



**UNIVERSITI PUTRA MALAYSIA**

***GROWTH PERFORMANCE, NUTRIENT DIGESTIBILITY AND SERUM  
GROWTH HORMONE LEVEL OF CROSSBRED BOER GOATS FED  
WITH OUTDOOR-GROWN HYDROPONIC MAIZE FODDER***

**LIM WHAY CHUIN**

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By

**LIM WHAY CHUIN**

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

**June 2021**

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

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**June 2021**

**Chair : Mohd Noor Hisham Bin Mohd Nadzir, PhD**  
**Faculty : Science**

In recent years, the Boer goats have been imported in large numbers into Malaysia to fulfill the local market demand. Crossbred Boer goats were well-known for their rapid growth, excellent meat quality, good adaptation, kidding percentage, and non-seasonal fertility. Hydroponics plays a significant role as an alternative fodder supply and helps in efficient livestock production. A preliminary study was conducted to identify the nutritive value of hydroponically sprouted maize fodder from two varieties of maize grains (popcorn and feed corn). Using completely randomised design (CRD) with three replications was used in which popcorn was irrigated with clean tap water (P1) and nutrient solution (P2); feed corn irrigated with clean tap water (P3) and nutrient solution (P4). After 24 hours of germination in wet cloths, sprouted maize grains were spread at a rate of 1 kilogram per tray with 1 – 1.5 cm layer thickness. Seven-days green fodders were sampled for chemical analysis. The total yield of 1.5 kg hydroponic maize fodder per kg feed corn was recorded lower than popcorn (2.5 kg per kg grains) per 7-day growth periods along with 20 - 21 cm height. The crude protein content was the highest at  $7.48 \pm 0.01\%$  in P4 compared to popcorn ( $P < 0.05$ ) and P3 ( $P > 0.05$ ). Treatment 3 showed the highest dry matter content as  $94.42 \pm 0.13\%$  ( $P > 0.05$ ) and organic matter content observed as  $98.29 \pm 0.13\%$  especially compared with P1 ( $P < 0.05$ ). The neutral detergent fibre (NDF) and acid detergent fibre (ADF) contents of feed corn were insignificantly different, but P3 was observed as  $67.66 \pm 0.05\%$  and  $41.55 \pm 0.04\%$ , respectively, which were higher than P1 ( $P < 0.05$ ). Although feed corn had better nutritional value than popcorn, popcorn showed a higher germination rate for the 7-day germination period, which was 7% higher than feed corn ( $84.3 \pm 0.88\%$ ) ( $P < 0.05$ ). Germination of 1 kg popcorn would produce approximately 2.5 kg of fresh fodder (P1 and P2) compared to 1 kg of feed corn that produced about 1.5 kg sprouts (P3 and P4). The use of the nutrient

solution for hydroponics fodder production is not mandatory since there is no notable difference in plant height compared with those irrigated with clean tap water throughout the 7-day growth periods. Thus, popcorn with a higher conversion ratio and the germination rate was used in the study to investigate the effects of feeding outdoor-grown hydroponics maize fodder (HMF) on growth performance, nutrient digestibility, and serum growth hormone level in goats. A total of fifteen male crossbred Boer goats of  $5.87 \pm 2.16$  months old with an initial body weight of  $17.3 \pm 0.88$  kg were allocated in a completely randomised design (CRD) to three treatments ( $n=5$ ). The animals in group T1 (control) were fed 500g commercial concentrate and Napier grass; T2, the animals were fed with 500g commercial concentrate and HMF, while T3 had solely fed with HMF. The study was conducted at a breeding farm in Lendu, Melaka, for 13 weeks after a 2-week adaptation period. The results showed that HMF had a better feed nutritive composition with a lower concentration of highly indigestible fibre ( $P < 0.05$ ) and a higher concentration of crude protein (CP), about  $12.28 \pm 0.25\%$  compared to CP in Napier grass ( $7.22 \pm 0.09\%$ ) ( $P < 0.05$ ). Dietary treatments had significant effects ( $P < 0.05$ ) on the goats' weight gain, feed intake, and feed conversion ratio. Goats in groups T1 and T2 fed with commercial concentrate had higher body weight gain with an average daily gain (ADG) of  $79 \pm 0.12$  g/day and  $48 \pm 0.01$  g/day compared to goats in group T3 ( $44 \pm 0.01$  g/day) ( $P < 0.05$ ). Feed intake was the highest ( $P < 0.05$ ) in goats in group T3 due to the sole feeding of HMF, while the lowest intake was in animals 500g commercial concentrate and HMF (T2). Feed conversion ratio (FCR) was improved ( $P < 0.05$ ) in T1 and T2 goats,  $14.93 \pm 2.18$  and  $16.62 \pm 2.92$ , respectively. Goats in groups T1 and T2 showed significantly higher dry matter digestibility ( $69.27 \pm 0.95\%$  and  $63.95 \pm 2.07\%$ , respectively) and crude protein digestibility ( $71.89 \pm 0.20\%$  and  $72.28 \pm 0.10\%$ , respectively) compared to group T3. The correlation coefficients between the final live weight with height at withers, body length, and chest girth were positive ( $P < 0.01$ ). Generally, the feeding of hydroponic maize fodder in Treatment 2 and Treatment 3 showed a high concentration of growth hormone during Week 1 ( $P < 0.05$ ) and Week 11 ( $P > 0.05$ ) of feeding treatment, respectively. Sole feeding of HMF exerted a minor impact on growth performance in the animals. However, the HMF could potentially replace the conventionally planted sprouts in conjunction with commercial concentrate to improve the growth performance of the small ruminants.

