Effect of turmeric (*Curcuma longa* Linnaeus) and ginger (*Zingiber officinale* Roscoe) powder in feed on nutrient digestibility and performance of sunda porcupine (*Hystrix javanica* F. Cuvier)

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**Abstract.** The experiment has been conducted to determine the effect of the addition of turmeric and ginger powder as antioxidants into the feed of young sunda porcupines (*Hystrix javanica*) at the Captivity of Small Mammals, Zoology Division, Research Center for Biology, Indonesian Institute of Sciences, Cibinong, Bogor Regency, West Java. The experiment lasted for 62 days, consisting of 2 periods namely Period I (PI) addition of turmeric powder as much as 0 g (T0); 0.3 g (T1); 0.6 g (T2); 0.9 g (T3) and Period II (PII) addition of ginger powder as much as 0 g (T0); 0.3 g (T1); 0.6 g (T2); 0.9 g (T3) in the feed. During the study, 8 sunda porcupines were placed in a cage space of 2.0 m x 2.25 m x 2.50 m respectively. The preliminary period for each period lasts 10 days and 21 days (3 weeks) for the data collection period. The highest average consumption of dry matter (DMI) in the PI is in the female porcupine T1 followed by a male porcupine and female T3, T0, male T1, and lowest female T2. In PII with the addition of ginger powder in the feed, dry matter intake (DMI) decreased in all treatments. Increased digestibility of nutrients T0<T1<T2<T3 occurs in both PI and PII. The digestibility of crude fat is lower than the digestibility of other nutrients in PI and PII. The average value of the use of feed efficiency in the PI increased in the administration of turmeric powder 0.3 g (T1), and decreased in T2 and T3, while feed efficiency in PII decreased in T1 and increased in the administration of ginger powder 0.6 g (T2), and lowest at T3. The performance of young sunda porcupine showed normal growth and no health problems occurred.

1. **Introduction**

The growth and development of wild animals in captivity is greatly supported by the provision of nutritious feed and health requirements. A good weight gain is an increase that is not too distorted, namely the growth of body weight gradually. Young sunda porcupine (*Hystrix javanica*) in captivity must be maintained so as not to overweight (obesity), because it will affect the health and reproductive processes. Based on this, it is necessary to study the feeding of antioxidants such as turmeric and ginger on the nutrient digestibility and performance of young porcupine in captivity.

Porcupines are monogastric herbivores and nocturnal. In their habitat, porcupines consume various kinds of plants, including grasses, seeds, flowers, leaves, twigs, roots, buds, and various other plants. Besides, porcupines also like to eat deer antlers to obtain mineral resources [1]. Reported by Batzli and Hume (1994), herbivores are often challenged in meeting nutritional requirements because many plants
contain low levels of nutrients, high levels of fiber, and secondary compounds that may reduce intake and assimilation of nutrients [2]. Therefore, many herbivores have physiological mechanisms that enable them to effectively extract nutrients from plant cell walls and cope with secondary compounds.

Currently only sunda porcupines have the status of being protected based on Minister of LHK Regulation Number: P/106/MENLHK/SETJEN/KUM.1/12/2018. Based on IUCN, the four species of Indonesian porcupines include the least concern category. Even though the status of is protected, illegal hunting of sunda porcupines continues, to use the meat sold in various restaurants in Central Java.

In this research, we will provide a formulation of feed by adding turmeric and ginger powder into feed on the nutrient digestibility and performance of young sunda porcupine. Turmeric (*Curcuma longa*) and ginger (*Zingiber officinale*) are known to act as antioxidants [3–8]. The active ingredients contained in turmeric are curcumin and in ginger are ginge-rol and hexahydrocurcumin 1–3. Both of these active ingredients are compounds that prevent the oxidation of oils and fats. Ginger has been proven effective against the growth of gram-positive and gram-negative bacteria including Escherichia coli, Proteus vulgaris, Salmonella typhi, Staphylococcus aureus and Streptococcus viridans [9].

2. Method
This experiment was conducted at the Captive Small Mammals, Zoology Division, Biology Research Center - LIPI, Cibinong, Bogor Regency, West Java. The research lasted for 62 days divided into 2 periods namely Period I added turmeric powder 0 g (T0); 0.3 g (T1); 0.6 g (T2); 0.9 g (T3) and Period II added of ginger powder 0 g (T0); 0.3 g (T1); 0.6 g (T2); 0.9 g (T3) into the feed. Each period lasts 10 days of preliminary (adaptation) and 21 days (3 weeks) data collection period. The material used was 8 young sunda porcupines aged 3 months consisting of 4 males and 4 females. Each porcupine was placed in an individual cage measuring 2 x 2.25 x 2.75m. Inside each cage is equipped with a food tray and a drinking basin. Before the study began, the eight young sunda porcupines had adapted in individual cages for 2 weeks. All feed ingredients before serving are washed clean and sliced so that the porcupine consumes them easily.

