Biosaintifika 11 (2) (2019) 186-193

Biosaintifika
Journal of Biology & Biology Education

http://journal.unnes.ac.id/nju/index.php/biosaintifika

# Potency of Brown Sugar as a Nectar Substitute for *Trichoglossus haematodus* in Captivity

**Siti Nuramaliati Prijono**✉, **Rini Rachmatika**

**DOI: http://dx.doi.org/10.15294/biosaintifika.v11i2.18730**

Zoology Division, Research Centre for Biology, Indonesian Institute of Sciences, Indonesia

## History Article

Submitted 8 April 2019
Revised 24 May 2019
Accepted 4 June 2019

## Keywords

Brown Sugar; Captivity; Nectarivorous Bird; Nutrition; Lorikeet

## Abstract

*Trichoglossus haematodus* (Linnaeus, 1771) is nectarivorous bird that feed on nectar as a source of carbohydrate. In captivity, it is not practical to provide a continued diet of nectar from the flowers. Therefore, this study aimed to find other carbohydrate sources such as brown sugar as substitute nectar for *T. haematodus*. Twelve wild *T. haematodus* in four cages offered five types different brown sugar solution with different concentrations. Since brown sugar has low protein content, therefore the birds also offered commercial baby biscuit to meet the protein requirement. The results showed that the birds like to consume all types of brown sugar solution with sugar concentration up to 40% . However, the *siwalan* brown sugar solution was the most favored by the bird. over the other type of brown sugar solutions (*aren*, coconut, sugar cane and regular commercial "palm" brown sugar). Furthermore, the result showed that the birds prefer commercial baby biscuit was soaked in the brown sugar solution with concentration 20%. This study provides the information that the brown sugar solution based diet has potency as an alternative carbohydrate source to substitute nectar for *T. haematodus* in captivity which is more practical and can increase the survival rate in birds.

## How to Cite

Prijono, S. N., & Rachmatika, R. (2019). Potency of Brown Sugar as a Nectar Substitute for *Trichoglossus haematodus* in Captivity. *Biosaintifika: Journal of Biology & Biology Education*, 11(2), 186-193.

✉ Correspondence Author:
Jl. Jakarta-Bogor KM 46, Cibinong, Jawa Barat, Indonesia
E-mail: sitiprijono58@gmail.com

p-ISSN 2085-191X
e-ISSN 2338-7610

## INTRODUCTION

*Trichoglossus haematodus* is included in the Psittaculidae family (Order: Psittaciformes). Coconut lorikeet has been designated as the official common name for this species by the International Ornithologists Union (Gill and Wright, 2006). This bird is a medium sized bird, with weighing of 130-134 g (Cabana and Lee, 2019). However, Lorikeet was endangered due to habitat destruction and heavily traded. According to the IUCN Red list status, this species has been evaluated in 2018 as of least concern (BirdLife International, 2018) and also included in the list of CITES Appendix II (CITES, 2017). *T. haematodus* has been included as a Protected Bird in Indonesia since December 2018. According to Astuti and Prijono (2017) genetic diversity information could be potential relevance the breeding management for conservation of the birds. Conservation breeding involves the captive propagation of endangered species to help maintain genetic diversity (Conde et al, 2011). Current feeding practices may be limiting factor for health and breeding successes of rarer species sought after in the pet bird trade, therefore possibly hindering conservation efforts (Cabana and Lee, 2019). In the wild, the Lorikeet primarily feed on nectar as a source of carbohydrate and pollen as a source of protein. Nectarivorous birds such as *T. haematodus* have a brush□ like tongue to ingest nectar and to harvest pollen efficiently (Napier et al., 2008). Nectar as a food source provides high energy due to its high sugar content with an average of 23% as feed (Kalmar et al., 2009). Amino acids are the next essential compound in nectar, but are nonetheless found in minute amounts, and nectar itself is not thought as a protein source (Leseigneur et al., 2007). In captivity, the Lorikeets also need to consume a nectar-based food as a source of carbohydrate, but the nectar diet is not practical. It is not easy to obtain real nectar and it can spoil quickly so that is must be replaced often. Therefore, their diet in captivity must mimic a nectar-based diet without having to be replaced often. Commercial nectar foods are available as principal nutrition for most Lorikeet species, but this commercial foods are not always available in the market in Indonesia. One source of carbohydrates that is abundant and easy to find in Indonesia is brown sugar. Brown sugar that is called *gula merah* in Indonesia is a natural sweetener with unique flavor and aroma as well as its nutritional content (Abdullah et al., 2015)

