



UNIVERSITI PUTRA MALAYSIA

**TOWARDS NUTRIENT CYCLING IN AN INTEGRATED
CATTLE-CASSAVA FODDER FARMING SYSTEM**

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By

CHE MINH TUNG

**Thesis Submitted in Fulfilment of the Requirement for the
Degree of Master of Science in the Faculty of Agriculture
Universiti Putra Malaysia**

May 2001



DEDICATION

**I dedicate this thesis to My Beloved Mother-Le Thi Ngot
and to Tropical Farmers**



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

**TOWARDS NUTRIENT CYCLING IN AN INTEGRATED
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Chairman: Associate Professor Liang Juan Boo, Ph.D.

Faculty: Agriculture

An initial investigation was undertaken at two commercial cattle farms (Kuang and Banting) prior to the actual experimentation of this thesis to elucidate the potential of environmental pollution from the unprocessed slurries of semi-intensive cattle production units, which were washed into the nearby waterways. The biological oxygen demand (BOD) and chemical oxygen demand (COD) of wastewater from the above farms were 5,560 and 19,492 mg/L and 4,703 and 13,280 mg/L, respectively. These values are well above the national permissible standards of 50 mg/L BOD and 100 mg/L COD for wastewater discharged from livestock farms.

Based on the above findings, experiments were conducted with the aim to reduce the impact of cattle manure on the environment. The first experiment was conducted to identify local cassava varieties, namely MM 92 (MM), Black Twig (BT) and Medan (MD) which were of high yielding and capable of extracting large



quantities of nutrients from the soil fertilized with livestock manure. Dry fodder yields of MM, BT and MD over the 8 harvests amounted to 8.6, 8.0 and 6.2 t/ha, respectively. They produced 2.2, 1.9 and 1.5 t/ha of crude protein (CP), respectively. The plant mortality rates were 9.9, 14.0 and 14.0% for MM, BT and MD, respectively. The results suggest that agronomically, MM is the most suitable variety.

The second experiment consisting of two trials was conducted to compare the ruminal and intestinal disappearances of cassava fodder (CaF) and grain concentrates (GC) in cattle. Three Charolais-Kedah Kelantan heifers weighing 300 kg, and each fitted permanently with ruminal and duodenal cannulae were used. The cattle were given a basal diet consisting of 70% oil palm frond (OPF), 15% GC and 15% CaF at 1.5% DM (dry matter) of their body weight. The DM effective degradability of CaF and GC was similar at the outflow whilst the CP effective degradability of CaF was higher than that of GC. Cassava fodder containing more than 20% CP was a good protein supplement for ruminants. Both CaF and GC could serve as a source of readily available N for synthesis of rumen microbial protein. Intestinal DM and CP disappearances of GC were much higher than those of CaF, implying that GC provided a higher proportion of digestible bypass nutrients than CaF.

The third experiment was conducted to determine the effects of substitution of GC with CaF in yearling cattle fed OPF-based diets. Three Brahman x Kedah-Kelantan males with an initial liveweight of 124 kg were randomly assigned to three treatments in a 3 x 3 Latin Square experiment. The diets were: A (70% OPF



plus 30% GC), B (70% OPF plus 15% GC plus 15% CaF) and C (70% OPF plus 30% CaF). The average daily gain (ADG) of animals fed diets A and B was not significantly different (413 and 373 g, respectively), but was higher than that of treatment C (278 g). The ADG of the animals was reflected by their nitrogen utilization where nitrogen retention of treatment C was significantly lower than those of treatments A and B. These results suggest that CaF can substitute GC up to 50% in an OPF-based diet for cattle.

Based on the nutrient contents (N, P and K) of manure excreted by the cattle in the fourth experiment (Chapter VII), the calculations show that one hectare of land grown with cassava plants can sustain 16 heads of cattle of 306 kg liveweight when they are fed a ration of 30% CaF and 70% OPF.



Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

**KEARAH KITARAN NUTRIEN DI DALAM SATU SISTEM
PERLADANGAN INTEGRASI LEMBU-FODER UBI KAYU**

Oleh

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Mei 2001

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Satu siasatan awal telah dijalankan di dua ladang lembu komersil (Kuang and Banting) sebelum penyelidikan sebenar untuk tesis ini untuk menentukan potensi pencemaran alam sekitar daripada najis yang tidak terproses yang dibuang ke dalam saliran berdekatan dengan unit pengeluaran lembu semi-intensif. Nilai permintaan oksigen biologi (BOD) dan permintaan oksigen kimia (COD) bagi air buangan dari kedua-dua ladang tersebut masing-masing sebanyak 5,560 dan 19,492 mg/L serta 4,703 dan 13,280 mg/L. (Nilai ini melebihi piawan nasional yang dibenarkan, iaitu 50 mg/L BOD dan 100 mg/L COD, bagi air buangan dari ladang penternakan).

