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Secondary Compounds and Food Selection by Olive Baboons (*Papio Anubis*) In A Wildlife Park

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Abstract
Nutritional ecology in the context of primate-plant interaction is essential in the understanding of primate survival and adaptation. Secondary compounds are major components of primate food plants. Studies on chemical basis of food selection by wild animals are invaluable in designing appropriate and deliberate conservation actions. We therefore investigated secondary compounds in food and non-food resources of Olive baboons in a view to establish if these phytochemicals formed the basis for food selection. The study was conducted in a wildlife park; Old Oyo National Park, Nigeria from January to March. Direct observation method was used to elicit data on the food and non-food resources of olive baboons. Feeding sites were obtained through trailing system and auditory clue methods. Secondary compounds (glycosides, alkaloids, phenolic and condensed tannin) were examined in the food and non-food resources of olive baboons using standardized procedures. Significant differences in the secondary compound content of the food and non-food resources consumed by the primates were tested through Analysis of Variance (ANOVA). The phytochemical analysis revealed that the secondary compounds examined were present in all the food resources consumed by olive baboon in the Park. Highest concentrations of glycosides, alkaloids, phenolic and condensed tannin were found in Magnifera indica ***(****0.28767%****),*** *Adansonia digitata (0.617%),* ***Magnifera indica*** *(0.351%), Parkia biglobosa (0.008533%) respectively.There was significant difference in the concentration of secondary compounds found in the food resources consumed by olive baboons. Secondary compound content of food resources of olive baboons in the park outweighed the secondary compound content of non-food resources, although they did not differ significantly. The secondary compounds investigated in the diet of olive baboons did not negatively affect their food selection in the wildlife park. Olive baboons in the study area did not prefer food with lower concentration of the secondary compounds. None of the secondary compounds acted as feeding deterrent. Olive baboons demonstrated high tolerance for the tested secondary compounds.*
Keywords: *olive baboon, food selection, glycosides, alkaloids, phenolic and condensed tannin*

INTRODUCTION

A study on nutritional ecology of wild animals, with emphasis on the chemical basis of food choice gives a clear insight on their feeding biology (Matsuda *et al.* 2013). Such investigations have provided the much needed

trend in primates' food selection (Davies *et al.*, 1988; Kar-Gupta and Kumar 1994; Chapman and Chapman, 2004).

Nutritional ecology in the context of primate-plant interaction is essential in the understanding of primate survival and adaptation (Glander, 1982). The record of secondary compounds present in food plants of primates in a particular habitat will form the basis for comparison with related primate species in other habitats. Secondary compounds are major components of primate food plants and there is therefore the need to unravel the relationship between the secondary compounds and food selection by primates. This study would help to better understand the feeding behavior of these primates. Phytochemical determination of wild ranging animals have been found to be resourceful in explaining habitat choices in the context of conservation and habitat management (Glander, 1982). In other words, inventory on the chemical basis of food selection by wild animals is invaluable in designing appropriate and deliberate conservation actions. Knowledge of the relationship between secondary compounds of primates' diet can also provide the much needed insight for captive care managers (Rothman, 2013).

Primates that feed on plant resources, just like other animals have the primary goal of maximizing nutrient intake. However, primate nutritional goal has been classified into different models. One of such models adopted in primate nutritional ecology is that primates select food with the aim of avoidance or regulation of intake of plant secondary compounds (Felton *et al*., 2009). Ecologists have suggested that vertebrate herbivores, as a matter of necessity, select food that offers the required nutrient but must, at the same time avoid plant secondary metabolites that could cause intoxication. For instance, (Jensen *et al.* 2015) reported that an herbivorous mammal; greater glider (*Petauroides volans*) fed on a diet that balanced potential gain of available nutrients and potential cost of plant secondary compounds. In essence, the studied animal maximized the nutritional gain but minimized the intake of plant secondary compounds. Plant secondary compounds are chemical molecules produced by plants, often as a form of defense against herbivorous animals (Sanchez-Sanchez and Morquecho-Contreras, 2017). Plants produce these secondary compounds to prevent or reduce injury and loss of productivity. This plant defense mechanism limits the chances of animals that feed on them in obtaining nutrients from the plant tissues (Mitchell *et al*. 2016.). Plant secondary compound could have some toxic effects on animals that feed on them, consequently reducing their palatability (Foley and McArthur 1994). These compounds play complex roles in animals to the extent of influencing diet selection in primates (Maisel *et al.*1994, Fashing *et al.* 2007, Foley and McArthur 1994). (Glander, 1975a & b) reported that secondary compounds in the diet of a primate species, howler monkey *(Alouatta palliata)* accounted for their feeding selectivity. It has also been suggested that secondary compounds in diet of howler monkeys could be responsible for facultative birth spacing and varying infant mortality (Glander, 1980).

