Food preference of Sumatran elephant (*Elephas maximus sumatranus*) to commodity crops in human-elephant conflict area of Aceh, Indonesia

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Abstract. Sumatran elephant (*Elephas maximus sumatranus*) experiences several conflict with human in rural population. Commodity crops tend to be destroyed or consumed by the elephants during crop raiding due to availability of palatable plants species. Comprehensive data and information are needed to synthesis conservation strategy towards their disturbance in human area. The study was aimed to obtain preferred commodity plant species by the elephants using electivity index. The study site was located in Elephant Conservation Centre, Saree, Aceh, Indonesia. The research was designed as to follow restricted feeding of several identified crops such as: areca palm (*Areca catechu*), banana (*Musa sp.*), oil palm (*Elais guineensis*), rice (*Oryza sativa*), rubber tree (*Hevea brasiliensis*), cacao tree (*Theobroma cocoa*), coffee (*Coffea arabica*), chili pepper (*Capsicum frutescens*), candle nut (*Aleurites moluccana*), and patchouli (*Pogostemon cablin*). The results showed three commodity plant which were not preferred by the elephants such as: chili pepper (*Capsicum frutescens*), candle nut (*Aleurites moluccana*), coffee (*Coffea arabica*), patchouli (*Pogostemon cablin*), and cocoa tree (*Theobroma cocoa*) and were further categorized as low palatability for elephants. The results then reflect a promising act by planting those species near elephant’s habitat in order to reduce frequency of elephant raiding into rural area.

1. Introduction

Elephant habitat naturally provides varied foods in the form of grass, bark, wood, roots, and fruits [1]. Elephant would most likely consume right after found their food and feeding activity will decrease as foraging distance gets farther [2]. Sumatran elephant (*Elephas maximus sumatranus*) is a species of browser animals (bush-eaters), folivore (leave-eaters), frugivore (fruit-eaters), seeds-eaters, and other parts of plants to suffice their mineral needs. Elephants possess high feeding rate to fulfill energy needs according to its body size, age, and sex. The megaherbivore animal consumes more than 400 species of different plants and various parts of plants, such as leaf, fruit, bud, midrib, stem or stalk, flower, bark, and liana, depend on the area, weather, and ecosystem where the elephant lives [3,4,5,6,7]. However, elephant is also very selective on choosing food [2,5] and also depends on the types of vegetation [8].
At the time of naturally food consuming, elephants have to choose changing land structure with different plant species, phenological level, type of structure, chemical composition, relative or absolute abundance, and patterns of plant distribution. If particular plant is often consumed or consumed in large quantities, it does not always mean that the elephants prefer that plants. Food selection depends on the level of food availability. It is not easy to determine elephants’ favorite food in the habitats with mixed types of bushes, grasses, and trees as it is also difficult to measure the relative availability of plant. Therefore, preference and dispreference upon particular plant or part of plant are uncovered during eating vis-à-vis the availability of several different plants simultaneously [4].

Furthermore, elephants also showed their preference and palatability in choosing foods. Palatability is food performance which represents their physical and chemical properties reflected by the organoleptics such as appearance, smell, flavour (bland, salty, sweet, bitter), texture, and temperature. Therefore, the food attract and stimulate animals to consume food [9]. Hence, palatability is an important factor to determine the level of food intake. Commodity crops of a community that were consumed, trampled, broken or revoked by the elephants, led to growth disruption of crops and increased financial loss to society. Crops that were destroyed by the elephants within human-elephant conflict zones could not be determined yet whether the elephants have high preference towards the damaged plants. Based on general information from people and several studies, it is reported that elephant behavior showed preference phenomena toward local’s commodity crops. High level of elephant preference indicates its fondness towards certain type of commodity crops. So far, there have been no comprehensive data and information collected upon the elephant’s food preferences toward people’s commodity crops, especially within human-elephant conflict zones in Aceh. Based on that idea, the study was aimed to: (1) analyze elephant’s food preference towards some types of agricultural/plantation commodity crops that are given at the same portion and time, (2) analyze commodity crop’s levels of preference and its palatability on elephants. When elephant’s level of preference towards certain type of plant is high, it is not an appropriate option for plant cultivation as local commodity crops in human-elephant conflict area. Conversely, crops with low level food preference of elephants are good choices to be planted by community in the area of human-elephant conflict. It is suggested to be an alternative solution of human-elephants conflict mitigation that would not only address elephant conservation problems, but also to promote co-existence between humans and elephants by selecting no-risk type of commodity crops with the elephants (Human-elephant co-existence).