The food is served by the cafeteria and drinking water is available ad libitum. During the study, we weighed each type of feed, then the feed was served at 04.30 pm., according to the nocturnal nature of porcupine. The rest of the feed is weighed the next day. Weighing the porcupine’s body weight is done at the beginning, every 7 days and the end of the study. To calculate the digestibility coefficient, feces collection is carried out every day based on the total collection method [10]. The nutrient digestibility parameters of both feed and feces were determined. Dry matter, ash, crude protein, crude fat, crude fiber, nitrogen-free extract, and energy were analyzed according to [11]. Gross energy (GE) was measured using a bomb calorimeter (*Analytical Methods for Oxygen Bombs* No. 207M, 1995). The results of the analysis are used to calculate nutrient intake and digestibility [12] as well as feed conversion ratio or feed efficiency. The observed variables were preference for the feed given, consumption, nutrient digestibility, weight gain, and efficient use of feed.

The data obtained were analyzed based on descriptive methods [13]. The use of this method is because the amount of material used in research is limited. The data is described by interpreting the research table or graph in a statement that can explain and summarize the results of the study.
Table 1. Feed composition in period I and period II.

| Feed                        | T0 (control) | T1   | T2   | T3   | T0 (control) | T1   | T2   | T3   |
|-----------------------------|--------------|------|------|------|--------------|------|------|------|
| Wild taro (stems and leaves)| 200          | 200  | 200  | 200  | 200          | 200  | 200  | 200  |
| Sweet corn                  | 250          | 250  | 250  | 250  | 250          | 250  | 250  | 250  |
| Sweet potatoes              | 250          | 250  | 250  | 250  | 250          | 250  | 250  | 250  |
| Guava                       | 150          | 150  | 150  | 150  | 150          | 150  | 150  | 150  |
| Watermelon                  | 100          | 100  | 100  | 100  | 100          | 100  | 100  | 100  |
| Coconut                     | 50           | 50   | 50   | 50   | 50           | 50   | 50   | 50   |
| Turmeric powder             | -            | 0.3  | 0.6  | 0.9  | -            | -    | -    | -    |
| Ginger powder               | -            | -    | -    | -    | -            | -    | -    | -    |
| Koi Pellet (2x in a week)   | 30           | 30   | 30   | 30   | 30           | 30   | 30   | 30   |
| **Total**                   | 1030         | 1030.3 | 1030.6 | 1030.9 | 1030         | 1030.3 | 1030.6 | 1030.9 |

*) provide on Tuesday and Saturday.

Table 2. Composition of nutrients base on dry matter (100%)*.

| Feed                        | DM        | Ash | CP        | CL  | CF  | NFE | GE        |
|-----------------------------|-----------|-----|-----------|-----|-----|-----|-----------|
| Wild taro                   | 10.82     | 11.52 | 23.72     | 5.25 | 21.69 | 37.82 | 4513      |
| Sweet corn                  | 20.67     | 3.03  | 14.16     | 7.16 | 1.62  | 74.03 | 4,411     |
| Sweet potatoes              | 23.36     | 2.94  | 3.20      | 0.90 | 8.40  | 84.56 | 3,661     |
| Guava                       | 31.94     | 4.13  | 4.66      | 1.46 | 33.97 | 55.78 | 4,649     |
| Watermelon                  | 15.06     | 4.16  | 9.62      | 2.17 | 3.48  | 80.57 | 3,963     |
| Coconut                     | 55.40     | 1.82  | 7.67      | 8.91 | 13.50 | 68.10 | 6,161     |
| Turmeric powder (Period I)  | 27.60     | 4.91  | 9.40      | 4.18 | 9.09  | 72.42 | 4,722     |
| Ginger powder (Period II)   | 28.16     | 6.30  | 11.98     | 2.30 | 11.41 | 68.01 | 4,278     |
| Koi pellet (2x in week)     | 91.44     | 6.16  | 43.12     | 2.23 | 3.94  | 44.55 | 4,487     |

*) analysis at the Lab. Nutrition Testing, RC for Biology – LIPI
* DM = dry matter; CL = crude lipid; NFE = nitrogen free extract; Ca = Calcium
* CP = crude protein; CF = crude fiber; GE = gross energy; P = Phosphorus