Brown sugar is a processed product of palm tree sap (nectar) such as *aren* (*Arenga pinnata* (Wurmb) Merr.), coconut (*Cocos nucifera* Linn), *siwalan* (*Borassus flabellifer* Linn.) and sugar cane (*Saccharum officinarum* Linn). Fresh sap (Nira), which is sweet, odorous, clear or translucent, with neutral pH, is a popular beverage in many local communities (Gupta and Kushwaha, 2011) and the Lorikeets also like it. According to residents in the Lamota area (Timor Island), Timor Lorikeets like to lick saps tapped on coconut trees (Duhan, 2017). However, this tapped sap should be consumed within a day, before it ferments spontaneously to alcohols and acids (Nguyen et al., 2016). Therefore it is also not practical as a food in captivity.

The specific nutritional requirements of *T. haematodus* in captivity for maintenance, growth, and reproduction are not known and the dietary information is mostly incomplete. In order to be able to meet the energy requirements of birds kept in captivity, it is necessary to know the type of feed as a carbohydrate source that is easily obtained and preferred by the bird. The aim of the study was to determine the preferences for brown sugar solutions a mimic of nectar diet in *T. haematodus* to meet their nutritional requirements in captivity. Since nectar is the main food for the birds, therefore the benefit of this study is to give a new information that the brown sugar solution can be an alternative carbohydrate source to substitute nectar for *T. haematodus* in captivity. The brown sugar solution based diet is more practical, reduce the mortality and will support conservation effort for the birds..

## METHODS

### Birds care and housing

Twelve wild *T. haematodus* from Ambon were lent to us by Mr. Suwita (CV. Pasundan) on May 2018. The birds used in this study were kept in 4 cages measuring 90 x 55 x 60 cm. Each cage contained three birds whose sex had not been ascertained because this bird is sexually monomorphic. The cages used in this study were belonging to the Zoology Division, Research Center for Biology, The Indonesian Institute of Sciences (LIPI), Cibinong, Indonesia.

In the adaptation period in the cage for three months (May-July 2018), the birds were introduced to various types of food, such as fruits (papaya, banana, watermelon, guava, apple in the form of puree, juices, small cubed or shredded), seeds (corn on the cob, sunflower seeds, red millet seeds, white millet seeds), bird pellets, honey, baby biscuits soaked in the brown sugar solution and vegetables (lettuce, Chinese cabbage, long

beans, cauliflower and broccoli).

**Preference test on brown sugar solution**

The study on preferences for different type of brown sugar solutions was carried out in August 2018. In this study, the brown sugar solutions provided were fresh and were administered along with supplemented diet. The supplemented diet was a choice of pellet, seeds (sunflower seed, red millet seed and white millet seed) and vegetables (cauliflower, broccoli, chinese cabbage, long bean) to fulfill their nutritional requirements. Water for drinking was provided *ad libitum*. The bird enjoyed bathing, therefore the water in swallowing bowl was also provided in each cage for bathing. This study was conducted in three experiments.. Each experiment was run for 12 hours (from 06:00 to 18:00). For each bird, overall daily consumption of each brown sugar solution was determined. These were quantified by subtracting the amount of the brown sugar solution left over the amount given. Evaporative water loss was also taken into account.

**Experiment 1**

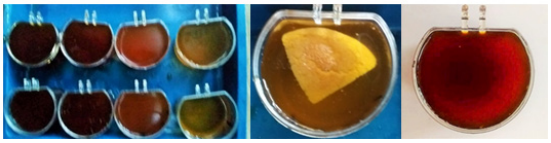
The birds were given four different types of brown sugar solution i.e. coconut, *aren*, *siwalan* and sugar cane brown sugar with concentration of 25% (Figure 1A.). These brown sugar solutions were placed in a cup (diameter of 5 cm, height of 4 cm) at two height levels. Four cups containing 50 ml of each type of brown sugar solution were placed at a height of 30 cm from the cage floor (Cups A) and 4 more cups were placed at a height of 45 cm from the cage floor (Cups B).