2. Materials and Methods

2.1. Time and Study Sites
Research was conducted on December 2014 in Elephant Conservation Centre, Saree, Aceh Province (05°44’41.65”N – 95°72’47.17”E) and located at an altitude of 436 m.a.s.l with type B of climate. Based on the data during observation at the Elephant Conservation Centre, Saree, Aceh Province, morning average temperature was 19°C to 24°C, while on the afternoon the temperature reached 28°C to 30.1°C. The range of average air humidity every morning is from 78% to 84% whereas in the afternoon the average air humidity was from 54% to 69%. The ranges of temperature and humidity were fluctuated but did not necessarily affected elephant's activities. The situation was tolerable, thus all elephants could still adapt to the environmental factors.

2.2. Data Collection
The main objects of this research were 10 elephants (*Elephas maximus sumatranus*), with 5 adult females and 5 adult males. The administered feed consist of 10 different types of agricultural/plantation economical crops that were expected to be destroyed or not destroyed by elephants, such as areca palm (*Areca catechu*), banana (*Musa sp.*), oil palm (*Elais guineensis*), rice (*Oryza sativa*), rubber tree (*Hevea brasiliensis*), cacao tree (*Theobroma cocoa*), coffee (*Coffea arabica*), chili pepper (*Capsicum frutescens*), candlenut (*Aleurites moluccana*), and patchouli...
(Pogostemon cablin). Those plants were chosen after preliminary study of several conflict areas in the Aceh Province. Each type of feed was supplied as much as 25 kg (10 types = 250 kg) and regarded as sufficient to find out the level of preference of various commodities provided in the test for an hour.

The equipment used in this research included weighting scale (for weighing feed), thermohygrometer (to measure temperature and humidity), food container, cart, wheelbarrow, clock (to limit observation interval), stationery, tally sheet (to record observation data), and video camera (to observe elephants behavior). Feed administration was performed using restricted feeding method. Previously, preliminary treatment for 7 days was exercised for adaptation for foods that will be administered. The elephants were then fed in the morning at 07.00 am to 08.00 am and in the afternoon at 04.00 pm to 05.00 pm for 7 times observation as replication. Administered feeds are relatively fresh materials weighed 25 kg respectively, then piled separately. Composition for each feeding was revamped. Next, an elephant was released at a distance of 5 m facing the pile of feeds. Counting began at that time for 60 minutes. Neglected feeds by the elephant were pulled out of the pile and calculated as the remaining feeds. Any consumed parts of leaves, broken twigs, barks, and small parts were not counted as remaining feeds. Once treatment duration is over, the elephants were released from feeding area.

Feeds preference data that were obtained from each remaining commodity crops was weighed again to get the consumed amount eaten from time interval at the beginning of feed administration. The weight of water contained in types of feed given was ignored in the measurement. Temperature and environmental humidity measurements were also carried out twice a day before the treatment begins. The tests did not satisfy the elephant’s appetite. Moreover, normal feeding were still administered after the treatment to prevent digestion shock due to dietary changes. There were no restrictions and changes in normal activities of the elephants outside treatment period. Additionally, a calm and quiet atmosphere during treatment were also sought because an unusual atmosphere may affect their eating patterns, such as too much noisy audiences approaching the elephant and so forth.