Berdasarkan penemuan tersebut diatas, eksperimen telah dijalankan bertujuan untuk mengurangkan impak najis lembu keatas alam sekitar. Eksperimen pertama telah dijalankan untuk mengenalpasti varieti-varieti ubi kayu tempatan iaitu MM 92 (MM), Black Twig (BT) dan Medan (MD) yang merupakan varieti-



varieti yang mengeluarkan hasil yang tinggi serta berupaya mengekstrakkan kuantiti nutrien dengan banyak daripada tanah yang telah dibaja dengan najis haiwan. Hasil foder kering daripada MM, BT dan MD daripada 8 kali tuaian masing-masing berjumlah 8.6, 8.0 dan 6.2 t/ha. Bahan ini masing-masing mengandungi sebanyak 2.2, 1.9 dan 1.5 t/ha protein kasar (CP). Kadar kematian pokok masing-masing ialah 9.9, 14.0 dan 14.0% bagi MM, BT dan MD. Dari segi agronomi, keputusan menunjukkan MM adalah varieti yang paling sesuai.

Eksperimen kedua yang merangkumi dua kajian telah dilakukan untuk membandingkan kehilangan foder ubi kayu (CaF) dan konsentrat bijian (GC) lembu. Tiga ekor lembu dara Charolais-Kedah Kelantan seberat 300 kg yang dipasangkan secara kekal dengan kanula rumen dan duodenum telah digunakan. Lembu tersebut diberi rangsum makanan asas yang mengandungi 70% OPF (pelepah kelapa sawit), 15% GC dan 15% CaF berdasarkan 1.5% DM (bahan kering) daripada berat badan. CaF yang mengandungi lebih daripada 20% CP merupakan sumber tambahan protein yang baik untuk ruminan. Keupayaan degradasi DM yang berkesan bagi CaF dan GC didapati sama pada kadar aliran keluar 5% dan 8%/jam, manakala keupayaan degradasi CP yang berkesan bagi CaF didapati lebih tinggi daripada GC. Kedua-dua CaF dan GC boleh menjadi sumber N yang tersedia untuk sintesis protein microbial di dalam rumen. Kehilangan DM dan CP dalam usus bagi GC didapati lebih tinggi dibandingkan dengan CaF; ini menunjukkan GC dapat memberikan lebih nutrien pintasan mudah cerna daripada CaF.

Eksperimen ketiga telah dilaksanakan untuk menentukan kesan penggantian GC dengan CaF dalam rangsum makanan berasaskan OPF untuk anak lembu berusia setahun. Tiga ekor lembu jantan Brahman x Kedah-Kelantan dengan berat hidup permulaan 124 kg setiap satu diberi tiga rawatan secara rawak, mengikut rekabentuk eksperimen Segiempat Latin 3 x 3. Tiga jenis rangsum digunakan sebagai rawatan: A (70% OPF campur 30% GC), B (70% OPF campur 15% GC campur 15% CaF) dan C (70% OPF campur 30% CaF). Kadar pertumbuhan lembu (ADG) yang diberi rangsum A dan B tiada perbezaan bermakna dengan masing-masing (413 dan 373 g/ekor/hari), tetapi ia lebih tinggi daripada lembu yang diberi rangsum C (278 g/ekor/hari). Kadar pertumbuhan ini telah digambarkan dengan penggunaan nitrogen oleh lembu tersebut, di mana pembendungan nitrogen oleh rawatan C didapati lebih rendah dibandingkan dengan rawatan A dan B (pembendungan nitrogen kedua-dua rawatan ini tidak berbeza dengan nyata). Keputusan penyelidikan ini menunjukkan bahawa CaF boleh menggantikan GC ke tahap 50% dalam rangsum berasaskan OPF bagi lembu.

Berdasarkan kepada kandungan nutrien (N, P dan K) yang dihasilkan oleh najis lembu di eksperimen keempat (Bab VII) serta kandungannya dalam CaF, adalah dianggarkan pengeluaran sehektar CaF dapat menampung sebanyak 16 ekor lembu dengan berat badan 306 kg yang diberi rangsum 30% CaF dan 70% OPF.



