BIBLIOGRAPHY

FORTES, MADELINE D. APRIL 2013. Preference and Acceptability of Chayote (*Sechium edule Jacq. Swartz)* Fruits and Leaves by Rabbits. Benguet State University. La Trinidad, Benguet.

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ABSTRACT

This study aimed to determine the palatability and acceptability of fresh chayote fruits and leaves as feed for rabbits. A total of five New Zealand White rabbits were distributed using the completely randomized design to the following treatments: T_1 = chayote young leaves, T_2 =chayote mature leaves and T3 = chayote fruits. The mean dry matter content of the test diets were 10.05, 12.85, and 6.36%, respectively. Among the three diets offered, young leaves were preferred most by the experimental rabbits. Acceptability of the test diets did not differ and was observed to be quite low.

INTRODUCTION

The domestic rabbit *(Oryctolagus cuniculus)* is a herbivore that feed by grazing on grass, forbs, and leafy weeds. Consequently, the diet contains large amounts of cellulose, which is hard to digest. This problem is solved by autocoprophagy in which rabbits reingest their own soft feces (Hirakawa, 2001) rather than chewing the cud as do other herbivores to digest their food further and extract sufficient nutrients. Feeding an appropriate diet to a rabbit is probably the single most important factor in maintaining its health.

Due to high cost of feeds, rabbit raisers keep on trying different alternative feeds and supplement to meet the requirement for excellent upkeep of rabbit. This situation is also made worse during dry season when green feeds are scarce. The challenge is to make use of feed material that could be available locally. The feeding of alternative forage to rabbits, especially in the dry season, is essential when grass and herbaceous forages are scarce. *Sechium edule* or chayote remains green most of the year and provides nutrients, being rich in amino acids, vitamins and minerals that are most often lacking in the dry season. However, there needs to further investigate the use of this plant because of its relative availability as alternative feed resource to rabbits (http://www.botanical-online.com/english/chayoteproperties.htm). Aung *et al*. (1990) mentioned that in addition to its fruits, chayote yields tender shoots for use as vegetable greens, vines as ornament for fences or as animal fodder, and edible subterranean storage roots.

However, acceptability of feeds by rabbits is a predicament in feeding and nutrition research. Pond *et a.l* (2005) mentioned that in essence, palatability is the result of a summation of many different factors sensed by the animal in the process of locating and consuming food. Palatability is determined by the appearance, odor, taste, texture,

temperature and other sensory properties of the food. These properties are, in turn, affected by the physical and chemical nature of the feed.

The palatability of forages is an important factor in rabbit production, particularly when the forages are expected to provide a major part of the daily nutrient intake. In research, palatability usually is measured by giving animals a choice of two or more feeds so that they can express more preference. Freshness is important to the rabbit, because this affects the palatability of the feed.

Specifically, the study aimed to:

1. determine the palatability of chayote as feed for rabbits, and
2. determine the acceptability of chayote by rabbits.

The palatability and acceptability tests were carried out from July to August, 2012 at Upper Tomay, La Trinidad, Benguet.

REVIEW OF LITERATURE

In selecting herbage for rabbits, the most important factors for consideration are: availability of the browse, the crude protein level, the digestibility factors and toxic constituents. However, the majority of previous studies are on browse plants such as grasses and legumes, and no literature on the use of chayote as animal feed was available to the researcher. Hence, only general information on chayote was reviewed.

Grass, both fresh and dried, is an important food for the domestic rabbit, although it varies very considerably. During the spring the grass grows rapidly, and at this period the plant is leafy and is rich in protein and low in fibre content. During summer when the plant flowers, there is a great increase in fibre and a reduction in protein and other digestible nutrients. The grass improves slightly in autumn, and then tails off again during winter. Titus young quickly growing grass is an excellent food for all classes of stock, although older grass is not so valuable, and rank old growth is not at all satisfactory, these variations are important, for young rabbits may easily starve if fed on old growth (Cheeke, 1987).