This informed the basis for our study on secondary compounds and food selection in a primate species; Olive baboon (*Papio anubis*) inhabiting a wildlife park; Old Oyo National Park (OONP), Nigeria.

Out of the wide array of secondary compounds in plants, tannins, glycosides, phenolics and alkaloids are some of the secondary compounds that have been implicated in plant-animal interactions and primate nutrition (Glander, 1982, Sanchez-Sanchez and Morquecho-Contreras, 2017). We therefore investigated secondary compounds in food and non-food resources of Olive baboons in a view to establish if these secondary compounds influenced or formed the basis for food selection. We aimed to ascertain if there is any relationship between these secondary compounds and food selection in these primate species.

METHODOLOGY

Study Area

The study was conducted in a wildlife park; Old Oyo National Park (OONP), located in Oyo state, Nigeria. It is the fourth largest, among seven of such National parks in Nigeria. It is a historic park, situated in the Southwestern region of the country and derived its name from the ruins of Oyo-ile, the political capital of ancient Oyo Empire.

The vegetation of the Old Oyo National Park comprises a high forest and dense savannah mosaic woodland ecosystem. The park has a rich biodiversity with diverse collection of flora and fauna resources. Dominant tree species in the park include Vitex doniana, Pterocarpus santaliodes, Bombax costatum, Anogeissus leiocarpus, Berbinia grandiflora, Afzelia Africana, Albizia adianthifolia, Daniella oliveri, Detarium microcaroum (Orimaye, 2002)

The park initially existed as two contiguous forest reserves namely, upper Ogun and Oyo-ile, which were gazzetted in 1936 and 1941 respectively (Oyeleke *et al.* 2015). The two forests reserves were later amalgamated in 1991. For ease of management, the park currently divided into 5 ranges; Marguba, Ogundiran, Tede, Oyo-ile, Sepeteri and Yemeso. The Park sits on a 2, 512km sq. land mass (Akinyemi and Kayode 2010).

Rainfall pattern in the park is bimodal; between April and July and thereafter between September and October, followed by dry season (Mengistu and Salami, 2007).

Data Collection

Direct observation method was used in collecting data on the food and non-food resources of olive baboons in the study area for three months (January-March). Feeding sites were identified through the following procedures:

i. Trailing System

This involved following behind or tracing the foot prints and fresh feacal droppings of the animals to their feeding sites. However it is worthy of note to state that considerable and appropriate distances were kept away from the animals depending on the visibility and vegetation cover. The minimum distance kept was 5m. This was to avoid the study animals from being agitated and to ensure that the observers were not attacked by the study animals.

ii. Auditory Clues

Olive baboons` feeding sites were identified by trailing their vocalizations such as long, alarm calls, warning barks and other forms of vocal communications they made intermittently. The study was conducted for a period of 12 months.

Food Samples Collection

Terrestrial food samples eaten by olive baboon were collected with the aid of machetes and plant pruners. Poles were used to extract arboreal foods. Opportunistic collection of food samples was also carried out whereby fruits dropped by monkeys or from fallen branches were picked. An average of 500g wet weight for each sample was collected as recommended by Rothman *et al.* (2011).The samples were weighed immediately after collection and labeled appropriately. They were thereafter air dried prior to transportation in a sealed plastic bag to the laboratory for phytochemical analysis. The essence of the drying was to inhibit enzymatic activity so as to prevent chemical shift (Rothman *et al.,* 2011).

Data Analysis

In order to investigate if the secondary compounds formed the basis of food selection by olive baboons, we conducted a phytochemical analysis on their food and non-food samples in their habitat. This was to unravel if the secondary compounds served as feeding deterrent. The chemical analysis was conducted in accordance with standardized procedures as presented by Marcano and Hasenawa (1991).

The outcome of the phytochemical investigation was subjected to Analysis of Variance (ANOVA) in order to examine significant differences in the secondary compound content of the food resources consumed by the primates. ANOVA was further used to test for significant differences between the secondary compound content between food and non-food sources of olive baboons in the park. The level of significance was at $P \leq 0.05$.

