EFFECTS OF TOTAL MIXED RATION WITH DIFFERENT LEVELS OF Lupinus angustifolius L. ON GROWTH PERFORMANCE AND MEAT QUALITY OF MALE BOER GOATS

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As one of the major critical success factors in goat production, feed cost and its management have been given attention today to improve efficiencies and productivity of goat production. Total mixed ration (TMR) is an effective way of feeding goats by delivering a complete and nutritionally balanced diet for growing goats in intensive production system. Lupin grain (lupin) has high protein and dietary fiber content with minimal starch and glycemic index. Therefore, it has the potential as an alternative feed ingredient for livestock. However, the comparative data on the performances of Boer goat as affected by giving TMR with different level of lupin are still unavailable. Hence, present study was conducted to evaluate the effects of TMR diets with different lupin inclusion on the growth performance, carcass characteristics and meat quality traits of Boer goat. Twenty-four Boer male goats, 8-9-month-old of 27.83 ± 0.52 kg live body weight were allotted randomly into three treatment groups, namely CON, TMR A and TMR B, of eight animals each. Total mixed ration (TMR) feeds were formulated at 0%, 10% and 30% of lupin inclusion for CON, TMR A and TMR B groups, respectively. The TMR feeds were adjusted to be isocaloric (metabolizable energy: 10.3MJ/kg) and isonitrogenous (crude protein: 16.3%). The animals were fed twice (9.30am and 2.30pm) daily *ad libitum* during the 103-day feeding trial. All animals were humanely slaughtered according to the Halal slaughtering procedure at the end of the feeding trial. Present study showed that the total feed intake of TMR B (110.76 ± 3.57 kg) animals were significantly lower ($P<0.05$) than those in CON (135.05 ± 5.04 kg) and TMR A (125.07 ± 3.60 kg) groups. However, the final live weight, weight gained, and feed conversion ratio of the animals were unaffected ($P>0.05$) by the experimental diets. In addition, experimental diets also did not affect ($P>0.05$) the blood chemical content, carcass characteristics and composition of the Boer goats. In this study, the intramuscular fat in the *longissimus dorsi* (LD) muscle of TMR B (13.24 ± 1.28%) was lower ($P<0.05$) than that of CON (21.05 ± 1.49%) and TMR A (19.63 ± 1.53%). There was insignificant difference ($P>0.05$) in the other meat quality traits of the LD muscle among the experimental diets. Meanwhile, the fatty acid composition of LD, *biceps branchii* (BB) and *semitendinosus* (ST) muscles were affected by the experimental diets. In LD muscle, the proportions of

lauric (C12:0), palmitoleic (C16:1) and linolenic (C18:3n-3) acids were significantly affected ($P<0.05$) by the experimental diets. Whilst, the proportion of pentadecanoic acid was significantly lower ($P<0.05$) in CON than that of TMR A in BB muscle. In ST muscle, TMR B had higher ($P<0.05$) proportion of lauric acid than CON, while the proportion of heptadecanoic acid was higher ($P<0.05$) in TMR A than that in TMR B. The total saturated fatty acid (SFA), monounsaturated fatty acid (MUFA) and polyunsaturated fatty acid (PUFA) as well as the PUFA: SFA and n-6: n-3 ratios in all the three skeletal muscles were unaffected ($P>0.05$) by the experimental diets. Present findings demonstrated that feeding TMR diets with the up to 30% inclusion of lupin did not adversely affect the growth performance, carcass characteristics and meat quality of Boer goats. Hence, this finding suggested that TMR feeding with up to 30% of lupin inclusion is suitable for intensive farming of goats and serve as an alternative protein source to the animals.

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

KESAN RANSUM CAMPURAN LENGKAP (TOTAL MIXED RATION – TMR) DENGAN KANDUNGAN BERBEZA ARAS Lupinus angustifolius L. KE ATAS PRESTASI TUMBESARAN DAN KUALITI DAGING KAMBING BOER JANTAN

