



UNIVERSITI PUTRA MALAYSIA

***EFFECTS OF HEAT AND TANNIC ACID TREATMENTS ON CASSAVA
TUBER AS GOAT FEED***

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**EFFECTS OF HEAT AND TANNIC ACID TREATMENTS ON CASSAVA
TUBER AS GOAT FEED**

By

RENUH A/P SELVARAJU

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in
Fulfilment of the Requirements for the Degree of Master of Science**

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DEDICATION

To myself and beloved family members, Dad (Selvaraju), Mom (Chellamal), Brother (Suman), Sister (Usha Thevi) and brother-in-law (Sugumaran). Lastly, to my tolerable buddy, Tharrvina.



Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

EFFECTS OF HEAT AND TANNIC ACID TREATMENTS ON CASSAVA TUBER AS GOAT FEED

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Cassava (*Manihot esculenta Crantz*) tuber, which contains high starch content is a good source of dietary energy for animal production. In ruminants, about 75% of the dietary starch fermented rapidly in the rumen. The objective of this thesis was to develop a combination of tannic acid and heat treatment to protect cassava tuber starch from rapid fermentation to allow more by-pass starch to flow into the small intestine to be hydrolysed to glucose for more efficient use by the animals. In brief, this thesis consisted of two studies: the first, to determine the most effective tannic acid x heat treatment combination which can reduce dry matter degradation; and the second, an *in vivo* trial to test the efficacy of feeding the treated cassava tuber on production, rumen fermentation parameters and nutrient digestibility.

In the first study, a 4 tannic acid levels x two temperatures factorial experiment, giving a total of 8 treatments: T60_C (control), T60_L, T60_M, T60_H (0, 2.5, 5 and 7.5% TA treated at 60°C) and T120_C, T120_L, T120_M, T120_H (0, 2.5, 5 and 7.5% TA treated at 120°C), was used. Degradation characteristics of the treatment samples were tested using *in vitro* gas production and *in sacco* nylon bag techniques. Both procedures showed that cassava tuber treated with T120_H was most effective to reduce its fermentation rate. Thus, T120_H was selected to treat cassava tuber in the follow-up feeding trial. In the feeding trial, 12 male Boer crossbred goats of 7-9 months old were randomly allocated into two dietary groups (control and treated). Goats in the control group was offered mixed diet consisted of 30% roughages and 70% concentrate (containing 30% cassava tuber), while the treated group was offered the same diet except that the cassava tuber was treated with the procedure of T120_H. There were no differences in the average daily gain and feed conversion ratio between the two groups. Dietary treatment did not alter rumen fermentation parameters, except it reduced ($P < 0.05$) acetate production in treated group. The dietary treatments also did not affect rumen microbial population except the goats in the treated group had lower methanogen population ($P < 0.05$). Dry

matter, crude protein and starch digestibility were not affected by dietary treatments; however, the digestible starch intake of the treated group was lower ($P < 0.05$) than the control. This could partly attribute to the binding of tannic acid with the starch to inhibit the total conversion of the starch to the respective reducing sugars during the analytical procedure in determining the starch content of diets.

It is concluded that treating cassava tuber with 7.5% tannic acid at 120°C significantly reduced degradation rate as evident by the 23% reduction in the effective degradation rate (ED, $k=0.05$) of cassava tuber in the *in sacco* study. The feeding of the treated cassava tuber did not improve growth performance in goats and the estimated digestible starch intake of goats in the treated group was drastically lower than that in the control group. The reason behind the lower digestible starch intake needs further investigation.



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KESAN HABA DAN ASID TANIK KE ATAS UBI KAYU YANG DIGUNAKAN SEBAGAI MAKANAN KAMBING

Oleh

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Ubi kayu (*Manihot esculenta Crantz*), mempunyai kandungan kanji yang tinggi merupakan sumber tenaga makanan bagi produksi haiwan. Dalam ruminan, sebanyak 75% kanji pemakanan berfermentasi cepat di dalam rumen. Objektif tesis ini adalah untuk menghasilkan gabungan asid tanik dan rawatan haba untuk melindungi kanji ubi kayu daripada fermentasi yang cepat untuk membolehkan lebih kanji pintas mengalir ke dalam usus kecil untuk dihidrolisis ke glukosa untuk lebih cekap digunakan oleh haiwan. Secara ringkas, tesis ini mengandungi dua kajian: pertamanya ialah menentukan gabungan asid tanik x rawatan haba yang paling berkesan yang boleh mengurangkan degradasi bahan kering; dan keduanya ialah percubaan *in vivo* untuk menguji keberkesanan pemakanan ubi kayu yang telah dirawat ke atas produksi, parameter fermentasi rumen, dan kebolehcernaan nutrien.