**Experiment 2**

The birds were given one type of sugar solution which was most favored in the first experiment with different concentrations of brown sugar (20%, 25% and 30%) without commercial baby biscuit and with the addition of 3 g baby biscuits (Figure 1B.). The addition of commercial baby biscuits was intended to increase the level of protein in the brown sugar solution-based diet. Fifty ml of the brown sugar solution from each concentration was placed in a cup (diameter of 5 cm, height of 4 cm) at the same height (40 cm from the cage floor).

**Experiment 3**

In this experiment, the birds were given the most preferred brown sugar solution in the first experiment compared with "palm" brown sugar solution (unspecified palm tree, regular commercial brown sugar) (Figure 1C.) in different concentrations of 20%, 30 % and 40%.



A B C

**Figure 1**. A. Four types of Brown sugar solution in Cups (left to the right: *aren* brown sugar, coconut brown sugar, sugar cane brown sugar and *siwalan* brown sugar); B. Brown sugar solution was added with commercial baby food; C. "Palm" Brown Sugar Solution (Regular commercial brown sugar/ unspecified palm tree).

**Analysis**

Data obtained were analyzed using two-way Analysis of Variance (ANOVA) and Duncan post hoc test by using a statistical analysis program of SPSS. Sugar analysis was conducted at the Indonesian Center for Agro Industry (BBIA), Agro Based Industry Calibration and Analytical Laboratories (ABICAL), Ministry of Industry in Bogor using HPLC (High-Performance Liquid Chromatography). While the proximate analysis of brown sugar was carried out in the Center for Biology-LIPI.

## RESULTS AND DISCUSSION

**Preferences on Type of Brown Sugar Solutions**

Temperature and humidity during the experiments varied from 20.3ºC to 31.9ºC and RH= 49.3- 90.7%. The results of the first experiment can be seen in Table 1. There is no significant difference in the consumption of the brown sugar solution based on the high level of cups. The position of the cups did not play an important role in the consumption of brown sugar solution. In Figure 2, it is showed that the bird consume the brown sugar solution in cup A (30 cm from the cage floor) and also in a cup B (45 cm from the cage floor).

Related to the type of brown sugar solutions, the result showed that the birds preferred the *siwalan* brown sugar solution (A= 16.13 ± 0.78 ml; B= 10.31 ± 3.45 ml) over the brown sugar from sugar cane (A= 6.78 ± 3.66 ml; B= 6.78 ± 1.53 ml), coconut (A = 3.57 ± 1.87 ml and B = 4.71 ± 0.91 ml) and *aren* (A= 2.07 ± 0.58 ml; B= 3.59 ± 0.99 ml). Sugar is an important organic compound as a calorie source food. Sucrose, glucose, and fructose are the three sugars that commonly found in floral nectar (Lotz and Schondube, 2006). Nectar-feeding birds tend to prefer

**Table 1**. Consumption of 4 types of brown sugar solution (ml) in *T. haematodus*

| Height levels of Cups | Consumption of Brown Sugar Solution (ml) | | | |
|---|---|---|---|---|
| | Coconut Brown Sugar Solution 25% | *Aren* Brown Sugar Solution 25% | *Siwalan* Brown Sugar Solution 25% | Sugar Cane Brown Sugar Solution 25% |
| 30 cm | 3.57 ± 1.87 [a] | 2.07±0.58 [a] | 16.13±0.78 [c] | 6.78±3.66 [b] |
| 45 cm | 4.71 ± 0.91[a] | 3.59±0.99 [a] | 10.31±3.45 [c] | 6.78±1.53 [b] |

[abc]Values within a row with different superscript indicate significantly different result (P <0.05) based on Duncan Test

**Figure 2.** *T. haematodus* consume the brown sugar solution

**Table 2.** Carbohydrate Composition of five types of brown sugars *

| Carbohydrates In Brown Sugars (%) | Coconut Brown Sugar | *Aren* Brown Sugar | *Siwalan* Brown Sugar | Sugar Cane Brown Sugar | "Palm"* Brown Sugar |
|---|---|---|---|---|---|
| Sucrose | 91.40 | 68.10 | 89.50 | 82.80 | 78.30 |
| Fructose | 0.86 | 4.24 | 0.26 | 3.73 | 2.58 |
| Glucose | 1.01 | 3.27 | 1.58 | 5.35 | 4.11 |
| Maltose | < 0.85 | < 0.85 | < 0.85 | < 0.85 | < 0.85 |

Note: Carbohydrate composition of this study was analyzed at the Indonesian Center for Agro Industry (BBIA), Agro Based Industry Calibration and Analytical Laboratories (ABICAL), Ministry of Industry in Bogor; * Regular commercial brown sugar/ unspecified palm tree

sucrose over glucose-fructose mixtures (Schondube and Martinez Del Rio, 2003).

