UNIVERSITI PUTRA MALAYSIA

MODELLING AND SIMULATION OF MILK PRODUCTION SYSTEM OF DAIRY GOATS IN MALAYSIA

MOHAMMAD NASIR HASSAN

MODELLING AND SIMULATION OF MILK PRODUCTION SYSTEM OF DAIRY GOATS IN MALAYSIA

MOHAMMAD NASIR HASSAN

MASTER OF SCIENCE
UNIVERSITI PUTRA MALAYSIA
1998

MODELLING AND SIMULATION OF MILK PRODUCTION SYSTEM OF DAIRY GOATS IN MALAYSIA

By

MOHAMMAD NASIR HASSAN

Thesis Submitted in Fulfilment of the Requirements for the Degree of Master of Science in Faculty of Veterinary Medicine and Animal Science, Universiti Putra Malaysia

March 1998

ACKNOWLEDGEMENTS

I would like to take this opportunity to express my deepest gratitude and appreciation to Associate Prof. Dr. Dahlan Ismail, the chairman of the supervisory committee and the Project Leader of Multi-species Unit, Universiti Putra Malaysia (UPM) for his invaluable support, assistance, guidance, advices, motivation and financial support throughout this study. My deepest gratitude and appreciation also goes to Associate Prof. Dr. Abd. Razak Alimon, Mr. Osman Awang and Prof. Datuk Dr. Mohd. Mahyuddin Mohd. Dahan, the committee members of the supervisory committee, for their invaluable advices, guidance, assistance and constructive views throughout this study.

Beside that, I would like to express my acknowledgement to the Department of Animal Science, Faculty of Veterinary Medicine and Animal Science, UPM for allowing me to use the facilities for this study. I am also very thankful to IRPA for their grant for this research and UPM for its PASCA-Post Graduate allowance which supported me financially throughout this study.

I would like to express my appreciation to Dr. Abdul Razak Zailan, Officer Incharge of Infoternak Farm, Sungai Siput (U), Perak (Department of Veterinary Services) for granting me his consent to use the animals and facilities at the Infoternak Farm for this study. My appreciation also goes to all the staff of the farm especially Mr. Ravi and all his staff at the Goat Unit for their cooperation and assistance.

Beside that, I wish to extend my gratitude to the Director of Veterinary Research Institute, Ipoh, Dr. Gan Chee Hiong for allowing me to use the laboratory and its facilities in carrying out the nutrition analysis. My appreciation also to Dr. N. Muniandy and his staff of the Biochemical Section for their guidance, cooperation and assistance.

I would also like to thank all the staff and the ex-staff of the Multi-species Unit especially to Nizam, Hazmi, Hassan and Sivam, all the staff of Farm 2 especially to Mr. Islah and also to my fellow friends, Mr. Chaiyawan and Mr. Mahmudul Islam and others for their friendship, advices and assistance.

Finally my deepest gratitude and appreciation to my beloved parents, parents-in- law, my wife and all the family members for their support, prayers and patience.

All of you have made this study possible.

Thank you.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

Abbreviation		Description
BCI	-	Intake of concentrate
BF	-	Butter fat
BFI	-	Intake of forage
BK	-	Bahan kering
BW	-	Body weight
CF	-	Crude fat
DCP	-	Digestible crude protein
DE	-	Digestible energy
DKS	-	Daun kelapa sawit
DM	-	Dry matter
DMD	-	Dry matter digestibility
DMI	-	Dry matter intake
DOM	-	Digestible organic matter
DOMNCF	-	Dry organic matter non crude fat
EL	-	Energy requirement for lactation
ELW	-	Empty live weight
EM	-	Energy in milk
EWG	-	Empty weight gain
F	-	Fat quantity
FCM	-	Fat corrected milk
FI	-	Feed intake
FP	-	Fat percentage
GE	-	Gross energy
LICRO	-	Livestock-tree cropping production system
LW	-	Liveweight
M	-	Milk quantity
MBW	-	Metabolic body weight
ME	-	Metabolizable energy
MEmbw	-	Metabolizable energy requirement for maintenance per metabolic body weight.
MERl	-	Metabolizable energy requirement for lactation
MERm	-	Metabolizable energy requirement for maintenance
MEvi	-	Metabolizable energy in voluntary intake
MJ	-	Megajoule
MW	-	Metabolic weight
MY	-	Milk yield
NE	-	Net energy
NEI	-	Net energy intake
NER	-	Net energy requirement
NERl	-	Net energy requirement for lactation
NFE	-	Nitrogen free extract