Dalam kajian pertama, 4 tahap asid tanik x dua suhu eksperimen faktorial, dengan jumlah rawatan adalah 8: T60_C (kawalan), T60_L, T60_M, T60_H (0, 2.5, 5 dan 7.5% TA dirawat pada 60°C) and T120_C, T120_L, T120_M, T120_H (0, 2.5, 5 dan 7.5% TA dirawat pada 120°C) telah digunakan. Ciri degradasi sampel rawatan telah diuji dengan produksi gas *in vitro* dan teknik beg nilon *in sacco*. Kedua-dua prosedur menunjukkan ubi kayu yang telah dirawat dengan T120_H paling berkesan bagi mengurangkan kadar fermentasi. Oleh itu, T120_H telah dipilih untuk merawat ubi kayu dalam percubaan pemakanan yang berikut. Dalam percubaan pemakanan, 12 ekor kambing jantan kacukan Boer berumur 7-9 bulan dibahagikan secara rawak kepada 2 kumpulan pemakanan (kawalan dan rawatan). Kambing dalam kumpulan kawalan telah diberi diet campuran yang terdiri daripada 30% rufaj dan 70% konsentrat (mengandungi 30% ubi kayu), manakala kumpulan rawatan telah diberi diet yang sama kecuali ubi kayu telah dirawat dengan prosedur T120_H. Tiada perbezaan dalam purata harian bertambah dan nisbah penukaran makanan antara kedua-dua kumpulan. Rawatan pemakanan tidak mengubah parameter fermentasi rumen kecuali ia mengurangkan ($P < 0.05$) produksi asetat dalam kumpulan rawatan. Rawatan pemakanan juga tidak menjejaskan populasi

mikrob rumen kecuali kambing dalam kumpulan rawatan mempunya populasi metanogen yang rendah ($P<0.05$). Kebolehcernaan bahan kering, protein kasar dan kanji tidak dijejasi oleh rawatan pemakanan; namun begitu, pengambilan kanji yang boleh dicerna bagi kumpulan rawatan adalah lebih rendah ($P<0.05$) daripada kumpulan kawalan. Ini mungkin sebahagiannya berpunca dengan tambatan asid tanik dengan kanji bagi merencatkan penukaran jumlah kanji ke gula semasa prosedur analisis untuk menentukan kandungan kanji pada diet.

Kesimpulannya merawat ubi kayu dengan 7.5% asid tanik pada 120°C mengurangkan kadar degradasi dengan bukti sebanyak 23% berkurangan dalam kadar keberkesanan degradasi (ED, $k=0.05$) oleh ubi kayu dalam kajian *in sacco*. Pemakanan ubi kayu yang telah dirawat tidak memperbaiki prestasi pertumbuhan dalam kambing dan anggaran pengambilan kanji yang boleh dicerna oleh kambing dalam kumpulan rawatan jauh lebih rendah berbanding kumpulan kawalan. Punca disebalik kekurangan kanji yang boleh dicerna perlu penyelidikan tambahan.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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LIST OF ABBREVIATIONS

%	Percentage
°C	Degrees centigrade
μL	Microliter
A/P	Acetate to propionate ratio
ADG	Average daily gain
BW	Body weight
CH ₄	Methane
Cm	Centimetre
CO ₂	Carbon dioxide
CP	Crude protein
DM	Dry matter
DNA	Deoxyribonucleic acid
FCR	Feed conversion ration
G	Gram
g/day	gram per day
H ₂	Hydrogen
HCN	Hydrocyanic acid
HT	Hydrolysable tannin
Kg	Kilogram
kg/d	Kilogram/day
Mg	Milligram
Min	Minutes
MJ	Mega joules
mL	Millilitre