The relative palatability of forages fed to rabbits was studied by Osakwe and Ekwe (2001). Significantly differences ($P<0.01$) in relative palatability index (RPI) were detected among the different forages offered. Based on their RPI, rabbits preferred in descending order of magnitude *Centrosema pubescens, Calopoganimar muconoides* and *Elacis guincensi* (RPI> 95%) to *Musa sapientum* (RPI>70%) and *Andropon gayanas* (RPI>40%). The preferences of oil polar leaves to banana leaves according to RPI are an interesting observation from the study.

The chayote is used mainly for human consumption. The fruit, stems and young leaves as well as the tuberized portions of the roots are eaten as a vegetable, both alone and

plain boiled, and as an ingredient of numerous stews. Because of its softness, the fruit has been used for children's food and drinks like juices, sauces and pasta dishes. In Mexico, an attempt has been made to increase the life of the fruit by drying it. The results have been positive and have enabled jams and other sweets to be prepared while also producing dried fruit which can be used as a vegetable after a certain time. Because of their flexibility and strength, the stems have been used in the craft manufacture of baskets and hats. In India, the fruit and roots are not only used as human food but also as fodder (Bermejo and León, 1994).

The chayote root is not much utilized for food by the Cordillerans, unlike Mexico's indigenous Mayans who also eat the starchy roots – like the fruits and tops – and added it to beans. Chayote was also the staple food of the indigenous Aztecs in Mexico. At present, chayote can be prepared and eaten raw as salad. It may be stuffed and baked and may be prepared mashed, fried or boiled. It can also be used as soup or cream. Unknown to many; however, the chayote is also a medicinal plant. Its leaves can be made into tea. It can dissolve kidney stones. On the other hand, it is also used to treat hypertension and arteriosclerosis, according to an article on chayote history and lore on the Internet (Allad-iw, 2005).

Samples of *Sechium edule*, also known as vegetable pear or mirliton, were analyzed for moisture and dry matter. Dry matter was further analyzed for crude protein, ether-extractable material, pectin, crude fiber, ash, selected minerals, and nitrogen-free extract. Fresh mirlitons contain 94% moisture. Carotene was not detected. The mirliton does not contain detectable amounts of lipoxygenase or polyphenol oxidase activity (compared to activity in mushroom). Amino acid concentrations in the seed were approximately twice

those of the flesh. Methionine was detected in the seed but not in the tissue. The data suggest that the mirliton can be a new fresh vegetable crop for the southern area and for processing into frozen food products (Flick *et al*., 1977).

Presently, only one study was reported to see the effect of feeding fiber from chayote on biological utilization of diet in the rat (Modgil and Modgil, 2004). Chayote had better biological value then the bottle gourd. Increase in fiber even from vegetable sources resulted in the decreased PER, DMD, BV, TPD, NPU, PRE and NPR in rats.

The edible parts of S. edule (fruit, seed, stem and root) are relatively low in fibre, protein and vitamins compared with other vegetables. Nevertheless, they have a high caloric and carbohydrate content, especially in young stems, root and seed, and the micro and macronutrient content of the fruit is adequate. The fruits, and the seed especially, are rich in several important amino acids such as aspartic acid, glutamic acid, alanine, arginine, cistein, phenylalanine, glycine, histidine, isoleucine, leucine, methionine (only in the fruit), proline, serine, tyrosine, threonine and valine (Flores, 1989 as cited by Lira, 1996).

A liquid chromatography−mass spectrometry (LC-MS)-based method was developed by Siciliano *et al*., (2004) for the characterization of flavonoids from edible parts of *Sechium edule* (Jacq) Swartz. Eight flavonoids, including three *C*-glycosyl and five *O*-glycosyl flavones, were detected, characterized by nuclear magnetic resonance spectroscopic data, and quantified in roots, leaves, stems, and fruits of the plant by LC-photodiode array-MS. The glycine moieties are represented by pigenin and luteolin, while the sugar units are glucose, apiose, and rhamnose. The results indicated that the highest total amount of flavonoids was in the leaves (35.0 mg/10 g of dried part), followed by roots (30.5 mg/10 g), and finally by stems (19.3 mg/10 g).

