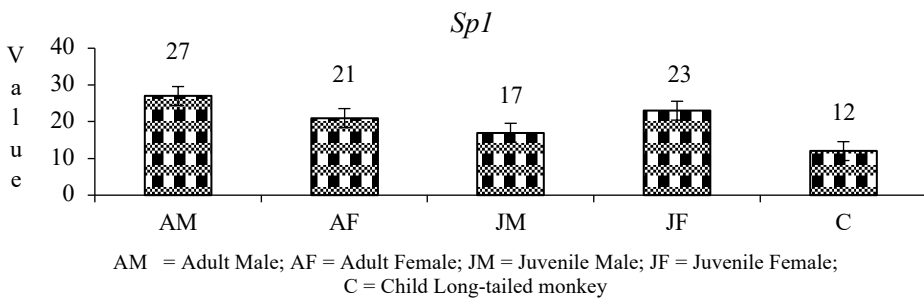


Fig. 6. The palatability level of *Sp1* as feed for long-tailed monkeys.

According to the graph above, the palatability of plants as food for long-tailed monkeys is determined by the number of individuals. This indicates that long-tailed monkeys exhibit varying feed preferences based on age and sex. A comparison between the males and females shows differences in the palatability level of plants as feed. According to Balcells and Baro [13], the classifications have been used widely to classify wild howler monkeys by their age at their wide distribution.

Samples of plant species that were successfully taken from the Tlogo Muncar and Tlogo Nirmolo areas were *Cinchona pubescens* Vahl, *Leucaena leucocephala* (Lam.) de Wit, *Melastoma polyanthum* Burm. F, *Carex flaca*, and *Sp1*. Based on age and sex, long-tailed monkeys had different preferences for the five plant species that were successfully sampled.

Quinine/Cinchona plants are the most preferred feed by adult males, with a 31% percentage. Adult females primarily consume *Leucaena* plants, accounting for 33%, followed by *Blue zinger* plants at 26%. In juvenile long-tailed monkeys and children, both males and females did not dominate the five types of forage plants. However, compared to the five types of feed, juvenile male long-tailed monkeys prefer *Melastoma* plants with a percentage of 24%. Juvenile female long-tailed monkeys prefer *Sp 1* plants, with a rate of 23%, while the aged children prefer *Blue zinger* plants, with a percentage of 15%. The difference in feed frequency can be seen in Figure 4.

Five types of plants that were successfully taken from the research location were allegedly chosen as food plants because of the benefits of these plants for long-tailed monkeys and their abundant availability. *Blue zinger* and *Sp 1* plants are plentiful in Tlogo Muncar and Tlogo Nirmolo locations. These two plants were chosen as a food source because although the long-tailed monkey's main diet is fruit, these primates are very flexible in their food choice. For example, after a forest fire destroys its food sources, this species eats insects and other food besides its natural plants [14].

Long-tailed monkeys widely eat quinine plants because this plant has properties as a stomachache medicine, antimalarial, and appetite enhancer [15], [16]. On the other hand, research by Ayssiwede *et al.* [17] demonstrated that *Leucaena leucocephala* is a vital feed source due to its high content of protein, essential amino acids, minerals, carotenoids, and vitamins, making it possible for this plant to be chosen by long-tailed monkeys for its food choice.

The *Melastoma* plants have the properties to heal wounds and are used as stomachache medicine [18]. The choice of *quinine*, *Leucaena leucocephala*, and *Melastoma* plants can be caused by the properties contained in these plants as described above. Long-tailed monkeys can detect long-distance food guided by olfaction, which requires detecting and identifying the cue, following the scent, and tracking its source. On a macroscopic scale, air movement can also be a source of scent for long-tailed monkeys [19]. Primates detect fruit to be eaten based on olfactory cues [20], [21]. Based on the observations of the plant consumption patterns exhibited by the *M. fascicularis* primate species at Kaliurang Nature Tourism Forest showed the five samples, the plant parts eaten by long-tailed monkeys were almost entirely left. The leaves that long-tailed monkeys eat are young. Ritonga *et al.* [22] state that leaves are abundant in nutrients like cellulose and fats, particularly in the young leaf shoots. The protein content in younger