3. Results and discussion

Table 3 shows the highest average dry matter intake (DMI) in the period I by adding turmeric powder to sunda porcupine feed, T1 female followed by male and female of T3, T0, T1 male, and lowest T2 female. In Period II with the addition of ginger powder in the feed a slight decrease in the DMI in all treatments T0, T1, T2, and T3. The average order of DMI from highest to lowest is T1, male and female of T3, male and female of T0, T1 male, and T2 female. Estimates of a slight decrease in feed intake in period II are the presence of the spicy taste of ginger so that there is a slight decrease in feed take. Lower DMI can be explained by differences in feed energy content [14]. Increased DMI may be caused by increased palatability of feed as energy content increases [15,16].
### Table 3. Fresh matter intake (FMI) and dry matter intake (DMI) (g/head/day).

| Feed                    | Period I (Turmeric powder) |          |          |          |          |          |
|-------------------------|----------------------------|----------|----------|----------|----------|----------|
|                         | T0                         | T1       | T2       | T3       |          |          |
|                         | Male | Female | Male | Female | Male | Female | Male | Female |          |
| Wild taro               | 131.00 | 144.00 | 97.86 | 145.36 | 112.43 | 88.50 | 118.36 | 94.21 |
| Sweet corn              | 199.71 | 208.71 | 198.14 | 219.00 | 195.29 | 187.43 | 204.71 | 191.14 |
| Sweet potatoes          | 121.93 | 126.14 | 138.86 | 202.71 | 114.50 | 181.64 | 163.07 | 184.00 |
| Guava                   | 130.36 | 105.00 | 122.64 | 135.36 | 125.64 | 96.64 | 147.93 | 143.79 |
| Watermelon              | 100.00 | 97.71  | 96.64  | 99.64  | 99.64  | 86.57 | 98.64  | 93.14 |
| Coconut                 | 30.00 | 30.00  | 30.00  | 30.00  | 30.00  | 30.00 | 30.00  | 30.00 |
| Turmeric powder         | 0 | 0.30  | 0.30  | 0.60  | 0.60  | 0.90 | 0.90  |          |
| Koi Pellet              | 8.57 | 8.57  | 8.57  | 8.57  | 8.57  | 8.57 | 8.57  |          |
| FMI                     | 721.57 | 720.14 | 693.01 | 840.94 | 683.67 | 679.96 | 772.19 | 745.76 |
| DMI                     | 249.20 | 248.71 | 239.34 | 290.43 | 236.11 | 234.83 | 266.69 | 257.56 |

| Feed                    | Period II (Ginger powder) |          |          |          |          |          |
|-------------------------|----------------------------|----------|----------|----------|----------|----------|
|                         | T0                         | T1       | T2       | T3       |          |          |
|                         | Male | Female | Male | Female | Male | Female | Male | Female |          |
| Wild taro               | 122.03 | 118.14 | 115.07 | 105.55 | 107.58 | 65.71 | 108.56 | 68.55 |
| Sweet corn              | 192.93 | 201.78 | 195.27 | 210.89 | 192.09 | 180.77 | 199.93 | 185.85 |
| Sweet potatoes          | 117.9 | 122.67 | 131.75 | 198.79 | 113.24 | 179.89 | 159.87 | 181.77 |
| Guava                   | 129.23 | 103.46 | 120.07 | 133.75 | 122.54 | 94.87 | 143.89 | 140.83 |
| Watermelon              | 99.97 | 96.89  | 93.91  | 96.97  | 94.67  | 84.57 | 95.49  | 91.12 |
| Coconut                 | 30 | 30  | 30  | 30  | 30  | 30  | 30  |        |
| Ginger powder           | 0 | 0.30  | 0.30  | 0.60  | 0.60  | 0.90 | 0.90  |        |
| Koi Pellet              | 8.57 | 8.57  | 8.57  | 8.57  | 8.57  | 8.57 | 8.57  |        |
| FMI                     | 700.63 | 681.51 | 694.94 | 784.82 | 477.20 | 644.98 | 747.21 | 707.59 |
| DMI                     | 242.46 | 235.85 | 240.49 | 271.60 | 165.14 | 223.20 | 258.58 | 244.87 |

The provision of koi pellets in porcupine feed in both periods is as a source of minerals and protein. The average pellets intake by male and female porcupines in both periods are the same 8.57 g/head/day because the pellets given each as much as 30 g twice a week (Tuesday and Saturday) consumed completely by the porcupines. According to Farida et al., (2013), commercial pellets can be used as an alternative feed for porcupines in captivity, whereas Dahlan et al., (1995) reported pellets given to porcupines because of their high phosphorus content [17,18]. From the results of research by Farida et al., (2011) shows that the provision of pellet ration formulations of porcupine has increased dry matter intake and nutrients, Ca, P, nutrient digestibility, TDN, body weight and feed conversion [19].