2.3 Data Analysis
Descriptive analysis in which a form of univariate analysis was utilized, to give a general idea on the total food amount consumed by the elephants. To determine the level of commodity crop preferences, Electivity index is expressed by:

\[ Ei = \frac{ri - ni}{ri + ni} \]

where:
- \( Ei \) = Ivlev’s electivity index on commodity crops
- \( ri \) = Percentage of plant species among feed crops
- \( ni \) = Percentage of available plant in the environment

Electivity index method is a method to find out food preference index on the animals. Changing electivity ranges from -1.0 to +1.0, with values between 0 and +1 indicating fondness of food, while values of 0 and -1 indicate dislike of feed [10]

3. Results and Discussions

3.1 Elephant’s Food Preference towards Several Types of Commodity Crops
Preference upon certain type of plants or parts of it could be seen when eating activity commenced vis-à-vis with availability of diverse plants at the same time. Naturally, it is uneasy to determine elephant’s most favored food in its habitat due to difficulties in measuring relative availability of plant types or food resources [4]. According to feeding result upon some food types to 10 elephants, it was found that they consumed several types of plants or certain parts of plants. Besides, there were differences in consuming part of plants, even plants that were not consumed at all were also found. It could be clearly seen on Table 1. The elephants preferred certain plants and certain part of plants out
of those provided. It indicated that selection factor towards certain types of foods existed. Elephants could be very selective upon choosing its food and will eat some taxa of very different plants [5]. Additionally, elephants eat very diverse part of plants, such as leaf, fruit, bud, midrib, stem or stalk, and flower [7,11,12].

| Types of feed | Parts of plants consumed by the elephants |
|---------------|-----------------------------------------|
|               | Stem | Bark | Midrib | Leaf | Fruits |
| Chili (Capsicum frutescens) | -    | -    | -      | -    | -      |
| Cocoa (Theobroma cocoa)       | -    | -    | -      | -    | +      |
| Rubber (Havea brassiliensis)  | Young | +    | -    | +    | -      |
| Oil palm (Elais gueneensis)   | -    | -    | ++ | -    | +      |
| Candlenut (Aleurites moluccana) | -    | -    | -    | -    | -      |
| Coffee (Coffea Arabica)       | -    | -    | -    | -    | -      |
| Patchuoli (Pogostemon cablin) | -    | -    | -    | -    | -      |
| Paddy (Oryza sativa)          | +++  | +++  | +++  | +++  | +++  |
| Areca (Areca catechu)         | Inner parts | -    | -    | -    | -      |
| Banana (Musa sp.)             | +++  | +++  | +++  | +++  | +++  |

(++) : most consumed foods, (++) : averagely consumed foods, (+) : less consumed foods, ( - ) : unconsumed foods.

For rubber trees, elephants chose the young stems, old barks, while leaves were less to be consumed. Naturally elephants also favored rubber tree, particularly its stems and consumed the whole plant by pulling it out [13,14]. They normally consumed barks of a larger plants [1,2]. However, elephants rarely choose barks to eat, they will only eat the barks from certain selected types of plants that considered as proper foods [2,15]. Furthermore, elephants consume barks to fulfill mineral needs of the body [4]. Elephants consume midrib and fruits of the oil palm trees. Average food consumption showed that oil palms also particularly chosen by the elephant as food source and are among the most preferred crops. Although in this study they consumed unconsiderable amount due to provision of other more preferred crops, wild elephants in fact often consumed palm tree’s apical bud or tip of leaves as well as its nodes which is central to trees growth, causing plants to die off. It is frequently happened when the elephants attacked oil palm plantations [14,16,17].