Oleh

AINUL YUZAIRI MOHD YUSOF

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Sebagai salah satu faktor utama kejayaan kritikal dalam pengeluaran kambing, kos makanan dan pengurusan telah diberi perhatian hari ini untuk meningkatkan kecekapan dan produktiviti pengeluaran kambing. Ransum campuran lengkap (TMR) adalah kaedah yang berkesan untuk pemberian makanan kambing yang mampu memastikan pengambilan nutrien yang lengkap dan seimbang untuk kambing dalam sistem pengeluaran intensif. Bijirin Lupin (lupin) mengandungi kandungan protein dan serabut diet yang tinggi serta kanji dan indeks glisemik yang minimum. Oleh itu, lupin berpotensi digunakan sebagai bahan makanan alternatif untuk ternakan. Namun, kesan TMR dengan pelbagai aras lupin ke atas prestasi kambing Boer masih tidak dikaji. Justeru itu, kajian ini dijalankan untuk menilai kesan TMR dengan pelbagai tahap lupin dalam makanan ke atas prestasi tumbesaran, ciri karkas dan kualiti daging kambing Boer. Dua puluh empat ekor kambing jantan berumur 8-9 bulan dengan purata berat badan 27.83 ± 0.52 kg telah diasingkan secara rawak kepada tiga kumpulan, iaitu CON, TMR A dan TMR B, dengan 8 haiwan dalam setiap kumpulan. Makanan dalam bentuk *total mixed ration* (TMR) telah diformulasikan dengan mengandungi 0%, 10% dan 30% lupin dalam kumpulan CON, TMR A dan TMR B masing-masing. Makanan TMR juga diselaraskan untuk mengandungi tenaga metabolik (10.3 MJ/kg) dan protein kasar (16.3%) yang sama. Kambing diberi makan dua kali sehari (9.30am dan 2.30pm) secara *ad libitum* selama 103 hari kajian ini dijalankan. Pada hari ke-103, semua kambing telah disembelih mengikut prosedur penyembelihan Halal. Hasil kajian menunjukkan bahawa jumlah pengambikan makanan kambing dalam kumpulan TMR B (110.76 ± 3.57 kg) adalah lebih rendah ($P<0.05$) daripada kumpulan CON (135.05 ± 5.04 kg) dan TMR A (125.07 ± 3.60 kg). Akan tetapi, berat badan akhir, tambahan berat badan dan nisbah perubahan makanan tidak dipengaruhi ($P>0.05$) oleh makanan yang diberikan. Tambahan pula, tidak terdapat perbezaan tererti ($P>0.05$) pada kandungan biokimia darah, ciri karkas dan komposisi di antara kumpulan kambing tersebut. Dalam kajian ini, kandungan lemak intraotot dalam otot *longissimus dorsi* (LD) adalah lebih rendah ($P<0.05$) dalam TMR B (13.24 ± 1.28%) berbanding dengan CON (21.05 ± 1.49%) dan TMR A (19.63 ± 1.53%).

Namun, tidak terdapat perbezaan tererti (P>0.05) pada ciri-ciri kualiti daging yang lain pada otot LD di antara kumpulan kambing tersebut. Sementara itu, komposisi asid lemak otot LD, *biceps branchii* (BB) dan *semitendinosus* (ST) adalah berbeza di antara kumpulan kambing kajian. Kandungan asid laurik (C12:0), palmitoleik (C16:1) dan linolenik (C18:3n-3) dalam otot LD adalah berbeza (P<0.05) di antara kumpulan kambing. Kandungan asid *pentadecanoic* dalam otot BB pula adalah lebih rendah (P<0.05) dalam kumpulan CON berbanding dengan TMR A. Dalam otot ST, kumpulan TMR B mengandungi asid laurik yang lebih tinggi (P<0.05) daripada CON, manakala kandungan asid *heptadecanoic* adalah lebih tinggi (P<0.05) dalam kumpulan TMR A berbanding dengan TMR B. Jumlah asid lemak tepu (SFA), asid lemak monotaktepu (MUFA) dan asid lemak politaktepu (PUFA) serta nisbah n-6: n-3 dan PUFA: SFA tidak mempunyai perbezaan tererti (P>0.05) di antara semua kumpulan kajian. Kajian ini menunjukkan bahawa makanan secara formulasi TMR yang dimasukkan dengan tahap lupin yang berbeza sehingga 30% komposisi diet tidak menjejaskan prestasi tumbesaran, ciri karkas dan kualiti daging kambing Boer. Oleh itu, kajian ini mencadangkan bahawa formulasi secara TMR yang menggunakan lupin sehingga 30% dari komposisi diet sesuai digunakan sebagai sumber protein alternatif bagi penternakan intensif kambing.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment 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

a*	Redness
ADF	Acid Detergent Fiber
ASL	Australian Sweet Lupin
b*	Yellowness
Ca	Calcium
CON	Control
CP	Crude Protein
CVD	Cardiovascular Diseases
DM	Dry Matter
DVS	Department of Veterinary Services
FAME	Fatty Acid Methyl Esters
FCR	Feed Conversion Ratio
g	Acceleration Of Gravity
h	Hour
HDL	High Density Lipoprotein
IACUC	Institutional Animal Care and Use Committee
IMF	Intramuscular Fat
L*	Lightness
LDL	Low Density Lipoprotein
M	Molar
min	Minute
ME	Metabolizable Energy
MOA	Ministry of Agriculture
MUFA	Monounsaturated Fatty Acids
Mt.	Metric Ton
N	Normal
NDF	Neutral Detergent Fiber
P	Phosphorus
PUFA	Polyunsaturated Fatty Acids
S.E.M.	Standard Error of Mean
SFA	Saturated Fatty Acids
TMR	Total Mixed Ration
UFA	Unsaturated Fatty Acid

CHAPTER 1

INTRODUCTION

Livestock production is the integral part for world population to provide protein source for human diet. Hundreds of millions of people in the world involve in livestock production and customarily rely on their animals to provide multiple products and services.