Table 4 shows that there was an increase in live weight gain in period II of T0 (male and female), but there was a decrease in live weight gain of T1, T2, and T3 treatments. This is in line with the slight decrease in feed intake in period II due to the addition of ginger powder into the feed. This was stated by Casasus et al., (2002), that porcupine performance and live weight gain are influenced in part by nutrition and adaptation levels, whereas Zawiślak et al., (2015) reported an increase in body weight interacting between animal species, feed types, feed nutrition balance, and sex [20,21].
Table 4. Changes in live weight of sunda porcupine during the experiment.

| Porcupines | Period I | Period II |
|------------|----------|-----------|
|            | Initial BW | Final BW | Weight gain | Initial BW | Final BW | Weight gain |
| T0 male    | 2.63      | 3.18     | 19.64       | 3.32       | 3.97     | 23.21       |
| T0 female  | 2.08      | 2.57     | 17.50       | 2.80       | 3.57     | 27.50       |
| T1 male    | 3.05      | 3.55     | 17.86       | 3.69       | 4.16     | 16.79       |
| T1 female  | 3.56      | 4.19     | 22.50       | 4.28       | 4.76     | 17.14       |
| T2 male    | 3.31      | 3.85     | 19.29       | 3.95       | 4.56     | 21.79       |
| T2 female  | 4.06      | 4.49     | 15.36       | 4.65       | 5.01     | 12.68       |
| T3 male    | 4.24      | 4.63     | 13.93       | 4.73       | 5.06     | 11.68       |
| T3 female  | 4.33      | 4.71     | 13.57       | 4.75       | 5.10     | 12.50       |

Table 5. Nutrient digestibility of sunda porcupine (%).

| Nutrient | Period I | Period II |
|----------|----------|-----------|
|          | T0       | T1       | T2       | T3       | T0       | T1       | T2       | T3       |
|          | Male     | Female   | Male     | Female   | Male     | Female   | Male     | Female   |
| DM       | 84.33    | 84.97    | 85.68    | 86.55    | 87.39    | 87.77    | 87.42    | 87.80    |
| OM       | 84.44    | 85.53    | 86.51    | 87.64    | 86.82    | 87.88    | 86.85    | 87.95    |
| Ash      | 75.70    | 80.62    | 82.43    | 82.79    | 82.54    | 82.86    | 82.76    | 82.90    |
| CP       | 80.23    | 81.81    | 83.39    | 85.57    | 83.57    | 83.64    | 83.72    | 85.71    |
| CL       | 67.51    | 70.59    | 71.63    | 72.48    | 71.77    | 72.61    | 71.85    | 72.82    |
| CF       | 80.65    | 81.51    | 81.56    | 82.34    | 81.85    | 82.87    | 81.91    | 82.95    |
| NFE      | 86.89    | 87.36    | 87.54    | 88.45    | 87.73    | 88.69    | 87.84    | 88.82    |

|          | Male     | Female   | Male     | Female   | Male     | Female   | Male     | Female   |
| DM       | 83.63    | 84.47    | 85.38    | 86.17    | 85.82    | 86.57    | 85.94    | 86.73    |
| OM       | 83.74    | 85.09    | 85.34    | 87.24    | 85.76    | 87.48    | 85.90    | 87.62    |
| Ash      | 75.18    | 80.12    | 82.03    | 82.36    | 82.74    | 82.59    | 82.81    | 82.65    |
| CP       | 80.02    | 81.39    | 82.45    | 86.08    | 82.79    | 86.71    | 82.83    | 86.82    |
| CL       | 67.17    | 70.08    | 71.24    | 72.12    | 71.76    | 72.74    | 71.80    | 72.81    |
| CF       | 80.23    | 81.26    | 81.55    | 82.14    | 81.88    | 82.79    | 81.90    | 82.83    |
| NFE      | 86.36    | 87.25    | 87.56    | 88.34    | 87.91    | 88.82    | 87.96    | 88.89    |

OM = organic matter.