Elephants also chose stem base by digging and pulling out its core to be consumed [4]. They spent long time to consume lots of ripe fruits from the family of Arecaceae, sometimes causing them to hangover due to fermentative fluids. In addition, during feed administration, elephants chose an inner part of the areca palm’s stem by ripping and pulling out soft parts to be consumed, but in very small amounts. According to [2], elephants are keen to choose inner part of stems from the family of Arecaceae. This is mainly caused by its rich water content and soft texture of the inner parts. For cacao tree species, elephants only select limited amounts of the fruits for consumption. They do not eat the plants from the family of Meliaceae, presumably caused by unpleasant taste of the trees. Cacao/ cocoa contains alkaloids, an extremely bitter taste that elephants do not preferred [18]. Cacao contains theobromine and caffeine, which are derived from methylxanthine that triggers poisoning. The highest purine alkaloids concentration is found in young cacao leaves containing significant amount of theobromine and caffeine [19]. Naturally, damage to cacao tree plantations is because the elephants pass through plantation areas although they slightly consumed cacao fruits [17]. Yet elephants did not consume this type of plants, they are just happened to trample on them [20].

Elephant needs approximately 250 kg of foods per day for adult with body mass of 3,000 to 4,000 kg [21,22]. However, during this research, female elephant consumed approximately 370.93 kg of food, whereas male elephant consumed 372.42 kg. Average consumption for an hour for female elephant was 52.99 kg, with average minimum weight of 50.32 kg and maximum weight of 56.38 kg.
While for male elephant, average consumption per hour were 53.20 kg, with lowest average of 52.26 kg and highest average of 55.05 kg.

During feed administration in the morning, it turned out that rice (Oryza sativa) being the most consumed one with an average of 22.57 kg/hour/individual to 23.79 kg/hour/individual, followed by banana (Musa sp.) reaching over 18.93 kg/hour/individual to 21.14 kg/hour/individual. On the other hand, the least consumed one was cacao tree (Theobroma cacao) with an average of 0.21 kg/hour/individual to 1.21 kg/hour/individual (Table 2). Furthermore, it was found that 4 species of plants were not consumed at all by the elephants. The plants were chili pepper (Capsicum frutescens), candlenut (Aleurites moluccana), coffee (Coffea Arabica), and patchouli (Pogostemon cablin).

Afternoon feeding (Table 3) also showed similar result to food administration in the morning. Elephants also chose rice to be the most consumed with an average of 22.43 kg/hour/individual to 24.00 kg/hour/individual. As in the morning result, cacao tree were slightly consumed (0.21 kg/hour/individualto 1.07 kg/hour/individual). Finally, similar to feeding activities in the morning, elephant did not consume chili (Capsicum frutescens), candlenut (Aleurites moluccana), coffee (Coffea arabica), and patchouli (Pogostemon cablin) at all.

Table 2. Average food consumption (wet weight) in the morning

| Types of feed | Average of food consumption (kg/hr/individual) |
|---------------|-----------------------------------------------|
|               | E1   | E2   | E3   | E4   | E5   | E6   | E7   | E8   | E9   | E10  |
| Chili (Capsicum frutescens) | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    |
| Cocoa (Theobroma cacao)       | 0.21 | 1.00 | 0.57 | 0.79 | 1.00 | 1.21 | 0.86 | 0.57 | 0.86 | 0.64 |
| Ruber (Havea brassiliensis)  | 4.71 | 2.36 | 4.86 | 5.71 | 4.57 | 3.50 | 7.00 | 4.43 | 7.14 | 2.86 |
| Oil palm (Elais gueenensis)  | 6.14 | 3.50 | 3.69 | 3.18 | 0.43 | 3.79 | 2.37 | 3.57 | 3.07 | 3.36 |
| Candlenut (Aleurites moluccana) | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    |
| Coffee (Coffea Arabica)      | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    |
| Patchouli (Pogostemon cablin) | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    |
| Paddy (Oryza sativa)         | 23.79| 23.43| 23.50| 23.36| 23.43| 23.50| 23.36| 23.50| 22.57| 23.79|
| Areca (Areca catechu)        | 0.75 | 2.86 | 1.39 | 0.71 | 1.14 | 1.84 | 0.86 | 1.09 | 1.32 | 1.23 |
| Banana (Musa sp.)            | 21.00| 18.93| 20.71| 19.21| 21.14| 19.71| 19.00| 20.00| 20.71| 20.64|