NWG	-	Net weight gain
OPBP	-	Oil palm by-product
OPF	-	Oil palm frond
OPFL	-	Oil palm frond leaflet
PF	-	Percentage of forage in diet
PP	-	Protein percentage
SNF	-	Solid non fat
TDM	-	Total dry matter
TDN	-	Total digestible nutrient
TS	-	Total solid
TSCM	-	Total solid corrected milk
UPM	-	Universiti Putra Malaysia
WD	-	Walking distance

Abstract of thesis submitted to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Master of Science

MODELLING AND SIMULATION OF MILK PRODUCTION SYSTEM OF DAIRY GOATS IN MALAYSIA

By

MOHAMMAD NASIR HASSAN

March 1998

Chairman : Associate Professor Dr. Dahlan Ismail

Faculty : Veterinary Medicine and Animal Science

The main purpose of this study was to construct a model for goats' milk production in Malaysia. Apart from that, the research meant to study the effect of several particular factors on milk production in Malaysia. Another objective was to study the dynamic behaviour of lactation curve of goats by modelling approach.

In order to gain the objectives, a few steps of study were taken. The first study was to identify the energy requirement of goats at the maintenance level. The second study aims to identify the content and the production of goats' milk. The next step was constructing a model of milk production system of goats based on reports made by previous researchers and the results obtained from the current studies. To validate the model constructed, validation steps were taken by comparing simulation data to the actual data on milk production system of goats.

The initial study was conducted on 8 non lactating adult Saanen goats which were reared by the intensive system. The goats were fed with oil palm frond leaflet silage mixed with 5 % DM molasses (OPFL) and also concentrate as supplement. The feed offered was adjusted in order to maintain the body weight. Later, an experiment was carried out to identify the digestibility of feed offered by using 6 goats from the same group. The second experiment was conducted on 17 adults, lactating goats reared by intensive system. The goats were also fed with OPFL silage and 33.6 % of DM concentrate (in the diet) as supplement.

The result of the research shows that the dry matter digestibility of feed with 77 % of DM OPFL silage and 23 % of DM concentarate by the Saanen goats was 44.1 % whereas the dry matter intake was 3 % of body weight. The energy requirement for maintenance was 433.3 kJ ME/kg $BW^{0.75}$/day.

The model developed was based on the energy utilization in the body system of goats. There were 4 main parameters considered in the model which influence the energy utilization for milk production. The parameters are feed intake, digestibility of feed, energy requirement for maintenance and energy conversion factor into milk production.

The metabolizable energy consumption of goats can be estimated using the equation, MEvi = FI x DMD x 14.94, where FI is dry matter intake (kg/day), DMD is dry matter digestibility and 14.94 is the metabolizable energy value in feed (MJ/kg DM). The metabolizable energy requirement for maintenance for goats can be estimated using the equation MERm = MEmbw x MBW, where MEmbw is metabolizable energy for maintenance per metabolic body weight (MJ/kg $BW^{0.75}$/day) and MBW is metabolic body weight. For goats in intensive system, MEmbw = 0.4333, however for grazing goats, MEmbw = 0.5416. The lactation curve and milk production can be estimated using the equation, $y = a \times n^b \times e^{(-c \times n)}$, where y is an average daily milk production, n is lactation week, a, b and c are constant. Metabolizable energy requirement for milk production can be estimated using the equation, MERl = 2.78 x MY/(0.463 + 0.1944 x DMD), where 2.78 is milk energy (MJ/kg) and MY is milk production (kg). The dry matter intake can be estimated using the equation, FI = (MEmbw x MBW + 2.78 x MY/(0.463 + 0.1944 x DMD))/(14.94 X DMD). In general, milk production in the Malaysian production system can be represented by the mathematical equation: MY = ((14.94 x FI x DMD - MEmbw x MBW) x (0.463 + 0.1944 x DMD))/ 2.78.

Assesment made on the Malaysian milk production system reveals that the main factors which effect milk production are breed and nutrition. Breeds that are suitable for producing milk in high quantity are dairy breeds which have the ability to adapt themselves with the environment in Malaysia. This study also finds that most of livestock feed sources in Malaysia has low or moderate in nutritive value. As a result, they are not suitable for high milk production. However, some of the sources such as oil palm frond (OPF) can be obtained from agricultural by-products. They are more suitable because the cost is cheaper and they can be obtained in a great quantity. In order to increase milk production, high quantity of concentrate should be given in the livestock feed.