Mm	Millimetre
NSC	Non-soluble carbohydrates
SAS	Statistical Analysis System
SSL	Self-sufficiency levels
TA	Tannic acid
TMR	Total mix ration
VFA	Volatile fatty acid
Vs	Versus
Mm	Micrometre
DMI	Dry matter intake
h	Hour

CHAPTER 1

INTRODUCTION

High ambient temperature and high humidity remained a major challenge against animal production in the tropical region. In fact, animals exposed to prolonged heat stress is known to experience reduction in feed intake, leading to low nutrient availability for growth and performance. Ruminants are especially vulnerable as the quality and quantity of nutrients arising from rumen fermentation is dependent on feed quality, amount of intake and the rumen environment itself. Therefore, feeding strategies are needed to compensate for the low feed intake under heat stress condition in ruminant animals, and this can be implemented by providing diets which are capable of delivering the essential nutrients to the animal despite the lower feed intake. The aim of this study was to determine the concept of providing part of the required nutrient, specifically dietary energy, in the form of by-pass starch in roughage-based (rice straw) diet to sustain animal growth performance using goats as the animal model.

Agro-industrial by-products such as rice straw can be used as part of ruminant diet. However, they are poorly fermented, and thus only supply limited fermentation products (especially shortage of propionate for gluconeogenesis) to meet the nutrient requirement of the animals. On the other hand, cassava tuber, which can be grown easily in many tropical and subtropical countries, is a valuable energy feed and when digested in the small intestine, capable of providing glucose directly to the animals which otherwise will need to be obtained through gluconeogenesis in the liver. Although, the cassava tuber is able to provide a utilizable energy in form of glucose in the small intestine, the starch from cassava tuber is highly degradable in the rumen, which besides being wasteful in term of efficient use of this feed material, may also lead to rapid decline in rumen pH resulting in metabolic disorders to the animal (Stone, 2004). Therefore, it is of advantage if this starch could be protected and to allow a larger proportion of it to by-pass the rumino-reticulum to escape rumen fermentation and be hydrolyzed in the small intestine (Deckardt *et al.*, 2013). Products of digested starch in the small intestine is readily absorbed and metabolized by the animals.

Thus, different approaches to slow down starch degradation by protect the starch in animal feed have been reported. Martínez *et al.* (2005) reported that tannins, which made up of a group of plant polyphenols, had the tendency to form complexes with macromolecules such as protein and carbohydrates (polysaccharides) which have the potential to impede digestive enzyme (Guzar, 2012; Nascimento *et al.*, 2017). Tannic acid is a hydrolysable tannin which is known to be environmentally secured and safe for food production, and in addition, has natural capability as a rumen modifier to enhance fermentation in ruminant animals (Frutos *et al.*, 2004; Salami *et al.*, 2018). On the other hand, Yu *et al.* (1998) reported that heat treatment by dry-roasting faba bean at 130°C and 150°C was effective to reduce starch degradation and thus enhance by-pass starch to flow into the small intestine. There were studies on tannic acid and also high temperature separately on starch degradation as mentioned above. However, no known study so far reported the combined use of tannins and high temperature to reduce starch degradation on cassava tuber and thus enhance by-pass starch.

This thesis aims to test the above concept with the following hypotheses and objectives:

Hypotheses statements:

- i. Inclusion of the appropriate amount of tannic acid and heat treatment, or the combination, reduces DM and starch degradation of cassava tuber.
- ii. Tannic acid and heat treatment protect starch of cassava tuber from rapid fermentation, allowing more by-pass starch for enzymatic digestion in the small intestine to produce glucose to sustain animal growth performance.

Objectives

The overall objective of this study was to apply combination of tannic acid and heat treatment to enhance by-pass starch in cassava tuber to sustain high growth in goats; and the specific objectives were:

- i. to determine the optimal tannic acid level and temperature treatment combination to reduce DM and starch degradation rate in cassava tuber using *in vitro* gas production and *in sacco* nylon bag studies.
- ii. to evaluate the efficacy of the treated cassava tuber on rumen fermentation characteristics, nutrient digestibility and animal performance in goats as animal model.

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