A majority of nectar feeders can digest and metabolize sucrose, glucose and fructose, which are digested at high efficiencies of nearly 100% app*aren*t digestibility (Lotz and Schondube, 2006). According to Fleming et al. (2004), sucrose solutions that are equivalent in sugar mass to a hexose sugar solution have approximately 5% more available energy. In this study found that the sucrose content of *siwalan* brown sugar is lower than coconut brown sugar, but higher than the other types of brown sugar. However, the hexose (fructose and glucose) content of *siwalan* brown sugar is higher than coconut brown sugar but lower than the other types of brown sugars (Table 2). Matson et al. (2001) stated that there is no significant preferences were found when two monosaccharides (glucose and fructose) and one disaccharide (sucrose) were tested independently.

*Siwalan* brown sugar has the lowest protein and gross energy content. The fat content of *siwalan* brown sugar is lower than coconut brown sugar but higher than the other types of brown sugars (Table 3).

According to Kalmar et al. (2009), Lorikeets will adjust their "nectar" intake based on the energy density of the nectar by having a higher intake with low energy/highly diluted "nectars" to reach energy maintenance. Renner et al. (2012) reported that food types with fat-rich content are preferred by birds, but in this experiment, it is showed that the birds prefer *siwalan* brown sugar over than coconut brown sugar which has higher fat content. *Siwalan* brown sugar is favored by the birds possibly because of the flavor of this sugar. Birds have individual preferences for foods based on the taste, habits, food placement, texture, size, shape and colour (McKenzie and Whittingham, 2010). Taste may also play a role in sugar type preferences (Hollo-

**Table 3.** Nutrient Composition of brown sugar (% Dry Matter )*

| Nutrient Componen | Coconut Brown Sugar | *Aren* Brown Sugar | *Siwalan* Brown Sugar | Sugar Cane Brown Sugar | "Palm"* Brown Sugar |
|---|---|---|---|---|---|
| Moisture | 9.36 | 11.90 | 4.65 | 9.99 | 8.49 |
| Fat | 0.36 | 0.06 | 0.10 | 0.04 | 0.04 |
| Protein | 0.81 | 1.86 | 0.72 | 0.88 | 1.05 |
| Ash | 2.53 | 1.94 | 0.06 | 1.96 | 1.09 |
| Gross Energy | 4179 | 4161 | 4039 | 4276 | 4304 |

Note: Nutrient composition of brown sugars in this study was analyzed in the Center for Biology-LIPI; * Regular commercial brown sugar/unspecified palm tree

**Table 4.** Consumption of *Siwalan* brown sugar solution with 3 different sugar concentrations without and the addition of commercial baby biscuits in *T. haematodus*

| Treatment | Consumption of *Siwalan* Brown Sugar Solution (ml) | | |
|---|---|---|---|
| | 20% sugar concentration | 25% sugar concentration | 30% sugar concentration |
| Without baby biscuit | $7.87 \pm 3.40^{a}$ | $8.24 \pm 3.79^{a}$ | $11.32 \pm 2.82^{b}$ |
| With added baby biscuit | $6.45 \pm 2.10^{a}$ | $6.27 \pm 1.94^{a}$ | $5.28 \pm 0.94^{a}$ |

[abc] Values within a row with different superscript indicate significantly different ($P < 0.05$) based on Duncan Test

wood et al., 2002). While Matson and Koutsos (2006) stated that tastes and specific appetites may sometimes drive the feed consumption.

Favored brown sugar solution with or without the addition of protein food.