The model constructed is able to helps farmers in planning and managing their farms. It enables farmers to predict feed requirement, milk production and financial requirement for the dairy herds. Indirectly, this will improve the goats milk production in Malaysia.

Abstrak tesis yang dikemukakann kepada Senat Universiti Putra Malaysia, sebagai memenuhi keperluan untuk mendapat Ijazah Master Sains.

MODELING DAN SIMULASI SISTEM PENGELUARAN SUSU UNTUK KAMBING TENUSU DI MALAYSIA

Oleh

MOHAMMAD NASIR HASSAN

March 1998

Pengerusi : Professor Madya Dr. Dahlan Ismail

Fakulti : Kedoktoran Veterinar dan Sains Peternakan

Tujuan utama penyelidikan ini adalah untuk membina model bagi pengeluaran susu kambing di Malaysia. Selain itu penyelidikan ini juga bertujuan untuk mengkaji kesan faktor-faktor tertentu terhadap pengeluaran susu di Malaysia dan mengkaji sifat dinamik bagi keluk pengeluaran susu kambing secara pendekatan permodelan.

Untuk mencapai tujuan tersebut, beberapa langkah kajian telah dilakukan. Kajian pertama ialah untuk mengenalpasti keperluan tenaga pada tahap mentenan oleh kambing. Kajian kedua ialah untuk mengenalpasti kandungan dan kadar pengeluaran susu oleh kambing. Langkah seterusnya ialah membina model bagi sistem pengeluaran susu kambing berdasarkan laporan-laporan oleh penyelidik-penyelidik terdahulu serta keputusan dari kajian yang dilakukan. Untuk mengesahkan model yang telah dibina, langkah validasi telah dilakukan dengan

kaedah simulasi model dan membandingkannya dengan data-data sistem pengeluaran susu kambing dalam suasana sebenar.

Kajian pertama dilakukan dengan menggunakan 8 ekor kambing Saane dewasa yang tidak mengeluarkan susu yang dipelihara secara intensif. Kambing-kambing tersebut di beri makan dengan silaj daun kelapa sawit yang dicampur dengan 5 % berat kering (BK) molases (DKS) dan konsentrat sebagai tambahan. Makanan dikawal untuk mengekalkan berat badannya. Seterusnya suatu eksperimen untuk mengenalpasti kadar penghazaman makanan yang diberikan tersebut dengan menggunakan 6 ekor kambing dari kumpulan tersebut. Eksperimen kedua dilakukan dengan menggunakan 17 ekor kambing dewasa yang mengeluarkan susu yang dipelihara secara intensif. Kambing-kambing tersebut juga diberi makan dengan silaj DKS dan 33.6 % BK konsentrat (dalam diet) sebagai tambahan.

Keputusan dari kajian menunjukkan bahawa kadar penghazaman bahan kering makanan dengan 77 % BK silaj DKS dan 23 % BK konsentrat adalah 44.1 % manakala kadar pengambilan bahan kering adalah 3 % dari berat badan. Keperluan tenaga untuk mentenan adalah 433.3 kJ ME/kg $BW^{0.75}$/hari.

Model yang dibina adalah berasaskan penggunaan tenaga dalam sistem badan kambing. Terdapat 4 perkara utama yang dipertimbangkan di dalam model ini yang mempengaruhi penggunaan tenaga untuk pengeluaran susu. Faktor-faktor tersebut ialah kadar pengambilan makanan, kadar penghazaman makanan, keperluan tenaga untuk mentenan dan faktor konversi tenaga kepada susu.