Table 3. Average food consumption (wet weight) in the afternoon

| Types of feed | Average of food consumption (kg/hr/individual) |
|---------------|-----------------------------------------------|
|               | E1   | E2   | E3   | E4   | E5   | E6   | E7   | E8   | E9   | E10  |
| Chili (Capsicum frutescens) | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0.00 |
| Cocoa (Theobroma cacao)       | 0.64 | 0.21 | 0.50 | 0.64 | 0.64 | 0.71 | 1.07 | 0.36 | 0.86 | 1.00 |
| Ruber (Havea brassiliensis)  | 3.50 | 1.43 | 3.29 | 5.57 | 3.29 | 3.21 | 5.50 | 3.57 | 6.57 | 2.43 |
| Oil palm (Elais gueenensis)  | 7.00 | 2.64 | 4.57 | 2.57 | 1.21 | 3.79 | 2.13 | 4.21 | 3.71 | 5.73 |
| Candlenut (Aleurites moluccana) | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    |
| Coffee (Coffea Arabica)      | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    |
| Patchouli (Pogostemon cablin) | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    |
| Paddy (Oryza sativa)         | 23.64| 24.00| 23.79| 23.50| 23.00| 22.43| 23.57| 23.00| 22.86| 23.14|
| Areca (Areca catechu)        | 0.50 | 2.14 | 1.96 | 0.57 | 1.43 | 2.54 | 0.71 | 1.43 | 1.43 | 1.29 |
| Banana (Musa sp.)            | 20.86| 18.14| 19.86| 20.07| 20.64| 19.00| 19.43| 20.57| 19.00| 18.43|

Remarks: E1 (Elephant Butet), E2 (Elephant Johana), E3 (Elephant Mega), E4 (Elephant Ida), E5 (Elephant Isabela), E6 (Elephant Abu), E7 (Elephant Bunta), E8 (Elephant Lilik), E9 (Elephant Midox), E10 (Elephant Ollo)
Based on elephant’s sex, consumption over several types of foods in the morning and in the afternoon showed no difference in the amount of food consumption for an hour with 7 times feeding repetition. Male and female elephants choose the same types of foods and nearly similar amount of consumption. This is because the elephants have similarities in selecting types of plant parts that were given as feed. After selecting, they revealed their favorite type of foods based on consumption amount vis-à-vis feed availability at the same time. Conversely, if the elephants do not consume even avoid to consume certain feeds, it means that the elephants do not prefer the food.

3.2 Level of Preference towards Species of Commodity Crops and Its Palatability

Based on feed preference index over types of foods administered in the morning, it is known that rice was the most selected by all elephants due to preference index reaching for 0.60 to 0.64, followed by banana with values of 0.56 to 0.61. Whereas feed preference index for chili pepper, candlenut, coffee, and patchouli is -1 meaning that all elephants avoided to consume these plants. For more details, the order of feed preference index of each elephant could be seen in Table 4. Feed preference index of each elephant towards type of foods administered in the afternoon is not much different from the index of preference in the morning. During afternoon feeding, rice is also selected as the most preferred food with an index of 0.62 to 0.66. Furthermore, the elephants also chose banana as the second most preferable food indicated by an index of 0.55 to 0.61. Whereas chili pepper, candlenut, coffee, and patchouli have an index of -1 because all elephants did not pick those crops and tend to avoid those plants. The preference index of all types of food administered to the elephants in the morning is shown in Table 4, while the preference index of all types of food administered in the afternoon is shown in Table 5.