RESULTS

The secondary compounds examined were present in all the food resources consumed by olive baboons in the study area (table 1). Concentrations of glycosides, alkaloids, phenolic and condensed tannin were highest in

Magnifera indica **(**0.28767%**),** *Adansonia digitata* (0.617%)**,** *Magnifera indica* (0.351%), *Parkia biglobosa* (0.008533%) respectively**.** Meanwhile, *Gardenia aqualla* had the least concentrations of glycosides (0.219%), alkaloid (0.378%) and phenolic (0.22433%). Condensed tannin was lowest in *Piliostigma thoningii* (0.0052%) (table 1).

Analysis of variance (ANOVA) indicated there was significant difference in the concentration of secondary compounds found in the food resources consumed by olive baboons in the National Park (table 2).

Remarkably, the secondary compound content of food resources of olive baboons in the park outweighed the secondary compound content of non-food resources (figures 1-4), although they did not differ significantly (**table 3**).

Table 1: Mean value of Secondary compounds in Food consumed by Olive baboons in OONP

S/N	Plant species	Glycoside (% /100g)	Alkaloid (% /100g)	Phenolic (% /100g)	Condensed Tannin (% /100g)
1	*Parkia biglobosa*	0.25933	0.58133	0.324	0.008533
2	*Rafia sudanica*	0.23567	0.42633	0.24333	0.0068
3	*Magnifera indica*	0.28767	0.50567	0.351	0.007733
4	*Gardenia aqualla*	0.219	0.378	0.22433	0.005433
5	*Adansonia digitata*	0.276	0.617	0.34367	0.006267
6	*Pilostigma thoningii*	0.24267	0.43733	0.258	0.0052

Table 2 Analysis of Variance for Secondary compound concentrations in food consumed by olive baboons in OONP

Secondary Compounds	**F value**	**P value**
Glycoside	258.983	.000
Alkaloid	3.619	.032
Phenolic	1485.523	.000
Tannin	97.338	.000

Table 3 Analysis of Variance between Secondary compound concentration in food and non-food resources of olive baboons in OONP

Secondary Compounds	**F value**	**P value**
Glycoside	.276	.603
Alkaloid	.168	.685
Phenolic	.032	.859
Tannin	3.329	.079

Figure 1. Tannin content of Food and non-food resources of Olive baboon in OONP

April 30, 2023

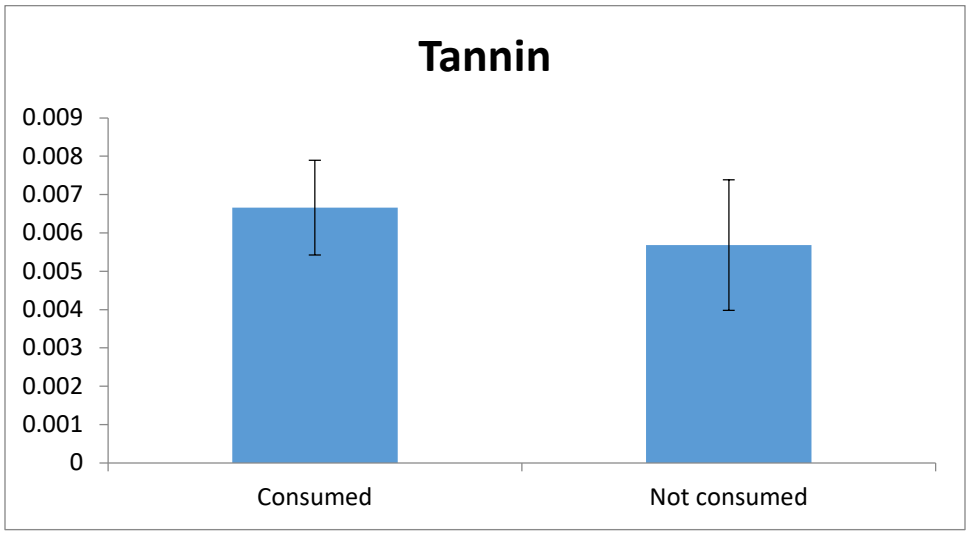


Figure 2. Glycoside content of Food and non-food resources of Olive baboon in OONP