Pengambilan tenaga metabolisma oleh kambing boleh dianggarkan menggunakan persamaan, $MEvi = FI \times DMD \times 14.94$, di mana FI ialah pengambilan bahan kering (kg/hari), DMD ialah kadar penghazaman bahan kering dan 14.94 ialah nilai tenaga metabolisma di dalam makanan (ME/kg DM). Keperluan tenaga metabolisma untuk mentenan bagi kambing boleh dianggarkan menggunakan persamaan MERm = MEmbw x MBW, dimana MEmbw ialah tenaga metabolisma untuk mentenan per berat badan metabolik (ME/kg $BW^{0.75}$/hari) dan MBW ialah berat badan metabolik. Bagi kambing dalam sistem intensif, MEmbw = 0.4333 manakala dalam sistem meragut, MEmbw = 0.5416. Keluk laktasi dan jumlah pengeluaran susu boleh dianggarkan menggunakan persamaan, $y = a \times n^{b} \times e^{(-c \times n)}$, dimana y adalah purata harian pengeluaran susu, n adalah minggu laktasi, a, b dan c adalah pemalar. Tenaga metabolisma yang diperlukan untuk pengeluaran susu boleh dianggarkan menggunakan persamaan, MERl = 2.78 x MY/(0.463 + 0.1944 x DMD), dimana 2.78 ialah tenaga dalam susu (MJ/kg) dan MY ialah pengeluaran susu (kg). Pengambilan bahan kering boleh dianggarkan menggunakan persamaan, FI = (MEmbw x MBW + 2.78 x MY/(0.463 + 0.1944 x DMD))/(14.94 x DMD). Secara umumnya pengeluaran susu di dalam sistem produksi di Malaysia boleh diwakili oleh persamaan matematik: MY = ((14.94 x FI x DMD - MEmbw x MBW) x (0.463 + 0.1944 x DMD))/ 2.78.

Penilaian yang dilakukan terhadap sistem produksi susu di Malaysia mendapati bahawa faktor-faktor yang utama yang mempengaruhi pengeluaran susu adalah baka kambing dan nutrisi. Baka-baka yang sesuai digunakan untuk pengeluaran susu yang banyak ialah baka-baka kambing tenusu yang boleh mengadaptasi dengan persekitaran iklim di Malaysia. Kajian ini juga mendapati kebanyakan sumber makanan ternakan di Malaysia mempunyai nilai nutrisi yang rendah atau sederhana menyebabkan ianya tidak sesuai untuk pengeluaran susu yang banyak. Walau bagaimanapun sebahagian sumber ini seperti pelepah kelapa sawit

(PKS) boleh didapati dari bahan sampingan pertanian sesuai digunakan kerana harganya yang murah dan boleh didapati dengan jumlah yang banyak. Untuk meningkatkan pengeluaran susu kuantiti konsentrat yang banyak perlu di berikan di dalam makanan ternakan.

Model yang dibina ini boleh membantu petani dalam menbuat perancangan dan menguruskan ladang ternakan mereka. Model ini boleh membantu petani untuk membuat jangkaan keperluan makanan, pengeluaran susu serta keperluan dari segi kewangan bagi ladang tenusu. Secara tidak langsung ini akan meningkatkan industri susu kambing di Malaysia.

CHAPTER I

INTRODUCTION

Goats form one of the most important group of ruminant in both temperate and tropical agriculture. They serve a variety of functions which vary in importance according to the area involved. Goats constitute natural renewable resources, very diverse in terms of genetic potential, distribution, function and productivity. However, there has been a situation of relative neglect as far as research and development are concerned compared to sheep because there are fewer goats than sheep in the world and they (goat) are concentrated in the tropics rather than in temperate zone. The situation is however changing quite rapidly; more attention is now being given both nationally and internationally to increase the contribution of this species. This development is especially significant to the less developed countries mainly in the tropics and subtropics in which 80 % of the world population of goats is found in contrast to 40 to 50 % of sheep (FAO, 1978). In these countries protein deficiency is widespread among the low income groups. The development of the goat industries for the production of food in these areas is therefore a very important objective, since protein rather than energy is often the main deficiency in human nutrition.

The products from the goats are milk, meat, fibre and hides. Milk is considered to be the most important, followed by meat (chevon) with the other user of much less significant (Devendra and Burns, 1970; Shelton, 1978). In temperate countries, goat are considered as dairy animals and milk is their main product. Most of the more productive dairy goat breeds of the world have been derived from European breed. In contrast, in many tropical countries the main product of goat is meat. However, many of the tropical goat breeds are also milked eventually, albeit for short periods or during favourable years only.

One of the main virtues of goats is their dairy potential. Milk yield varies between breeds but most of them are able to produce some milk in addition to the requirements of their kids. Producing milk has the advantage of continuous daily protein supply, while meat from goats is produced at irregular intervals. Moreover meat tends to be prepared for men while milk is more likely to be fed to children, diseased and aged people who happen to be the ones most in need of animal protein.

The main limiting factors to goats production are feed resources, land tenure, diseases, genetic disposition, knowledge and management practices, supporting infrastructure, capital and input to product-price relationship. The order of importance of these constraints may vary (Gall, 1981a). A studies have been done on those aspect in order to solve the problems. This has resulted in improving and increasing goats products especially in milk and meat production in developed countries. However, traditional research methods and procedures have stressed considerably on the analysis phase, breaking down a system into its component or event subcomponents and on the study of these components as individual entities. This has led to lack of understanding of the whole animal production system.