The global livestock industry is focusing to improve production and productivity driven by the expanding human population and better income that create better market for meat and dairy products particularly in developing countries. However, the impact of livestock farming to the environmental issues such as climate change has created concern among professionals to reevaluate the sustainability of livestock products in our diet. In the attempt to increase meat production, more efficient animal production systems, duly managed of natural resources and measures to reduce waste and environmental pollution is necessary approach for us to achieve viable and sustainable animal industry. The current livestock industry has been impelled by least cost of production while trying to meet various product and market segment and requirements to achieve maximal returns (Hayes, et.al. 2013; Wyness et al., 2011; Peacock & Sherman, 2010)

According to Sivasupramaniam (2006), majority of ruminant farmers in Malaysia can be classified under the category of smallholders or traditional farmers. However, since the implementation of ninth and tenth (9th and 10th) Malaysian Plan, there are increased of number of commercial goat farms that using intensive production system. In the intensification of goat farming in Malaysia, farmers faced the challenge of increasing production cost particularly the feed cost to fatten goats for slaughter which usually will require a good quality feed and more concentrates. Forages and fodder feed sources alone in intensive goat production system is inadequate to achieve balanced nutrient for fast growing animals and concentrates need to be supplemented in order to maintain acceptable goat performance. Furthermore, the fact of inconsistent supply in terms of quantity and quality of fodder in goat farms due to climatic changes and land scarcity for fodder production (Röös et al., 2016) can affect goat farmers to find alternative feed sources.

Malaysia still dependent on importation of live goats and frozen meat from sheep and goat to meet the local demand. In 2015, Malaysia imported 32,206.78 Mt. of frozen lamb and mutton from Australia and New Zealand while 145,353 heads of live sheep and goats imported mostly from Australia (Department of Veterinary Services, 2016). With only 12.22% self suffieciency level and 1.43 kg of per kapita consumption in 2015 for sheep and goat meat (Department of Veterinary Services, 2016), the prospect for growth of small ruminant farming seems to be quite engaging.

The increasing feed price particularly grains such as soybean meal and corn as important protein and energy sources for animal feed in the world commodity market recently is a

serious threat to the competitiveness of intensified goat farming in Malaysia. To overcome this problem, farmers can opt to shorten the rearing period to fatten for their goat to achieve market size by applying cost effective feeding management and using faster growth breed with good genetic potential to produce good quality carcass and meat.

To properly fed goat commensurate to their nutritional requirements, there are several opportunities in using good quality and affordable ingredients such as palm kernel expeller, wheat pollard, soya bean meal, soya waste and fishmeal. The nutritional values, anti-nutritional factors, consistencies in nutritional quality and supply and also cost of the ingredient are the important factors in the formulating cost effective feed (Wan Zahari & Wong, 2009)

Lupin seed has been adapted as one of feed ingredients for livestock production in Australia, Japan, and Korea and also in several countries Europe and Asia (Petterson, 2000). Lupin seed has been recognized by its high protein and dietary fiber and minimal starch and glycemic index that have potential as alternative feed ingredients for ruminants, poultry, pig and fish production (van Barneveld, 1999). The limitation of using lupin in TMR feed for goat are the dependency of lupin supply from imported source particularly from Australia since lupin is not suitable to be planted in Malaysian tropical climate. Despite the limitation on the risk of economic viability for using lupin today in Malaysia, the technical feasibility of using lupin in goat feed is still worth to be studied since other common feed source for ruminant concentrate particularly soybean meal are also imported ingredient and subject to price and supply availability fluctuations. The current study has only examined usage of raw lupin grain in TMR to feed male Boer goats.

During the Western Australia-Malaysia Technical Working Group (TWG) meeting that was held on 13th -14th July 2006 in Perth Western Australia, in the areas of technical cooperation between the two countries for feeds and nutrition management, Lupin has been identified as one of potential feed ingredient that can be explored to be used in goat feeding in Malaysia. However, the information on the effects of TMR with different level of lupin inclusion on the performance of goats is still unavailable. Hence, this study aimed to provide information, which can support the strategies to utilize TMR and lupin more efficiently as goat feed in Malaysia. The findings of this study will contribute the knowledge on the usage of TMR and lupin grain in formulating dietary requirement for the Boer goats in order to maximize their genetic potential in the tropical environment.

Hypothesis

By considering the demand of the goat farming sector for good quality feed in developing countries and the necessity of a suitable alternative, it was hypothesized that TMR with *Lupinus angustifolius* (lupin) inclusion can be used as source of protein in animal feed for intensive farming system without causing adverse effects on growth performance, carcass characteristics and meat quality of male Boer goats.

Objective

The current study was carried out to determine the effects of feeding TMR with different levels of *Lupinus angustifolius* (lupin) inclusion on growth performance, carcass characteristics and meat quality of male Boer goats.

Specific Objectives:

1. To determine the effects of feeding TMR with different levels of lupin inclusion on the growth performance and carcass characteristics of male Boer goats.

2. To investigate the effects of feeding TMR with different levels of lupin inclusion on the meat quality traits of male Boer goats.

3. To evaluate the effects of feeding TMR different levels of lupin inclusion on the fatty acid composition in skeletal muscles of male Boer goats.

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