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

**PERTUMBUHAN, ANGGARAN PENGHADAMAN DAN TAHAP HORMON  
PERTUMBUHAN DALAM SERUM KAMBING KACUKAN BOER YANG  
DIBERIKAN MAKANAN JAGUNG HIDROPONIK  
YANG DITANAM SECARA TERBUKA**

Oleh

**LIM WHAY CHUIN**

Jun 2021

**Pengerusi : Mohd Noor Hisham Bin Mohd Nadzir, PhD**  
**Fakulti : Sains**

Dalam beberapa tahun kebelakangan ini, kambing Boer telah diimport dalam jumlah besar ke Malaysia untuk memenuhi permintaan pasaran tempatan. Kambing kacukan Boer terkenal dengan pertumbuhan cepat, daging yang berkualiti tinggi, dan penyesuaian yang baik. Hidroponik berperanan penting sebagai makanan alternatif dan membantu pengeluaran ternakan yang cekap. Satu kajian awal dilakukan untuk mengenal pasti nilai nutrien makanan jagung yang ditanam secara hidroponik dari dua jenis bijirin jagung (*popcorn* dan jagung makanan). Dengan menggunakan reka bentuk eksperimen secara rawak ( $n=3$ ), bijirin *popcorn* disiram dengan air paip bersih (P1) dan larutan nutrien (P2); bijirin jagung makanan yang disiram dengan air paip bersih (P3) dan larutan nutrien (P4). Setelah percambahan 24 jam di bawah kain basah, bijirin jagung ditaburkan dengan kadar 1 kilogram per dulang dengan ketebalan lapisan 1 - 1.5 cm. Pada hari pertumbuhan ketujuh, sampel tumbuhan hijau akan dikumpul untuk analisis komposisi. Jisim basah tumbuhan hidroponik sebanyak 1.5 kg per kg bijirin jagung makanan dicatatkan iaitu lebih rendah daripada *popcorn* (2.5 kg per kg bijirin) dengan ketinggian sebanyak 20 - 21 cm. Kandungan protein kasar adalah tertinggi pada P4 dengan  $7.48 \pm 0.01\%$  berbanding *popcorn* ( $P<0.05$ ) dan P3 ( $P> 0.05$ ). Tumbuhan P3 menunjukkan kandungan bahan kering tertinggi adalah  $94.42 \pm 0.13\%$  ( $P>0.05$ ) dan kandungan bahan organik diperhatikan sebanyak  $98.29 \pm 0.13\%$  terutamanya berbanding dengan P1 ( $P<0.05$ ). Kandungan serat pencuci neutral (NDF) dan serat pencuci asid (ADF) jagung makanan tidak menunjukkan perbezaan yang signifikan, tetapi rawatan P3 mencatat  $67.66 \pm 0.05\%$  NDF dan  $41.55 \pm 0.04\%$  ADF yang lebih tinggi daripada P1 ( $P<0.05$ ). Walaupun jagung makanan mempunyai nilai pemakanan yang lebih baik, *popcorn* menunjukkan kadar percambahan yang lebih tinggi untuk tempoh percambahan 7 hari iaitu