MATERIALS AND METHODS

A. Dietary Palatability Test

Experimental animals. A total of five mature rabbits (3 months old) were used in the study. The rabbits were of the same age, weight and breed (New Zealand White) and were purchased from a single source to minimize variations. The animals were treated against endo-and ecto-parasites following recommended practices. The rabbits were housed individually in elevated cages made of metal framework and wire screen.

Preparation of test diets. Fresh chayote fruit and leaves with petiole and tendrils were collected within 24 hours. The unpeeled fruits were chopped into four equal parts, while the leaves were offered upon after collecting. The fruit and leaves served as dietary treatments:

T_1 = Chayote young leaves including petioles and tendrils

T_2 = Chayote mature leaves including petioles

T_3 = Chayote mature fruit (unpeeled)

Experimental procedure. The experimental animals were given a choice from several diets or feedstuffs. The relative intakes of the diets were measured quantitatively to represent the response of the animals. The cafeteria-style was used in which rabbits are given a selection of different food items presented in equal amounts simultaneously.

The preference trial lasted for 10 days in two phases: protocol conditioning and preference testing. A 5-day conditioning phase was necessary for familiarizing animals with each test diet. Following the protocol conditioning phase, a preference trial was conducted over 5 days. Data on the amount of feed offered and left-overs were gathered during the last phase.

Each feedstuff was weighed and offered simultaneously in separate containers. Rabbits were offered an initial amount of 1 kg of the test diets twice daily at 6:30 am and 5:00 am. This amount was adjusted based on actual intake during the conditioning phase. Sufficient feed was placed in each container so that feed would not be depleted and force the rabbits to eat other feeds. Any feed remaining from the previous feeding was weighed to determine amount consumed before the containers are refilled. The location of the containers in the cages was randomized at each feeding to prevent bias due to position. Drinking water was supplied *ad libitum* in earthen containers or crocks.

B. Dietary Acceptability Test

The dietary acceptance trial made use of the single choice selection in which experimental animals were not given a choice of diets. Only one test diet was offered to the experimental rabbits at a time for a period of 30 minutes. The same dietary treatments were tested in this trial to involve the same experimental animals used in the palatability trial.

Each rabbit was offered an amount of 1 kg of T1 (Chayote young leaves including petioles and tendrils) at 6:30am for two days. The diet was withdrawn from the animals 30 minutes after this was offered and weighed for leftovers. At this time, the animals were fed with a basal diet of Galinsoga forage for the rest of the day. Another test diet (T2 = Chayote mature leaves including petioles) was offered in same amount and period of time over two days. The last test diet, (T3 = Chayote fruits), was offered in same amount and period for the last two days of the experiment.

Samples of the test diets were dried at 60 °C for 24 hours in a Memmert convection oven for dry matter determination.

Data Gathered

The following data were gathered from both experiments:

1. Amount of feed offered daily(g).The amount of each test diet given to an experimental animal was measured daily using a feed scale.

2. Amount of feed leftover (g). The amount of feed not consumed by each experimental animal was also weighed before a new feed was given in the morning.

3. Weight of feed samples before and after drying (g). The weights before and after oven-drying were used to compute for dry matter content.

Data Computed

From the data gathered, the following indicators were computed:

1. Amount of dry matter in feed (g). The amount of dry matter in the test diet was computed as:

$$\% \text{ DM} = \frac{\text{Weight of Feed Samples after Drying}}{\text{Weight of Feed Samples before Drying}} \times 100$$

2. Total feed intake, fresh basis (g). This was obtained by getting the difference between the amount of feed refused and feed offered to each experimental animal.

3. Total feed intake, dry matter basis (g). This was computed by multiplying the total feed intake, fresh basis, of each animal with the DM content of the test diet it consumed.