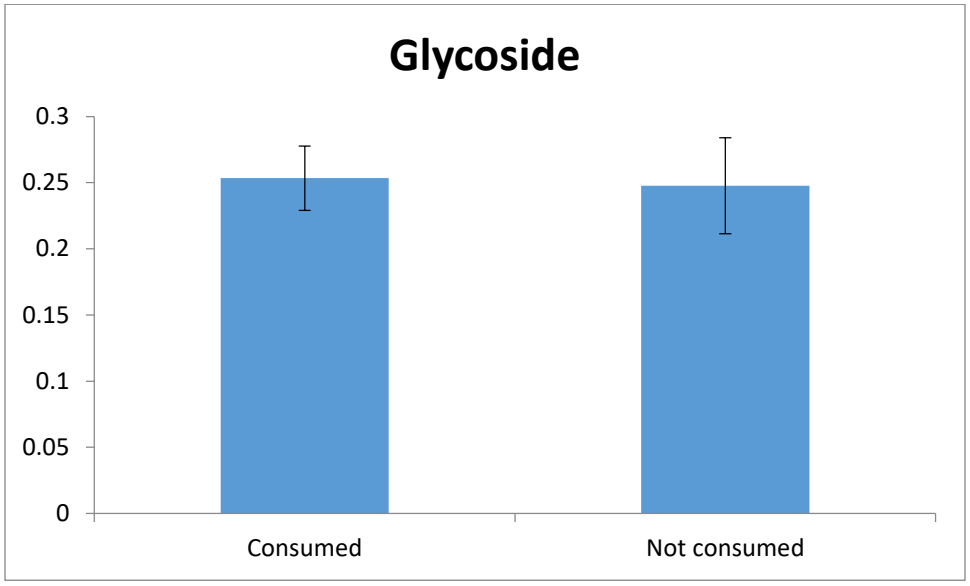


Figure 3. Phenolic content of Food and non-food resources of Olive baboon in OONP

April 30, 2023

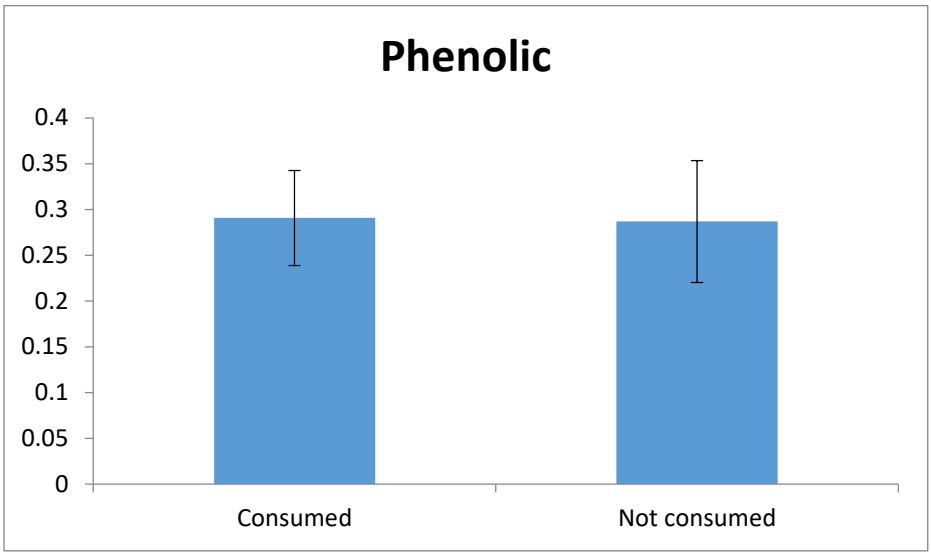
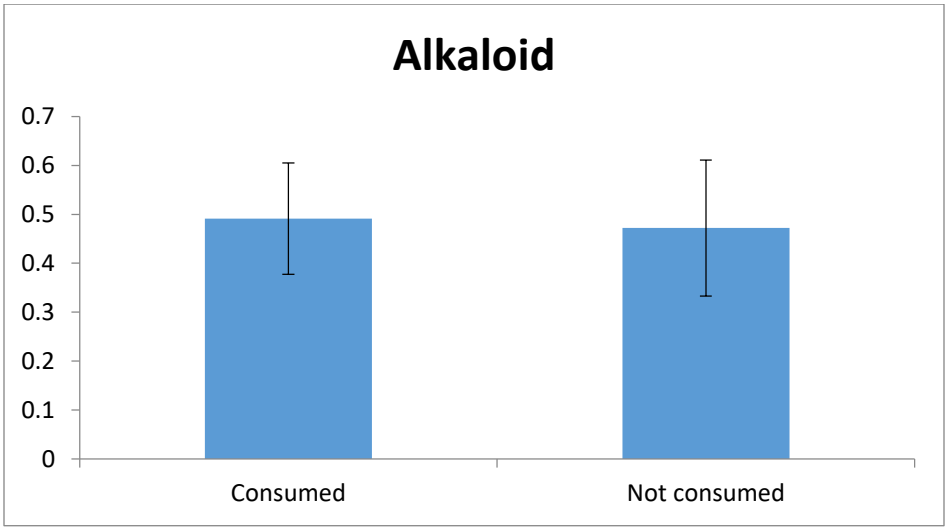