Table 4. Feed preference index on several types of foods in the morning

| Types of feed                 | Average of food consumption (kg/hr/individual) |
|------------------------------|-----------------------------------------------|
|                              | E1  | E2  | E3  | E4  | E5  | E6  | E7  | E8  | E9  | E10 |
| Chili (Capsicum frutescens)  | -1  | -1  | -1  | -1  | -1  | -1  | -1  | -1  | -1  | -1  |
| Cocoa (Theobroma cocoa)      | -0.93 | -0.68 | -0.81 | -0.74 | -0.68 | -0.63 | -0.72 | -0.80 | -0.73 | -0.78 |
| Ruber (Havea brassiliensis)  | -0.09 | -0.38 | -0.06 | 0.04  | -0.06 | -0.21 | 0.13  | -0.09 | 0.12  | -0.30 |
| Oil palm (Elais guenensis)   | 0.04 | -0.20 | -0.20 | -0.25 | -0.85 | -0.17 | -0.39 | -0.20 | -0.29 | -0.22 |
| Candlenut (Aleurites moluccana) | -1  | -1  | -1  | -1  | -1  | -1  | -1  | -1  | -1  | -1  |
| Coffee (Coffee Arabica)      | -1  | -1  | -1  | -1  | -1  | -1  | -1  | -1  | -1  | -1  |
| Patchouli (Pogostemon cablin) | -1  | -1  | -1  | -1  | -1  | -1  | -1  | -1  | -1  | -1  |
| Paddy (Oryza sativa)         | 0.62 | 0.64 | 0.62 | 0.63 | 0.64 | 0.63 | 0.63 | 0.63 | 0.60 | 0.64 |
| Areca (Areca catechu)        | -0.77 | -0.29 | -0.59 | -0.76 | -0.64 | -0.49 | -0.72 | -0.66 | -0.62 | -0.62 |
| Banana (Musa sp.)            | 0.58 | 0.57 | 0.58 | 0.57 | 0.61 | 0.57 | 0.56 | 0.58 | 0.58 | 0.59 |
Feed preference index of all elephants to some types of feed given in the morning and in the afternoon showed similar level of preference in terms of the primary and secondary choice that they chose rice and banana crops. In addition to that, all elephants avoided consuming chili pepper, candlenut, coffee, and patchouli as food sources. The differences in the order of food preference for each elephant appeared when they selected rubber tree, oil palm, areca palm, and cacao tree. Female elephants (G1, G3, and G5) and male elephants (G6, G7, and G8) represented those differences. The other 2 female elephants (G2 and G4) and 2 male elephants (G9 and G10) showed similar order of feed preference index in choosing some types of foods administered in the morning and the afternoon.

Elephants consumed all parts of rice and banana crops in large amount compared to other plants. In addition to that, feed consumption patterns on each repeating test showed similar pattern between morning and afternoon consumption. The average amount of feed consumption and order of preference are a measurement of elephant’s ability to select preferred feed, and thus causing rice and banana crops to be sequentially preferred feeds because of their preference indexes close to 1. Even under natural conditions, the elephants also favored rice and banana crops a lot [16,17,20,23]. Selectivity in choosing supplied feeds correlated with sensation upon feeds before and after consumed, thus certain feeds might become more likeable than the others [24]. This selectivity was a mechanism to obtain required food nutrients. It pointed to elephant’s preference phenomena to palatable foods.

Despite all kinds of feeds containing proteins, carbohydrates, fats, minerals, and vitamins, elephants avoid edto consume foods containing phytochemical compounds that are harmful to their digestion. Palatability was food’s performance attributes as a result of the physical and chemical state of food reflected by the organoleptics such as appearance, smell, flavour (bland, salty, sweet, bitter), texture, and temperature [9]. The food attracts and stimulates animals to consume some types of foods. In line with the findings, other authors argued that palatability response is measured based on central nervous system that integrates flavors and internal state signal, combined with sign from previous association [25].