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ABBREVIATIONS

ADG	average daily gain
Anon	anonymous
AOAC	Association of Official Analytical Chemists
APHA	American Public Health Association
APM	animal production/manure
APU	animal population unit
ARC	Agriculture Research Council
ASAE	American Society of Agricultural Engineers
BOD	biological oxygen demand
BT	Black Twig
BW	body weight
C	carbon
CaF	cassava fodder
CaF12	cassava fodder incubated in the rumen for 12 hours
CaF16	cassava fodder incubated in the rumen for 16 hours
CIAT	Centro Internacional de Agricultura Tropical
CO ₂	carbon dioxide
COD	chemical oxygen demand
CP	crude protein
CTs	condensed tannins
d	day



DM	dry matter
DMD	dry matter digestibility
FAO	Food and Agriculture Organization
FCR	feed conversion ratio
FI	feed intake
FN	fecal nitrogen
FYM	farmyard manure
g	gram
GC	grain concentrates
GC12	grain concentrates incubated in the rumen for 12 hours
GC16	grain concentrates incubated in the rumen for 16 hours
h	hour
HCN	hydrogen cyanide
ID	intestinal degradable
<i>in vitro</i>	in animal
K	potassium
kcal	kilo calorie
MARDI	Malaysian Agricultural Research and Development Institute
MD	Medan
MJ	mega joules
MM	MM 92
MP	manure production
N	nitrogen
NI	nitrogen intake
OM	organic matter

OMD	organic matter digestibility
OPF	oil palm (<i>Elaeis guineensis</i>) frond
P	phosphorus
ppm	part per million
RD	ruminal degradable
s	second
SAS	Statistical Analysis System
SEM	standard error of mean
t	ton
TDM	total dry matter
TTS	total solid
TVS	total volatile solid
TWF	total wet feces
UD	undegradable
UN	urinary nitrogen
W	weight
$W^{0.75}$	metabolic body weight



CHAPTER I

INTRODUCTION

In tropical countries, quality forage for livestock feeding is often in short supply either due to climatic or demographic reasons; the latter particularly being the case in South East Asia (FAO, 1997). It has been shown that feedstuffs used in Malaysia for feeding ruminants were mainly based on natural vegetation, pastures, crop residues and other agro-industrial by-products (Soon and Yuen, 1991 and Alimon, 1993). Due to lack of high quality feed sources, animal performance is often low and thus self-sufficiency of the country in red meat and milk is still estimated to be low by the year 2010 (Mohd Nordin, 2000).

As the world's human population grows, the need for food production also increases. It was estimated that there will be a surge in demand for meat from present levels of 206 million tons to 275-310 million tons or more per year by 2020. This demand is particularly large and expected to triple in Asia and Africa (Haan *et al.*, 1997). In recent years livestock farms have become more specialized and dependent on purchased feeds to sustain the high levels of animal production, needed to meet the increasing requirements for animal products.

Despite providing large amounts of meat, milk and eggs, intensive livestock production units are facing with the associated feed cost and resources. Projections of the effect of global trade reforms show that prices of cereal will increase greater than milk and meat (Alexandratos, 1995). Research efforts are therefore needed to formulate low cost feedstuffs by using agro-industrial by-

products. Numerous studies have been done to assess the use of agricultural by-products such as sugarcane tops, cashew apple waste, rice straw and oil palm frond (Mahmudul, 1998 and Khang, 1999) as ruminant feed. In addition, a major problem in most intensive livestock production units is waste disposal. The issue is not only the cost of processing the waste materials, but the potential pollution caused by animal density exceeding the available land area for waste disposal. Accumulation of wastes, the cost of their disposal and the risk of pollution of the environment are serious consequences of the intensification of livestock enterprises. In contrast to this situation, the wastes from crop and livestock production in a mixed farming system are valuable sources of nutrients that can be used for crop growing.

Resource use in mixed farming is often interdependent as nutrient flow from crops to livestock, and back. Preston and Leng (1987) pointed out that the integration of livestock with crop production was a mean of establishing sustainable farming systems aiming at optimizing resource use. Integrated farming systems make more efficient use of native pastures, crop residues and fibrous agro-industrial by-products by ruminants. However, these feed resources do not always contain a balance of nutrients, in particularly N needed to support high animal productivity. The supplements needed to balance these feed resources for ruminants can be obtained from the growing protein supplements on the farm. Cassava leaves and other foliage legumes, for instance, are potential crops that supply fermentable N, other nutrients for the rumen microbes, readily fermentable cellulose and bypass protein. Moreover, these crops adapted well in the tropics