leaves is higher compared to other plant parts, such as fruits or mature leaves [7], [23], [24]. Young *M. fascicularis* preferred leaves as their feed, as they could digest the fiber in the leaves better than adult individuals, so long-tailed monkeys prefer young leaves more than old leaves. According to Wulandari *et al.* [25], long-tailed macaques tend to eat leaves, fruit, and flowers. The observations show that long-tailed monkeys will first smell the food before it is consumed. In addition, five types of plants selected as feed, *quinine/Cinchona*, *Leucaena*, *Blue zinger*, *Melastoma*, and *Sp 1*, have the characteristics of young leaves that are soft and hairless.

3.2 Phytochemical test

The substances generated by plants are known as phytochemicals. These are synthesized through the plant's primary and secondary metabolic processes. Phytochemicals play a crucial role in helping plants survive and defend against other plants, animals, insects, microbial pests, and pathogens [11]. A phytochemical test was performed to identify the secondary metabolites in the long-tailed monkey's food. The results of the phytochemical test are shown in Table 2.

Table 2. Phytochemical Testing of Long-Tailed Monkey Feed

Plant Type	Phytochemical Test					Total Positive
	Steroid	Flavonoid	Fenol	Saponin	Triterpenoid	
<i>Cinchona pubescens</i> Vahl	+	-	+	+	-	3
<i>Leucaena leucocephala</i> (Lam.) de Wit	+	-	+	-	-	2
<i>Melastoma polyanthum</i> Burm. f	-	+	+	-	-	2
<i>Carex flaca</i>	-	+	-	-	-	1
<i>Sp1</i>	-	-	+	+	-	2

The results of phytochemical tests show that plants were steroids, flavonoids, phenols, saponins, and triterpenoids. This phytochemical test was carried out on samples of *Cinchona* (leaves), *Leucaena* (leaves), *Melastoma* (stems), *Carex flaca* / *Blue zinger* (leaves), and *Sp 1* (leaves). The table above shows that *Cinchona* plants were detected to contain more phytochemicals than other plants. *Cinchona* gave positive results on steroid, phenol, and saponin tests. In contrast, flavonoids were the only phytochemical detected in the *Carex flaca* / *Blue zinger* plant during the tests. The *Leucaena* plant showed positive results for both steroid and phenol tests. *Melastoma* stems tested positive for flavonoids and phenols. Additionally, *Sp 1* yielded positive results in both phenol and saponin tests.

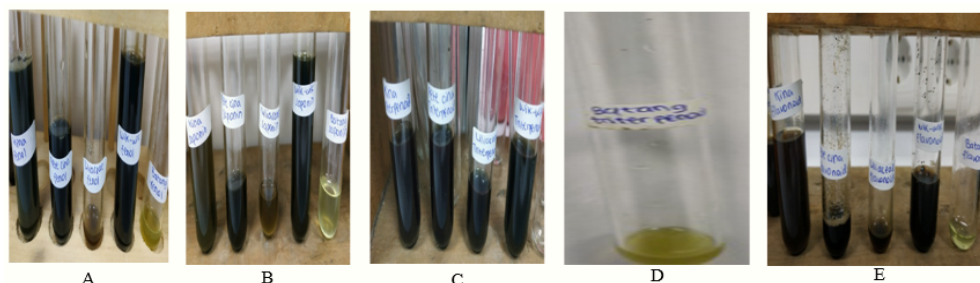


Fig. 7. Test results of Phenol (A), Saponins (B), Triterpenoids (C, D), and Flavonoids (E) five samples.