4. Relative palatability index. This was calculated as:

$$\text{Relative Palatability Index: } \frac{\text{Daily Feed Intake}}{\text{Highest feed intake}} \times 100$$

5. Relative acceptability index. This was calculated using the formula:

$$\text{Acceptability Index} = \frac{\text{Amount of Feed Consumed}}{\text{Amount of Feed Offered}} \times 100$$

Data Analysis

All data were subjected to one-way analysis of variance for Completely Randomized Design of an experiment. In case of significant differences, treatment means were compared using the Duncan's Multiple-Range Test.

RESULTS AND DISCUSSION

Dry Matter Content of Chayote

Table 1 shows the dry matter content of the experimental diets. Statistical analysis revealed that dry matter content is significantly different among the parts of chayote used in the experiment. As expected, the fruit has the lowest dry matter content at 6.36% only. Flick et al. (1977) reported that fresh chayote fruits contain 94% moisture or 6% dry matter. Chayote young leaves including petioles and tendrils contained 10.05% dry matter. The mature leaves including petioles had the highest dry matter content (12.85%). These figures are within the values reported by Nguyen Van and Nguyen Thi (2008) for water spinach (9.63%) and sweet potato vine (8.56%).

Preference of Test Diets by Rabbits

Data on feed intake of the experimental animals are presented in table 2. Both daily and total feed intakes are significantly different among dietary treatments. Young leaves of chayote were ingested by the rabbits with the greatest amounts both in total and daily intakes (824.64 g and 164.93 g, respectively). This implies that among the three diets offered young leaves were preferred by the experimental rabbits.

Table 1. Dry matter content of the test diets

TREATMENTS	MEAN
Chayote young leaves	10.05[b]
Chayote mature leaves	12.85[a]
Chayote fruits	6.36[c]

**Means with the same letter superscript are significantly different (P<0.05) by DMRT.

Table 2. Mean feed of the test diets by rabbits during the palatability trial

TREATMENTS	TOTAL FRESH BASIS (g)	DAILY FRESH BASIS (g)
Chayote young leaves	824.64[a]	164.93[a]
Chayote mature leaves	717.04[b]	143.41[b]
Chayote fruit	745.08[b]	149.02[b]

Means with the same letter superscript are not significantly different (P<0.05) by DMRT.

Total intakes of fruits and mature leaves are similar at 745.08 and 717.04g, respectively. Similarly, daily intakes of fruits and mature leaves are not significantly different (149.02 and 143.41 g, respectively). According to Baumont *et al*. (2000), for a given plant, ingestibility is dependent on the vegetation stage and the number of the vegetation cycle. During the first vegetation cycle, ingestibility decreases with the age of the plant. Ball *et al.* (2001) further explained that maturity at harvest also influences forage consumption by animals. As plants mature and become more fibrous, forage intake drops. This preference for high quality forage has been suggested for rabbits by Kuijper *et al*. (2004) and Rödel (2005) as cited by Somers *et al*. (2008).

Relative Palatability Index

Table 3 shows the relative palatability and preference ranking of chayote diets by rabbits. Statistical analysis showed no significant differences among treatments. Based on numerical value, rabbits preferred in descending order of magnitude chayote young leaves (96.56 %), mature leaves (92.66 %), and fruits (86.94%). The exact reasons for the

Table 3. Relative palatability index and preference ranking of the test diets

TREATMENTS	RELATIVE PALATABILITY INDEX, %[ns]	PREFERENCE RANKING
Chayote young leaves	96.56	1st
Chayote mature leaves	92.66	2nd
Chayote fruit	86.94	3rd

Means with the same letter superscript are not significantly different (P<0.05) by DMRT

differences in relative palatability of rabbits fed different forages is not known, and could not be explained by this study. This is because palatability is a complex phenomenon determined by dietary type and environmental variables (Molyneux and Ralph, 1992 as cited by Osakwe and Ekwe, 2007).