In the second experiment, the birds were offered *siwalan* brown sugar solution (as the most favored in the first experiment) in different concentrations of sugar (20%, 25% and 30%) with and without the addition of commercial baby biscuit According to Nicolson and Thornburg (2007), nectar in the wild besides being a source of carbohydrates, also contains essential amino acids even though the protein content is low. The nutrient rich sap has an abundant source of minerals, 17 amino acids, vit-C, B vitamins and has nearly natural PH (Misra, 2006). Brown sugar solutions that were offered to the birds not only have low protein content similar to nectar, with the range between 0.72-1.86 % (Table 3), but also rich in nutrient (amino acids, vitamin and mineral) as present in the sap from which it is derived. It is considered healthier and more nutritious than other natural and artificial sugar substitutes due to its vitamins, minerals and amino acids (Florido and de Mesa, 2003). Birds require 12 essential amino acids: phenylalanine, valine, tryptophan, methionine, arginine, threonine, histidine, isoleucine, lysine, leucine, glycine, and proline (Matson and Koutsos, 2006). If there is an imbalance of amino acids, it will cause anorexia or lack of appetite so that feed consumption will be low (Koutsos et al., 2001).

From the first experiment, the result showed that the birds favor *siwalan* brown sugar. In fact, the *siwalan* brown sugar has the lowest protein content compared to the other brown sugars. According to Tsahar et al. (2006), protein requirement for nectarivorous birds much lower than omnivore species, however appropriate protein supply is often became problematic for this birds. To meet the protein requirement for the birds, therefore the brown sugar solution as the primary diet should be added with the other food as a protein source. The commercial baby biscuit was choosen as an alternative for protein food since this biscuit has a sweet taste and the birds like it. The commercial baby biscuits contain 9% protein and also rich in vitamin and minerals. The results of the second experiment are shown in Table 4.

The results showed that if the *Siwalan* brown sugar solution was added with baby biscuits, then the birds preferred *siwalan* brown sugar with 20% sugar concentration ($6.45 \pm 2.10$ ml) over 25% ($6.27 \pm 1.94$ ml) and 30% sugar concentration ($5.28 \pm 0.94$ ml), although it is not significantly different. Due to the commercial baby biscuits also contain 32% sugar as a carbohydrate source, the *siwalan* brown sugar solution with sugar concentration higher than 20% that is added with commercial baby biscuits will increase the level of available energy in the diets resulted in the birds that reduce the amount of food intake.

Preferred sugar concentration on favored brown sugar solution

In order to be more convincing that the Lorikeet preferred the *siwalan* brown sugar solution, the third experiment was carried out. In the third experiment, the birds were given *siwalan* brown sugar and "palm" brown sugar (regular commercial brown sugar, unspecified palm tree) with different sugar concentrations of 20%, 30% and 40%. The results of the third experiment can be seen in Table 5. The results showed that the Lorikeet consumes more *siwalan* brown sugar solution over palm brown sugar solution because the *siwalan* brown sugar has lower sucrose and gross energy content.

According to Kalmar et al. (2009) Lorikeets will adjust their "nectar" intake based on the energy density of the nectar, having a higher intake with low energy or highly diluted "nectars" to reach energy maintenance. In both type of brown sugar solution, the birds preferred sugar concentration of 40% (*siwalan*=9.23 ± 2.17 ml; "palm" sugar= 7.6 ± 3.01 ml) over sugar concentration of 30% (*siwalan*=6.4 ± 1.16 ml; "palm" sugar= 5.89 ± 1.97 ml) and sugar concentration of 20% (*siwalan*=6.35 ± 1.08 ml; "palm" sugar= 3, 25 ± 0.90 ml). From the third experiment, it is showed that the Lorikeets prefer the *siwalan* brown sugar solution with a sugar concentration of 40% to achieve their energy requirement. This suggests that energy requirements influence food preferences and that bird will select brown sugar solution that is higher in energy. This also shows that birds increase their food intake initially to achieve their energy requirements. (Wilson and Downs, 2011). *T. haematodus* are very active birds, so they require a large amounts of a higher level of energy. According to Matson and Koutsos (2006), a bird's energy requirement will change along with activity level, higher activity levels will increase energy needs.

The result of this study showed that the bird consumed 76.41% of its diet in the form of the brown sugar solution, while the supplemented diet (seed, vegetables and pellets) were consumed by the birds only 23.59% (seed, vegetables and pellets was 7.37%, 15.55%, 0.67% of its diet respectively) (Table 6). According to Cannon (1982) in Fleming et al. (2008), *T. haematodus* is a specialist nectar bird (nectarivorous), therefore 87% (seasonally ranging from 68% to 100%) its diet consist of nectar and pollen with the remainder made up of fruits (particularly seeds) and leaf. The supplemented diet feed provided for the birds were determined in total during this study, since the supplemented diet were only to make sure the bird was getting proper nutrition. According to Bosque and Pacheco (2000), domestic vegetables are higher in energy and water, but lower in other essential nutrients compared with their relatives in the wild.