Phytochemical tests in this study included triterpenoids, flavonoids, phenols, saponins, and alcohol. The phenol test gave positive results in 4 plant samples, namely stems of *Melastoma*, *Cinchona/quinine*, *Leucaena*, *Blue zinger/Carex flaca*, and *Sp 1*. A color change to black indicated a positive result in the phenol test (Figure 7A). According to Kurang and Kamengon [26], the presence of phenol is confirmed by developing a bluish-black color. The color change indicates the positive test results for phenol. The extract is identified as containing phenolic compounds if there is a substantial change in color to green, blue, red, purple, or black. The color change is concentrated because FeCl_3 reacts with aromatic hydroxyl groups [27]. According to Harborne [28], qualitative evidence showing the presence of phenol can be obtained using a 1% FeCl_3 reagent. Phenol is a polar compound in the form of a colorless crystalline substance with a distinctive odor [29]. Studies have shown that long-tailed monkeys prefer to consume the stems of *Melastoma*, *quinine*, *Leucaena*, *Blue zinger*, and *Sp 1* due to their phenolic compound content. The flavonoid test returned positive results, with the *Melastoma* stem turning yellow and the *Blue zinger* plant turning orange. The appearance of a red-orange color after adding HCl and Mg powder is a typical indicator of flavonoid compounds [30]. This color change suggests the reduction of flavonoid components, further confirming their presence in the extract [31].

Positive steroid test results were shown on *quinine* and *Leucaena* plants by forming a dark green color. The formation of the green color is based on H_2SO_4 , which reacts in an acetic anhydride solvent. Adult males primarily consume quinine plants, while *Leucaena* plants are eaten mainly by adult females, which contain steroid compounds. According to Saraswati *et al.* [32], the presence of steroids is indicated by the formation of a blue/green color. On the other hand, the terpenoid test returned negative results for all plant samples, as no brown color appeared. The color change observed was due to the reaction of sulfuric acid added to the extract, which had been diluted with chloroform [26].

The Saponin test showed positive results on *Quinine* and *Sp 1* plants with foam formation for 15 minutes. Meanwhile, the stems of *Melastoma*, *Leucaena*, and *Blue zinger* gave negative results with the formation of foam that did not last for 15 minutes. Saponins are compounds that have a polar group and a nonpolar group and will be surface active. When shaken with water, saponins can form micelles. The foam produced in this test occurs because the polar groups are oriented outward in the micelle structure, while the

nonpolar groups face inward. According to Kafelau *et al.* [33], the saponin test yielded positive results due to the foam formation. Saponins, a type of glycoside, can generate foam in the air, indicating a positive outcome. The saponin compound group comprises a polar glycosyl group and non-polar steroid and triterpenoid groups. Compounds containing both polar and non-polar groups are active at the surface.

The Liebermann-Burchard test was used to identify the steroid compound group, and the results showed a positive reaction, indicated by the formation of a dark green color. The principle behind this test is the ability of the compound to react with concentrated sulfuric acid in an acetic anhydride solvent, resulting in the release of H₂O and a combination with a carbocation. In related studies, Chapman and Chapman [34] explored the connection between nutritional and secondary components in the diet selection of red colobus monkeys (*Procolobus badius*) in Kibale National Park, Uganda. These monkeys prefer young leaves over older ones due to the phytochemical differences between the two types of leaves.

4 Conclusions

Based on the research that has been done, it has found that the plant species selected by the long-tailed monkeys in the Tlogo Muncar and Tlogo Nirmolo areas were *Cinchona pubescens* Vahl, *Leucaena leucocephala* (Lam.) de Wit, *Melastoma polyanthum* Burm. f, *Carex flaca* and *Sp 1*. Based on age and sex, long-tailed monkeys had different feed preferences. The most widely eaten plant parts by long-tailed monkeys are leaves. Phytochemical tests used steroids, flavonoids, phenol, saponin, and triterpenoids. Four of the five samples of long-tailed monkey feed contained phenolic compounds that play a role in growth.

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