Chili pepper, candlenut, coffee, and patchouli are species of plants that were not selected and were not consumed by the elephants, making these plants possessed preference index of -1. It means that those feeds were not favored and tend to be avoided for consumption. Chili extract contains capsaicin compound which results its spiciness [26]. Consuming chili may cause heartburn stinging of taste buds, heat inside the mouth, burning sensation in the trunk and mucous membranes, as well as watery eyes [27,28,29], thus making this plant not palatable to the elephants. In fact, the trigeminal nerve impulses would be disturbed and making elephants behave poorly when they ate chilies [30].

Table 5. Feed preference index on several types of foods in the afternoon

| Types of feed | Average of food consumption (kg/hr/individual) |
|---------------|-----------------------------------------------|
|               | E1    | E2    | E3    | E4    | E5    | E6    | E7    | E8    | E9    | E10    |
| Chili (Capsicum frutescens) | -1    | -1    | -1    | -1    | -1    | -1    | -1    | -1    | -1    | -1    |
| Cocoa (Theobroma cacao) | -0.79  | -0.92  | -0.83  | -0.78  | -0.77  | -0.76  | -0.66  | -0.87  | -0.73  | -0.68  |
| Ruber (Havia brasiliensis) | -0.23  | -0.55  | -0.24  | 0.03   | -0.21  | -0.23  | 0.02   | -0.20  | 0.10   | -0.36  |
| Oil palm (Elais guineensis) | 0.11   | -0.30  | -0.08  | -0.35  | -0.61  | -0.15  | -0.42  | -0.12  | -0.18  | 0.05   |
| Candlenut (Aleurites moluccana) | -1    | -1    | -1    | -1    | -1    | -1    | -1    | -1    | -1    | -1    |
| Coffee (Coffea Arabica) | -1    | -1    | -1    | -1    | -1    | -1    | -1    | -1    | -1    | -1    |
| Patcholi (Pogostemon cablin) | -1    | -1    | -1    | -1    | -1    | -1    | -1    | -1    | -1    | -1    |
| Paddy (Oryza sativa) | 0.62   | 0.66   | 0.63   | 0.63   | 0.64   | 0.63   | 0.64   | 0.62   | 0.62   | 0.63   |
| Areca (Areca catechu) | -0.84  | -0.38  | -0.47  | -0.80  | -0.56  | -0.34  | -0.76  | -0.58  | -0.58  | -0.60  |
| Banana (Musa sp.) | 0.58   | 0.58   | 0.57   | 0.58   | 0.61   | 0.57   | 0.58   | 0.59   | 0.55   | 0.56   |

Remarks: E1(Elephant Butet), E2 (Elephant Johana), E3 (Elephant Mega), E4 (Elephant Ida), E5 (Elephant Isabela), E6 (Elephant Abu), E7 (Elephant Bunta), E8 (Elephant Lilik), E9 (Elephant Midox), E10 (Elephant Ollo)
Candlenut was not preferable for the elephants. It might be due to its chemical contents. The flesh, leaves, and root of candlenut contain lignin, saponin, flavonoid, and polyphenol. Moreover, the flesh of candlenut contains laxative oil which cannot be digested directly because of its raw state containing poisonous hydrocyanic acid. In accordance with other study plants containing alkaloids and cyanogenic compounds in large amount, those phytochemicals could affect physiological functions and might cause death [4]. Lignin slower digestibility of the hemicellulose and cellulose as well as inhibits nutrients availability [31,32]. Therefore, candlenut possessed low palatability to the elephants.

Coffee (Coffea arabica) was not preferred by the elephants because it contains 8.85% tannin and resins fat of 1.18% reducing food palatability to the elephants [33]. Elephants also did not prefer patchouli (Pogostemon cablin) suspectedly because it contains patchouli oil which is a product of essential oil with distinctive aroma. Essential oil is secondary metabolites which normally acts as self-defense tool preventing plants to be consumed by animals. The whole parts of patchouli such as root, stem/stalk, petiole, as well as its leaves contain patchouli oil with different content qualities [34]. Patchouli oil contains several compounds, such as benzaldehyde (2.34%), caryophyllene (17.29%), α-patchouliene (28.28%), buenesen (11.76%), and patchouli alcohol/patchouliol (40.04%) [35]. Meanwhile, oil contents in the stem/stalk, petiole, or twigs are much smaller (0.4-0.5%) than the rest of the leaves (5-6%). However, component that greatly determines the quality of patchouli oil is patchouli alcohol/patchouliol as a primary identifier [36].