It seems that the nutritional requirement for *T. haematodus* could be fulfilled by the brown sugar solution as the bird's primary diet. According to Florido and de Mesa (2003), the brown sugar is considered healthier and more nutritious than other natural and artificial sugar substitutes due to its vitamins, minerals and amino acids. Therefore, if seed is made available in captivity, it should be minor to a diet since seed mixes (edible

**Table 5.** Consumption of *Siwalan* brown sugar and "Palm" brown sugar solution with 3 different sugar concentrations in *T. haematodus*

| Treatment | Consumption of Brown Sugar Solution (ml) | | |
|---|---|---|---|
| | 20% sugar concentration | 30% sugar concentration | 40% sugar concentration |
| *Siwalan* Brown Sugar Solution | 6.35±1.08 [b] | 6.40±1.16 [b] | 9.23±2.17 [d] |
| "Palm" Brown Sugar Solution* | 3.25±0.90 [a] | 5.89± 1.97 [b] | 7.6±3.01[c] |

[abc] Values within a row with different superscript indicate significantly different (P <0.05) based on Duncan Test; * Regular commercial brown sugar/ unspecified palm tree

**Table 6.** Total consumption of brown sugar solution and additional feed

| Type of Feed | Total Consumption (g/bird/day) | Percentage of Consumption |
|---|---|---|
| Brown sugar solution | 138.09 | 76.41 |
| Supplemented diet | 42.63 | 23.59 |
| - Seed | 13. 32 | |
| Vegetables (including corn on the cob) | 28.10 | |
| - Pellet | 1.21 | 0.67 |

part) are not a balanced diet because they lack vitamin A, D, K, E and calcium, and they are too rich in fat (Harrison et al., 2006).

During the adaptation period before the experiments were carried out, the bird's feathers look dull and rough in appearance. After the birds were fed on a brown sugar solutionbased diets and this study was finished, the birds look healthier and have shiny, brightly colored and smooth plumage. It seems that consuming brown sugar solution can strengthen the body defense factors so that they are not susceptible to disease. According to Aeimsard et al. (2015), palm sugars are shown to have phenolic content which can act as an antioxidant. Antioxidants help to counter the detrimental effects of oxygen-free radicals (Harrison et al., 2006). Antioxidants could be advisable for weaker birds (Larcombe et al, 2010). Aryanti et al. (2013) reported that the addition of brown sugar in drinking water to chicks will improve their growth and will be able to increase stamina and supply easily absorbed energy sources. According to Tanuwijaya et al. (2017), consumption of the brown sugar solution can improve physical fitness higher than consumption of ordinary drinking water.

The birds feed throughout the day and 70% of their time is spent feeding in order to satisfy their daily requirements (Klarich, 2012). Feeding the birds such as *T. haematodus* is one of the most challenging aspects of their care, primarily because of dietary information for *T. haematodus* is mostly incomplete. An imbalanced diet is a common problem with birds in captivity which can cause illness that lead to an individual's death or failure to reproduce. This study provides the information regarding the potency of local food sources such as the brown sugar solution as an alternative carbohydrate source to substitute nectar diet for *T. haematodus* in captivity. Therefore, it will contribute to the aw*aren*ess of proper nutrition for health of the birds in captivity and conservation efforts.

## CONCLUSION

*T. haematodus* were fed brown sugar solution based diets looks healthy. The birds have shiny, brightly colored and smooth plumage (feathers). The bird consumed 76.41% of its diet in the form of the brown sugar solution, while the supplemented diet (seed, vegetables and pellets) were consumed by the birds only 23.59% Therefore the brown sugar solutionbased diet has potential to be used as an alternative carbohydrate source to substitute nectar based diets for *T. haematodus* in captivity. The brown sugar solution based diet should be added other food as a protein source such as commercial baby biscuit to substitute pollen and insect to meet the protein requirement. Future studies should be found other potential food as a protein source which prefer by the birds to get proper nutrition to increase captive propagation success.