Recently, there has been increasing recognition of the importance of employing the results of analysis to produce combined or integrated views of the whole system (Jeffers, 1974). This was done by a system approach study. A system approach considers a process under study in relation to some defined system and not as an isolated phenomenon (Morley, 1972). A system approach attemps to incorporate in the study all the elements which influence a decision or response or the understanding of some phenomenon within defined boundaries.

Application of system approach on goats production has been carried out in various aspects. A system study has allowed ones to predict the lactation curve and total milk yield of the goats from a few data of the early lactation (Grossman and Koops, 1988a; Gipson and Grossman, 1989; Dahlan et al., 1995). It can also be used to help identify sick animals before clinical signs appear. Thus, it can help farmers to manage their farms more efficiently. Maintenance and production of energy requirement of goats in the farm can also be predicted by energy utilization models derived (Dahlan et al., 1994). This study was conducted in order to get more information on production of goats especially in milk production under Malaysia condition.

The main objectives of this study are:

1. To study the maintenance and lactation requirements of goats in local condition by modelling approach.
2. To study the milk production system of goats in local condition by modelling approach.
3. To establish a model of milk production of goats in local condition.

CHAPTER II

LITERATURE REVIEW

Definition of a System

System refers to a complex set of interrelated components within an autonomous framework (boundary) (Dent and Blackie , 1976). All systems conform to the following general features: 1) A system is fully defined both by a set of identifiable components (entities) and interconnections between them and by the limits to their organisational autonomy (boundary). 2) A system is a hierarchial structure comprising of a number of subsystems, each with autonomous definition. The subsystems in turn embody the next layer of detail. The point of entry into the hierrarchie in any system of study depends on the objectives for which the subsystem is being studied. 3) System is dynamic and the understanding of system requires explicit consideration of time and rates of change. 4) System is sensitive to the environment in which it exists. This environment is usually unpredictable and certainly variable.

System Simulation

Simulation is a technique that involves setting up a model of a real situation (system) and performing experiments on the model. Simulation therefore involves a two phase operation - modelling and experimentation. In simulation, the real system is replaced by an analogous physical experimentation under the context of the real system (Dent and Blackie, 1976).

Simulation technique has a number of specific advantages: 1) It enables the study system, whereby real life experimentation is impossible owing to cost and possible disruption of the real system. 2) By synthesizing system in a model form, it permits the exploration of system that does not exist. 3) It permits the study of long term effects since the model is run according to the time span, stipulated by model builder. 4) It enables objective examination of the system through critical review of knowledge concerning the system.

Modelling Livestock Production System

Models have long been used in the analysis of livestock data. Earlier works by Wright (1934) and Lush (1931) have used models to describe the genetic relationship between individuals by way of path coefficients in closed system. In the development of selection indices aggregate genetic merit of individual animals are defined in terms of performance in selected trait appropriately weighs with relevant economic values (Hazel and Lush, 1943).

Sanders and Cartwright (1979) described a deterministic model for simulating beef cattle production under a wide range management conditions and environments using cattle of different genetic potential for mature size, growth and milk production. Forage and other feed intake was calculated as a function of size and physiological status of the animal and available digestible crude protein of feed. Animal performance was determined from nutrient intake and animal condition. In this model, nutrition has a very important role that limits the potential production of the different genotypes in size, maturing rate, milk production and reproductive performance. The maximum potential production is only realised when the required plane of nutrition is met.

A dynamic model described at the level of the individual animal was developed at Texas A&M University by Blackburn and Cartwright (1987) for sheep. Sheep are classified into breeding ewes and replacements and form the simulated flock. The system is opened with feed resources and environmental influences. They have direct or indirect effects on the output of the system. Available energy and protein supplies are partitioned into the various physiological requirements. Body condition and number of sheep fluctuating depend on the availability of feed resources which usually changes with the weather conditions. The genotype potential of a sheep is described in the model by six primary characteristics: size, maturity, milk, ovulation rate, photoperiod and wool. The potential maturity size is specified from the growth pattern of structural size. Thus, growth of the animal at any age is determined by maturity size and rate.

An application of the system analysed in integration with the Livestock-Tree cropping production systems (LICRO) has been developed by Dahlan (1989).