7% lebih tinggi daripada jagung makanan ( $84.3 \pm 0.88\%$ ) ( $P < 0.05$ ). Percambahan 1 kg popcorn akan menghasilkan kira-kira 2.5 kg makanan segar (P1 dan P2) berbanding 1 kg jagung makanan yang menghasilkan kira-kira 1.5 kg makanan segar (P3 dan P4). Penggunaan larutan nutrien untuk pengeluaran makanan hidroponik bukan wajib diguna kerana tidak menunjukkan perbezaan yang tinggi dalam ketinggian tanaman berbanding dengan penyiraman dengan air paip bersih sepanjang tempoh pertumbuhan 7 hari. Oleh itu, popcorn dengan nisbah penukaran makanan dan kadar percambahan digunakan yang lebih tinggi dalam kajian untuk menentukan kesan makanan jagung hidroponik (HMF) yang ditanam secara terbuka terhadap pertumbuhan, anggaran penghadaman dan tahap hormon pertumbuhan dalam serum kambing. Dengan menggunakan reka bentuk eksperimen secara rawak, lima belas ekor kambing jantan berumur  $5.87 \pm 2.16$  bulan dengan berat badan awal  $17.3 \pm 0.88$  kg dibahagikan kepada tiga kumpulan rawatan ( $n = 5$ ). Kambing T1 (Kawalan) diberikan makanan 500g konsentrat komersil dan rumput Napier; kambing T2 diberikan makanan 500g konsentrat komersil dan HMF dan diet kambing T3 adalah HMF. Kajian ini dilaksanakan di ladang penternakan yang terletak di Lendu, Melaka selama 13 minggu selepas menjalani tempoh adaptasi selama 2 minggu. Hasil kajian menunjukkan bahawa HMF mempunyai komposisi nutrien makanan yang lebih berkualiti iaitu kepekatan serat yang tidak dapat dicernakan adalah rendah ( $P < 0.05$ ) dan kepekatan protein kasar (CP) iaitu  $12.28 \pm 0.25\%$  yang lebih tinggi berbanding dengan CP rumput Napier ( $7.22 \pm 0.09\%$ ) ( $P < 0.05$ ). Rawatan makanan mempunyai kesan yang signifikan ( $P < 0.05$ ) terhadap kenaikan berat badan, pengambilan makanan, dan nisbah penukaran makanan kambing. Kambing T1 dan T2 yang diberikan konsentrat komersil menunjukkan kenaikan berat badan yang lebih tinggi dengan purata kenaikan berat badan harian (ADG) sebanyak  $79 \pm 0.12$  g/hari and  $48 \pm 0.01$  g/hari apabila dibandingkan dengan kambing T3 ( $44 \pm 0.01$  g/day) ( $P < 0.05$ ). Pengambilan makanan adalah paling tinggi ( $P < 0.05$ ) bagi kambing T3 disebabkan makanan terdiri daripada HMF sahaja di mana kambing T2 yang diberikan 500g konsentrat komersil dan HMF menunjukkan pengambilan makan terendah. Nisbah penukaran makanan (FCR) T1 dan T2 lebih rendah daripada T3 iaitu  $14.93 \pm 2.18$  dan  $16.62 \pm 2.92$  ( $P < 0.05$ ). Kambing T1 dan T2 menunjukkan anggaran penghadaman bahan kering ( $69.27 \pm 0.95\%$  dan  $63.95 \pm 2.07\%$ ) dan anggaran penghadaman protein kasar ( $71.89 \pm 0.20\%$  dan  $72.28 \pm 0.10\%$ ) yang lebih tinggi daripada kambing T3 secara signifikan ( $P < 0.05$ ). Pekali korelasi antara berat badan akhir dengan ketinggian badan, panjang badan dan lilitan dada adalah positif ( $P < 0.01$ ). Kambing T2 dan T3 yang melibatkan makanan HMF menunjukkan tahap hormon pertumbuhan yang tinggi pada minggu pertama ( $P < 0.05$ ) dan minggu ke-11 ( $P > 0.05$ ) masing-masing. Pemakanan tunggal HMF memberi kesan kecil terhadap prestasi pertumbuhan haiwan. Walau bagaimanapun, HMF berpotensi menggantikan makanan yang ditanam secara konvensional bersama-sama dengan konsentrat komersil untuk meningkatkan prestasi pertumbuhan ruminan kecil.