## ACKNOWLEDGEMENTS

We would like to thank the Research Center for Biology, Indonesian Institute of Sciences for financial assistance. We also thank Mr Suwita (CV Pasundan) for kindly lending us his Lorikeets; Prof. Dr. Ibnu Maryanto and Dr. Wartika Rosa Farida for his valuable advice and proofreading; Tri hadi Handayani and R. Lia Rahadian Amalia for helping us to do proximate analysis. Thank you to Head of Zoological Division, Research Center for Biology LIPI which has provided cage facilities for research.

## REFERENCES

Abdullah, E.G., Rianse, U., Iswandi, R.M., Taridala, S.A.A, Rianse, I.S, La Zulfikar, Z., Baka, L., La Abdi, A. 2015. Potency of natural sweetener: brown sugar. *Wseas Transactions on Business and Economics*, 12, 99-110. E-ISSN: 2224-2899

Aeimsard, R., Thumthanaruk, B., Jumnongpon, R. & Lekhavat, S. (2015). Effect of drying on total phenolic compounds, antioxidant activities and physical properties of palm sugar. *Journal of Food Science and Agricultural Technology*, *1*(1), 126-130

Aryanti, F., Aji, M.B. & Budiono, N. (2013). Pengaruh pemberian air gula merah terhadap performans ayam kampung pedaging. *Jurnal Sains Veteriner*, 31 (2), 156-165.

Astuti, D., & Prijono, S. N. (2018). Diversity of The Ornate Lorikeet (Trichoglossus ornatus) Birds Based on Mitochondrial DNA Protein Coding Gene. *Biosaintifika: Journal of Biology & Biology Education*, 10(2), 465-471.

BirdLife International. (2018). *Trichoglossus haematodus*. The IUCN Red List of Threatened Species 2018. Retrieved from: http://dx.doi.org/10.2305/IUCN.UK.2018-2..RLTS.T22

Bosque C & Pacheco M.A. (2000). Dietary nitrogen as a limiting nutrient in frugivorous birds. *Rev Chil Hist Nat*., 73, 441–450.

Cabana, F & Lee, J.G. (2019). Feeding cluster preferences in four genera of Lories and Lorikeets (Loriinae) that should be considered in the diet of nectarivorous psittacine species in captivity. *Journal of animal Physiology and Animal Nutrition*, 103 (1), 354-362.

CITES (2017). Convention on International Trade in

Endangered Species of Wild Fauna and Flora. Appendices I, II and III.valid from 2 January 2017. 69 p.

Conde DA, Flesness N, Colchero F, Jones OR, Scheuerlein A. (2011). An emerging role of zoos to conserve biodiversity. *Science,* 331(6023):1390-1391

Duhan, G. U. U. B. (2017). Habitat mencari makan dan habitat berbiak Perkici Timor (*Trichoglossus euteles*) di pulau Adonara. *Prosiding Konferensi Peneliti dan Pemerhati Burung Indonesia 3 (KPPBI 3)* (pp. 12-22). Indonesia: Universitas Udayana, Bali.

Fleming, P. A., Hartman Bakken, B., Lotz, C. N. and Nicolson, S. W. (2004). Concentration and temperature effects on sugar intake and preferences in a sunbird and a hummingbird. *Funct. Ecol.*, 18, 223-232.

Fleming, P. A., Xie, S., Napier, K. R., McWhorter, T. J. and Nicolson, S. W. (2008). Nectar concentration affects sugar preferences in two Australian honeyeaters and a lorikeet. *Funct. Ecol.*, 22, 599-605.

Florido, H.B, P.B de Mesa. (2003). Sugar Palm [*Arenga pinnata* (Wurmb.) Merr.]. *Research Information Series on Ecosystems*, 15 (2), 1-7.

Gill, F., & Wright, M. (2006). *Birds of the World: Recommended English names.* London: Croom Helm & Princeton University Press.

Gupta, N., & Kushwaha, H. (2011). Date Palm as a source of Bioethanol producing microorganisms. In: Jain, S.M., Al-Khayri, J.M. & Johnson, D.V. (eds). *Date Palm Biotechnology*. Dordrecht: Springer. pp. 711-727.

Harrison, G. J., Harrison, L. R., & Ritchie, B. W. (2006). Nutrition. In: Harrison, G.J., Harrison, L.R. & Ritchie, B.W. (eds). *Avian Medicine Principals and Application*. Florida: Spix Publishing Inc. pp85–140.

Hollowood,T. A., Linforth, R. S. T., & Taylor,A. J. (2002). The effect of viscosity on the perception of flavour. *Chem. Senses*, 27, 583-591.