Many studies concerning palatability used cafeteria-type situation where animals showed inclination in choosing diverse foods [37]. This study exemplifies elephant’s preference towards particular plant/ feed involving selection factor on the consumed food. Thereafter, inclination over consumed type of plant/ feed appears. It is caused by high level of palatability of that plant/feed. Meanwhile, other author mentioned that herbivores can digest chemical compounds well. Enzymes produced by intestinal microorganisms can break toxins inside the compounds down, especially in alkaline stomach of the ruminants [4]. Unlike non-ruminant animals, elephant’s stomach environment has an acidic pH of 3.2. Furthermore, herbivores could also break down toxins through microsomal metabolizing enzymes in the liver. Elephants may not be able to digest plants with efficient defense as ruminants do. Thus, elephants should avoid to consume several types of plants containing defensive compounds and lower palatability.

Elephants tend to avoid plants with considerable tannin content because it would slow down the digestion process, even though it depends on the amount of the tannin content. Tannin binds the resolution of proteins and slow it down to be hydrolized by proteolytic enzymes. Tannin has astringent-like taste if it obsculates membrane protein and taste receptor. Tannin could be found in most plants with different levels and qualities. It acts as defensive compound during growth period of certain part of plants. Acceptance or rejection behavior of elephants towards particular foods might depend on their experiences. It involves lots of learning processes by connecting stimuli and physiological effects after consuming the foods. This learning process could immediately be memorized or could also take a long time to do so [4].

Elephant’s low preference towards several types of commodity crops are determined by low palatability of the referred plants. The research pinpointed that cacao tree (Theobroma cacao), chili pepper (Capsicum frutescens), candlenut (Aleurites moluccana), coffee (Coffea Arabica), and patchouli (Pogostemon cablin) possessed low palatability. Therefore, elephants did not choose aforementioned plants to be consumed. Hence, these low palatable plants are potential to be cultivated in agricultural/ plantation areas near elephant habitat. It is expected to be an alternative solution for human-elephant conflict mitigation through promoting co-existent life concept between human and elephant (human-elephant co-existence) by selecting non-risk cash crops in the Aceh Province.

4. Conclusions
Elephants are very selective in choosing types and parts of plants for consumption. Moreover, there were no significant differences in consumption pattern of the elephants during feeding time both in the morning and the afternoon. The most consumed types of feeds were rice (Oryza sativa) and banana.
(Musa sp.), whereas the least one is cacao tree (Theobroma cocoa). Type of plants that were not consumed at all by the elephants were chili pepper (Capsicum frutescens), candlenut (Aleurites moluccana), coffee (Coffea Arabica), and patchouli (Pogostemon cablin).

Based on Electivity Index, the most selected and preferable food types were rice (Oryza sativa) and banana (Musa sp.) with a value close to 1, while cocoa (Theobroma cacao) was chosen as the least preferable with a value close to -1. Furthermore, chili pepper (Capsicum frutescens), candlenut (Aleurites moluccana), coffee (Coffea Arabica), and patchouli (Pogostemon cablin) were not preferred and even tend to be avoided with a value of -1. Thus, chili pepper (Capsicum frutescens), candlenut (Aleurites moluccana), coffee (Coffea arabica), patchouli (Pogostemon cablin), and cocoa tree (Theobroma cacao) are types of plants with low palatability for elephants. These species of commodity crops are potential to be cultivated in agricultural and plantation areas near the elephant habitat, so it is expected to reduce frequency of elephant attacks in the human-elephant conflict zones.

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