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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

ANOVA	Analysis of variance
ADF	Acid detergent fibre
ADL	Acid detergent lignin
CP	Crude protein
CRD	Completely Randomised Design
DM	Dry matter
DMI	Dry matter intake
ELISA	Enzyme-linked immunosorbent assay
HMF	Hydroponic maize fodder
ITAFoS	Institute of Tropical Agriculture and Food Security
LW	Live weight
NDF	Neutral detergent fibre
OM	Organic matter
SPSS	Statistical Package for Social Sciences
%	Percentage
ft	Feet
g	Gram
g	Relative centrifugal force
kg	Kilogram

# CHAPTER 1

## INTRODUCTION

### 1.1 Background of Study

Goats are one of the earliest domesticated livestock and goat meat is widely consumed all over the world. Based on Selected Agricultural Indicators (Department of Statistics Malaysia, 2020) in Malaysia, mutton production decreased by 2.3% to 4.3 million tonnes in 2019. However, the domestic self-sufficiency level was at 12.1% in 2019, showing a 0.6% increment compared with an 11.5% self-sufficiency level in 2015. The mutton consumption indicates the most significant increment compared to other red meat such as beef that recorded an increase of 8.06% in per capita consumption; pork decreased by 3.14% (based on consuming population of 40% non-Muslim) from 2012 to 2018 (Department of Veterinary Services [DVS], 2018). There is a high likelihood that the increasing pattern of imported mutton will remain because of the increasing population and growing affluence.

Increased population growth accompanied by urbanisation and growing affluence is likely to increase Malaysia's demand for better quality animal protein. There is a widely-held misconception that goat meat is high in cholesterol and saturated fats (Kaur, 2010). A study by Baharuddin and Abdullah (2015) revealed that the mutton (sheep meat) showed significantly higher fat content as compared to chevon (goat meat). Chevon has been documented to be lower in calories, total fat, saturated fat, and cholesterol than other traditional red meats (Casey, 1992; Sial et al., 2021). In this respect, goat meat could be a healthier alternative animal-based protein source for red meat consumption. In addition, there are no religious taboos attached to goat meat as compared to beef or pork; thus, it becomes favoured by all ethnic groups in Malaysia.

The breed is an essential factor in carcass quality, as it is closely related to the fat deposition's amount and location in goat meat. The Boer goat and its crosses stored more subcutaneous and intermuscular fat deposition than the other breeds, resulting in better eating quality (Dhanda et al., 2003; Ding et al., 2010). Goats deposit fat in a favoured order, and carcass fat levels become noticeable when goats are close to or at their mature body weight (Simela et al., 2008; Webb et al., 2005). Although Mahgoub et al. (2004) showed that gender could influence the growth of body tissues and carcass composition of animals, goats breed and nutritional status had a more significant impact on fat deposition than the gender (Webb et al., 2005). Animals should be given sufficient nutrients based on their sex, age, breed, types of production (dairy or meat), body size, physiological stages, and climate (Rashid, 2008). Poor

nutrition is mostly to blame for the slow growth rate (Gbangboche et al., 2006). In the present study, male crossbred Boer goats were used to prevent the mix-up faeces with urine while the faecal samples were collected with gloved hands.

In Malaysia, fodder is currently being utilized as a significant component in the ruminant diet. Consistency in the quality and production of high-quality fodder is fundamental for a successful animal production system. Various types of fodder have been fed to ruminants, particularly from the plant family Gramineae (grasses) and Fabaceae (legumes) like Napier grass (*Pennisetum purpureum* Schumacher), a perennial tropical grass in the Poaceae family and is currently the most used fodder in both dairy and feedlot production in livestock management (Halim et al., 2013). It is the most prevalent forage species due to its high nutritive value and is quickly established through stem propagation (Wijitphan et al., 2009). It is mainly used in the cut-and-carry system (Food and Agriculture Organization [FAO], 2015). However, this feeding method is labour-intensive, which requires sowing, earthing up, fertilizing, weeding, and harvesting. Furthermore, the yield and quality of Napier grass can be affected by cultivar selection (Halim et al., 2013), type and rate of fertilizer (Fauzi & Soetanto, 2020; Jusoh, 2005), plant density (Mukhtar et al., 2003), and lastly the cutting management such as cutting frequency (Mukhtar et al., 2003) cutting intervals (Bayble et al., 2007; Jusoh et al., 2014) and cutting height (Wijitphan et al., 2009).