Figure 4. Alkaloid content of Food and non-food resources of Olive baboon in OONP



DISCUSSION

The presence of all the examined secondary compounds (glycoside, alkaloid, phenolic and condensed tannin) in all the food samples consumed by olive baboons in the park alluded to existing literature that these phytochemicals are indeed associated with primate food resources. These secondary compounds have been established to have deleterious effects on primates' nutrition and health. For instance alkaloids, glycosides and condensed tannins could impair gut function (War *et al.*2012, Matsuda *et al.* 2013). Tannins considerably reduces the palatability of unripe fruits and combines with protein to reduce its digestibility, thereby acting as anti-feedants (Wrangman and Waterman 1983, Robbins et al. 1991). Tannins destroy intestines and kidneys of mammals, which in effect, stunts their growth and may lead to death (Mole and Waterman 1987)

The examined phytochemicals have adverse effect on digestibility and nutrient uptake (Rhoades and Cates, 1976). It is consequential to submit that these secondary compounds negatively affects foo selection in primates. In a bid to achieve their nutritional goals, primates adopt the strategy of either feeding on plant resources with minimal content of these chemicals or they avoid food resources containing them. (War *et al.* 2012 and Scholz, *et al.* 2016) referred to these phytochemicals as defense compounds and that animals find ways to bypass them. Howler monkeys **(***Alouatta palliata* **)** were reported to have restricted their feeding activities to trees with leaves devoid of alkaloids and tannins (Glander, 1981). The strategy of wild animals

avoiding completely plant resources containing these toxic compounds may be somewhat herculean especially in habitats with lean food resources. A more realistic approach would be to consume food with minimal presence of secondary compounds, as observed in the food composition of South Indian leaf monkey; *Presbytis johnii*, where a substantial portion of the diet contained minimal content of condense tannin (Kool, 1992). (Milton, 1979) also hypothesized and established that howler monkeys opted for young leaves because of the presence of lower quantity of toxic secondary compounds. Similarly, greater gliders (*Petauroides volans*) ingested leaves with minimal concentration of toxins in order to achieve a balance between available nutrients and potential cost of feeding on some leaves (Jensen *et al.* 2015). In the same vein, chimpanzees in Guinea, Bossou ate leaves with little concentrations of condensed tannin (Takemoto, 2003). The leaves from plant species consumed had a relatively lower concentration of condensed tannin when compared with leaves from non-food resources.

Remarkably and on the contrary, we found out that olive baboons consumed food resources containing concentrations of the examined secondary compounds higher than what was in the non-food resources. This was a deviation from the initial proposition that primates adopt a feeding strategy of either avoiding food resources containing toxic secondary compounds or minimize the ingestion of food resources with these harmful compounds, in instances where total avoidance is neither feasible nor sustainable. The implication of this finding is that the olive baboons have a high tolerance for the secondary compounds. This may also explain why they are referred to as generalist feeders. A combination of factors could be suggested as being responsible for the high tolerance for secondary compounds in their diet. The dilution of these secondary compounds in the gut of olive baboons may explain why they could ingest food substances high in secondary compounds. (Kool, 1992) suggested that South Indian leaf monkeys were not deterred by the presence of alkaloid because of their dilution in the gut.

The secondary compounds we investigated which act as feeding deterrents could also have been tolerated because of their detoxification in the fore stomach of the animals. The fore stomach of certain animals possess the capacity to detoxify some secondary metabolites. This view was also expressed by (Kool, 1992), to the extent that colobines adopted this a coping strategy. (Nijboer, 1997) further opined that certain microbial populations could offer vital detoxification mechanism for dealing with secondary compounds found in food ingested by the animals. It is believed that some bacterial floral in the stomach helps in the detoxification of chemicals deemed harmful to animals.

This coping strategy could also be achieved over time through evolution. For instance (Mckey 1978) reported over time through evolution of foregut fermentation in colobine as strategy or adaptation for the processing of secondary compounds found in their diet.

CONCLUSION

The secondary compounds investigated in the diet of olive baboons did not negatively affect their food selection in the wildlife park. There was no correlation between the secondary compounds and food choice. Olive baboons in the study area did not prefer food with lower concentration of the secondary compounds. In other words, the phytochemicals examined did not have effect on their feeding behavior. None of the secondary compounds acted as feeding deterrent. Olive baboons demonstrated high tolerance for the tested chemical compounds. We recommend that similar study be conducted in other habitats to have a basis for comparison, in other to ascertain if these findings are site specific.

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