Kalmar, I. D., Loon, M., Bürkle, M., Reinschmidt, M., Waugh, D., Werquin, G., & Janssens, G. P. J. (2009). Effect of dilution degree of commercial nectar and provision of fruition food, energy and nutrient intake in two rainbow lorikeet subspecies. *Zoo Biology*, 28, 9 8 –106

Klarich, R. (2012). *Husbandry Guidelines for the Rainbow Lorikeet.* NSW Australia: TAFE NSW-Western Sydney Institute, Richmond College.

Koutsos, E.A, Matson, K.D., & Klasing, K.C. (2001). Nutrition of birds in the Order Psittaciformes: A Re-view. *Journal of Avian Medicine and Surgery*, 15(4), 257-275.

Larcombe, S. D., Coffey, J. S., Bann, D., Alexander, L., & Arnold, K. E. (2010). Impacts of dietary antioxidants and flight training on post-exercise oxidative damage in adult parrots. *Comparative Biochemistry Physiology*. Part B, 155, 49–53.

Leseigneur, C. D. C., Verburgt, L., & Nicolson, S. W. (2007). Whitebellied sunbirds (Nectarinia talatala, Nectariniidae) do not prefer artificial nectar containing amino acids. *Journal of Comparative Physiology*, B, 177, 679–685.

Lotz, C.N. & Schondube, J.E. 2006. Sugar Preferences in Nectar- and Fruit-Eating Birds: Behavioral Patternsand Physiological Causes. *BIOTROPICA*, 38(1), 3–15 2006.

Matson, K.D., & Koutsos, E.A. (2006). Captive Parrot Nutrition: Interactions with Anatomy, Physiology, and Behavior. In: Luescher, A.U (ed). Manual of Parrot Behavior. Oxford: Blackwell Publishing, Ltd. pp. 49-58.

Matson, K.D., Millam, J.R., & Klasing, K.C. (2001). Thresholds for sweet, salt, and sour taste stimuli in cockatiels (Nymphicus hollandicus). *Zoo Biol*, 20 (1), 1–13.

McKenzie, A. J., & Whittingham, M. J. (2010). Birds select conventional over organic wheat when given free choice. Journal of Science of Food and Agriculture, 90, 1861–1869.

Misra, B. (2016). Neera: The coconut sap: A review. *International Journal of Food Science and Nutrition*, 1(4), 35-38

Napier, K. R., Purchase, C., McWhorter, T. J., Nicolson, S. W., & Fleming, P. A. (2008). The sweet life: Diet sugar concentration influences paracellular glucose absorption. *Biology Letters*, 4, 530–533.

Nguyen, D.V., Rabemanolontsoa, H., & Saka, S. (2016). SAP from various palms as a renewable energy source for bioethanol production. *Chem. Ind. Chem. Eng.* , 22 (4) , 355−373.

Nicolson, S. W., & Thornburg, R. W. (2007). Nectar chemistry. In Nectaries and nectar. Dordrecht: Springer. pp. 215-264.

Renner, S.C, Baur, S., Possler, A., Winkler, J., Kalko, E.K.V., Bates, P.J.J., & Mello, M.A.R. (2012). Food Preferences of Winter Bird Communities in Different Forest Types. *PLoS ONE* 7(12):e53121. doi:10.1371/journal.pone.0053121

Schondube, J.E. & Martínez Del Rio, C. (2003). Concentration-dependent sugar preferences in nectar-feeding birds: mechanisms and consequences. *Functional Ecology*. 17 (4), 445-453.

Tanuwijaya, R.R., Kristiyanto, A., & Doewes, M. (2017) Pengaruh Pemberian Air Gula Merah Terhadap Kebugaran Jasmani. *Jurnal Gizi,* Universitas Muhammadiyah Semarang, 6 (2), 12-19.

Tsahar, E., Arad, Z., Izhaki, I., & Martinez Del Rio, C. (2006). Do nectar and fruit-eating birds have lower nitrogen requirements than omnivores? An allometric test. *Auk*, 123, 1004–1012.

Wilson, A.L., & Downs, C.T. (2011). Food preferences of Knysna and purple-crested turacos fed varying concentrations of equicaloric and equimolar artificial fruit. *The Journal of Experimental Biology*, 214, 613-618.