The majority of livestock farmers in Malaysia are smallholders prone to providing low quality and quantity of feed, which unavoidably leads to low productivity. There is less concern for nutritional management due to limited time, cost constraints, and labour issues (Ghani et al., 2017). The challenges faced by smallholder farmers include the reduced pasture area and unavailability of land for fodder cultivation, forcing them to rely more on concentrates than roughage, which increases production cost (Hashim, 2015; Malhi et al., 2020; Rahman et al., 2014). Wong and Chen (2006) reported that about 59% of the farmers are landless for livestock activities and, 17% own less than 1 hectare. Due to the small land holding size, they cut natural forages growing on the roadside or in paddy fields, or their goats are free-ranged to graze on native grasses and shrubs either on abandoned agricultural land, under permanent tree crops, or in the plantations where they work contributes to a poor feeding regime. A proper feeding regime is importantly provided and implemented for the requirement of goats to support optimal farm production and be economical (Martínez-Marín et al., 2012).

Recently, automated and mechanized intensive production systems such as hydroponics technology were introduced as future alternative growing fodder for livestock (Naik et al., 2013). The hydroponic technology embodies the concept of "owner-operator," which means a smallholder who typically runs the farm's day-to-day operations. Hence, much research has implemented the suggestion of growing different fodder crops through hydroponic technology, including barley (Fazaeli et al., 2011; Fazaeli et al., 2012; Reddy et al., 1988);

oats, wheat (Kantale et al., 2017; Snow et al., 2008); sorghum, alfalfa, cowpea (Al-Karaki & Al-Hashimi, 2012) and maize (Naik et al., 2011; Naik et al., 2012). This system has been highlighted as a cost-effective method due to its ability to increase fodder production with minimal land or space, water, and labour (Al-Karaki & Al-Hashimi, 2012; Kide et al., 2015; Naik et al., 2015). High digestibility and crude protein contents make hydroponic fodder suitable for ruminants (Naik et al., 2014). In Malaysia, a commercial hydroponic fodder system hailed as “landless fodder production” was introduced by a foreign company. The system's performance was conducted at Universiti Putra Malaysia (UPM) in 1996 to produce feed for animals that required high energy feed, such as horses and ruminants (Abdullah, 2001). The barley grass was hydroponically germinated and grown in this imported environmentally controlled cabin.

## **1.2 Problem Statement and Justification of Study**

As mentioned earlier, most smallholder goat farms practise improper feeding regimes due to poor knowledge and information, resulting in lower growth and reproductive performance of the goats, feed consumption, and production (Ghani et al., 2017). Moreover, the consumption of mutton in Malaysia substantially increased (DVS, 2018). Nevertheless, the reports on the effect of hydroponic fodder on the growth performance and growth hormone profile of goats, particularly in Malaysia, are scarce. Reviews have shown that hydroponic fodder is alternative to green fodder for animals (Chrisdiana, 2018; Kammar et al., 2019; Mohapatra et al., 2019; Raghavendran et al., 2020). However, developing low-cost devices for hydroponic fodder production using locally accessible materials on different livestock categories requires more focus.

Meanwhile, the commercial marketability of the imported system is aimed primarily at high-value animals, such as equine and livestock producing high-value products such as dairy cows, milk goats, deer, and ostriches (Agius et al., 2019; Francis et al., 2018; Naik et al., 2014; Naik et al., 2015; Verma et al., 2015; Wong & Chen, 2006; Wootton-Beard, 2019), resulting in limited literature published that solely addressed hydroponic fodder for goat.

### **1.3 Objectives**

This study aims to develop a low-cost device for hydroponic fodder, which plays the role of a new goat feeding system in achieving successful and profitable goat farming. The main objectives of this study are:

- i. To identify the chemical composition of hydroponically sprouted maize fodder from two varieties of maize grains (popcorn and feed corn).
- ii. To compare the nutritional composition of Napier grass and hydroponic maize fodder (HMF).
- iii. To determine the feed intake, nutrient digestibility, and growth performance among treatment groups (T1, T2, and T3) using Completely Randomised Design (CRD).
- iv. To compare the serum growth hormone (GH) among treatment groups (T1, T2, and T3) using enzyme-linked immunosorbent assay (ELISA).

### **1.4 Hypothesis of Study**

The general hypothesis tested in the thesis was the effects of hydroponic maize fodder on the feed intake, nutrient digestibility, and growth performance of crossbred Boer goats. This study expected a better understanding of the growth hormone profiles in goats. The outcomes of this study should thus benefit the smallholders of the goat industry by contributing knowledge and future practice on the use of hydroponically grown fodders.

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