From Table 5 it can be seen that there is an increase in the digestibility of nutrients T0<T1<T2<T3 both in period I and period II. The digestibility of CL is lower than the digestibility of other nutrients in both periods. According to Tillman et al., (1991) and Björnhaug (1987), CF is a component that has a great effect on digestion, because high CF content in rations can reduce the digestibility coefficient of feed [22,23]. In general, it can be seen in Table 5, that young sunda porcupines in all treatments can digest nutrients properly, which is more than 65%. Reported by McDonald et al., (2002) that cecum and colon of porcupine contain protozoa and bacteria similar to ruminants, consisting of 30% protein digesters, 75%–85% carbohydrate digesters and 15%–30% soluble carbohydrate digesters [24]. Maneewan et al., (2012) state, the addition of turmeric powder 0.10% and 0.20% in pig ration, has increased the digestibility of crude protein, crude fat, crude fiber, ash, and the biological value of the protein compared to the control group [25]. Turmeric is a strong antioxidant and anti-inflammatory agent [26–28]. Allegedly strong, turmeric can improve digestion and increase nutrient metabolism [29,30]. This shows that most nutrients can be absorbed and then used by young porcupines to meet their nutritional needs.
Feed Efficiency (FE) is a comparison between weight gain and dry matter intake. A good FE is determined by the amount of feed intake that can produce a good daily body weight gain. Table 6 describes the average of FE on the young porcupine.

Table 6. Bodyweight gain (g/head/day) and feed efficiency (%).

| Variable      | Period I |          |          |          |          |          |
|---------------|----------|----------|----------|----------|----------|----------|
|               | T0       | T1       | T2       | T3       |          |          |
| BWG Male      | 19.64    | 17.50    | 17.86    | 22.50    | 19.29    | 15.36    | 13.93    | 13.57    |
| BWG Female    | 17.50    | 16.79    | 17.14    | 21.79    | 12.68    | 11.68    | 12.50    |          |
| DMI intake Male | 249.20  | 248.71   | 239.34   | 290.43   | 236.11   | 234.83   | 266.69   | 257.56   |
| DMI intake Female | 223.46  | 235.85   | 249.49   | 271.60   | 231.46   | 223.20   | 258.58   | 244.87   |
| FE (%) Male   | 7.88     | 7.04     | 7.46     | 8.75     | 8.17     | 6.54     | 5.22     | 5.27     |
| FE (%) Female | 7.46     | 7.60     | 7.36     | 5.25     |          |          |          |          |

Feed Conversion or feed efficiency plays an important role in animal management because feed costs range from 60–70% of total production costs. The more efficient the use of feed, the lower the production costs. Feed efficiency can be seen from the feed conversion ratio which is the amount of feed needed to produce one kilogram of body weight gain. In general, the lower the feed conversion ratio, the better the feed efficiency because the amount of feed needed to produce one kilogram of body weight becomes less. The amount of feed intake and body weight gain determine the amount of feed conversion. According to Leeson and Summers (2001), the amount of feed intake determines the size of the resulting body weight gain [31].

The average of FE in period I (addition of turmeric powder) showed an increase in the administration of turmeric powder 0.3 g (T1), then decreased in T2 and T3. The average of FE in period II (addition of ginger powder) decreased in the treatment of T1 and increased in the administration of ginger powder 0.6 g (T2), and then decreased again in T3. This is in line with the increase and decrease of porcupine body weight. Feed consumed contains substances that will be absorbed in the digestive tract. The remaining nutrients in the body will be used to meet the body’s needs and to increase bodyweight. As reported by Scott et al., (1982), the amount of feed conversion is determined by the amount of feed intake and body weight gain obtained [32]. Durrani et al., (2006) reported that turmeric increases the efficiency of broiler feed in the starter and finisher phases [33]. According to Tillman et al., (1991), the amount of feed efficiency depends on the amount of dry matter intake, which can provide body weight gain [22]. Rations will be more efficiently used if consumed in small amounts but able to provide a large life benefit. Also, the feed conversion ratio is affected by the disease, feed quality, and breeding management [34].

The performance of young sunda porcupine which was added with turmeric and ginger powder into the feed showed rapid development, did not cause obstacles in health and growth.

4. Conclusion
This experiment showed that the addition of turmeric powder and ginger powder to the sunda porcupine’s feed had a positive impact on its growth performance. The addition of the two types of powders containing antioxidants showed the digestibility value of nutrients above 65%. Feed efficiency in period I increased with the addition of 0.3 g of turmeric powder, while in period II the increase was in the addition of 0.6 g of ginger powder.

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