Acceptability of Test Diets by Rabbits

Table 4 presents the data on feed intake of the experimental diets in daily and total basis. Chayote mature leaves had a mean daily acceptance of 96.23 g within a 30-minute period, followed by chayote fruit at 89.04 g. Young leaves were consumed at a mean of 61.73 g per day. However, treatment differences were found to be non-significant (P<0.05). Thus, the part of chayote as feed had no effect on acceptability by rabbits. Data show that experimental rabbits had the same acceptability of the different parts of chayote. The mean daily feed intake of the fresh test diets by rabbits is 82.33 g

Acceptability Index

The effect of chayote part on relative acceptability index within the allowed foraging time is shown in table 5. Analysis of variance revealed no significant differences among the treatment means. It was observed, however, that test diets had low acceptability

(6.17 - 9.62%) by rabbits within a period of 30 minutes only. This can be due to the very short duration at which the diets were made available to the test animals.

Table 4. Mean feed intake of the test diets by rabbits during the acceptability trial

TREATMENTS	TOTAL FRESH BASIS (g)	DAILY FRESH BASIS (g)
Chayote young leaves	370.40	61.73
Chayote mature leaves	577.40	96.23
Chayote fruit	534.20	89.04

Means with the same letter superscript are not significantly different (P<0.05) by DMRT.

Table 5. Relative acceptability index and ranking

TREATMENTS	ACCEPTABILITY INDEX, %	ACCEPTABILITY RANKING
Chayote young leaves	6.17	3rd
Chayote mature leaves	9.62	1st
Chayote fruit	8.89	2nd

Means with the same letter superscript are not significantly different (P<0.05) by DMRT.

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The tests on preference and acceptability of chayote fruits and leaves by domestic rabbits were carried out from July to August, 2012 at Upper Tomay, La Trinidad, Benguet. Fresh chayote fruits and leaves with petiole and tendrils were collected within 24 hours. The unpeeled fruits were chopped into four equal parts, while the leaves were offered upon after collecting. The fruits and leaves served as dietary treatments: T_1 = Chayote young leaves including petioles and tendrils; T_2 = Chayote mature leaves including petioles; and T_3 = Chayote mature fruit (unpeeled).

A total of five mature rabbits (3 months old) of the New Zealand White breed were used in the palatability trial which lasted for 10 days and in acceptability trials carried out in two days for each part of chayote. In the palatability trial, the cafeteria-style was used in which rabbits were given a selection of the diets presented in equal amounts simultaneously. Rabbits were offered 1 kg of the test diets in separate containers twice daily at 6:30 AM and 6:00 PM. The location of the containers in the cages was randomized at each feeding to prevent bias due to position.

The same dietary treatments were tested in the acceptability trial involving the same rabbits used in the palatability trial. Only one test diet was offered to the experimental rabbits at a time for a period of 30 minutes. Each rabbit was offered an amount of 1 kg of T1 (Chayote young leaves including petioles and tendrils) at 6:30am for two days. The diet was withdrawn from the animals 30 minutes after this was offered and weighed for leftovers. At this time, the animals were fed with a basal diet of Galinsoga forage for the rest of the day. Another test diet (T2 = Chayote mature leaves including petioles) was

offered in same amount and period of time over two days. The last test diet, (T3 = Chayote fruits), was offered in same amount and period for the last two days of the experiment. Samples of the test diets were dried at 60 °C for 24 hours in a Memmert convection oven for dry matter determination.

Among the parts of chayote used as test diets, young leaves were preferred most by the experimental rabbits. However, chayote fruits and leaves have low acceptability by rabbits.

Conclusions

Relative palatability was affected by the part of chayote as test diet. Young leaves were preferred most by rabbits. Chayote fruits and leaves had no apparent effect on acceptance by rabbits. Thus, the fruits, mature and young leaves including petioles and tendrils can be fed to rabbits.

Recommendations

Fresh chayote fruits, unpeeled and quartered, and the leaves whether mature or young, including petioles and tendrils, are recommended as alternative feed for rabbits. These local resources are especially beneficial during shortage of feed supply. Moreover, this finding has to be confirmed in a feeding trial involving growing and fattening rabbits.

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