UNIVERSITI PUTRA MALAYSIA

GROWTH PERFORMANCE, RUMEN FERMENTATION AND MICROBIAL POPULATION, CARCASS CHARACTERISTICS AND MEAT FATTY ACID COMPOSITION OF GOATS FED DIETS BASED ON OIL PALM KERNEL CAKE AND DECANTER CAKE

ABDELRAHIM ABUBAKR MOHAMMED

FP 2013 71

GROWTH PERFORMANCE, RUMEN FERMENTATION AND MICROBIAL POPULATION, CARCASS CHARACTERISTICS AND MEAT FATTY ACID COMPOSITION OF GOATS FED DIETS BASED ON OIL PALM KERNEL CAKE AND DECANTER CAKE

By

ABDELRAHIM ABUBAKR MOHAMMED

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirements for the Degree of Doctor of Philosophy

May 2013

COPYRIGHT

DEDICATIONS

TO THE SOUL OF MY MOTHER AND FATHER WITH

SUPPLICATION FOR FORGIVENESS

TO MY BROTHERS AND SISTERS, WITH LOVE

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Doctor of Philosophy

GROWTH PERFORMANCE, RUMEN FERMENTATION AND MICROBIAL POPULATION, CARCAS CHARACTERISTICS AND MEAT FATTY ACID COMPOSITION OF GOATS FED DIETS BASED ON OIL PALM KERNEL CAKE AND DECANTER CAKE

By

ABDELRAHIM ABUBAKR MOHAMMED

May 2013

Chairman: Professor Abdul Razak Alimon, PhD

Faculty: Agriculture

Shortage of feed in terms of quantity and quality is one of the most central factors that limit the development of the ruminant livestock industry in many tropical countries, including Malaysia. To overcome such problems, maximizing the use of locally available feed resources could be an alternative approach. The present study aimed to evaluate the effect of feeding diets based on palm kernel cake and decanter cake on rumen microbial population, growth performance and meat fatty acid profile of goats.

In the first study, sixteen rumen-cannulated Boer X Kacang crossbred goats were used to evaluate the effect of crude palm oil, (PO), palm kernel cake (PKC) and decanter cake (DC) on the rumen fermentation characteristics, microbial population and nutrient digestibility. Goats were fed one of the four concentrate

diets (treatments) namely, control diet (CD), decanter cake diet (DCD), palm kernel cake diet (PKCD) and CD plus 5% palm oil diet (CPOD).

Feeding DCD and PKCD appeared to modify the rumen microbial population, increasing the DNA copy number of total bacteria ($P < 0.01$) and *Ruminococcus albus* ($P < 0.01$). The DNA copy number of *Fibrobacter succinogenes* was lower ($P < 0.05$) for the treatment CPOD compared to other treatments. The mean ciliate protozoa numbers were considerably higher for treatment CD (6.2×10^5/ml) than for other treatments (DC, DCD, PKCD and CPOD (2.1×10^5/ml)) and decreased rapidly between day 4 and 6 in goats fed treatments DCD, PKCD and CPOD. Rumen methanogenic archaea was significantly reduced in goats fed PKCD (1.50×10^9/ml) and CPOD (1.32 × 109/ml) compared to that fed CD (2.48×10^9) however, their populations in goats fed DCD (1.96×10^9/ml) and CD were similar. The trend showed a severe reduction after day 4 and 6 of the start of the feeding experimental diets. Ammonia-N concentration in rumen fluid of goats was significantly lower for treatments DCD (35.0 mg/L), PKCD (34.4 mg/L) and CPOD (33.9 mg/L) than for treatment CD (49.9 mg/L) and pH was lowest for the treatment DCD (6.1) and highest for treatment PKCD (6.4). Total volatile fatty acid concentrations were significantly lower for treatment PKCD (94.8 mmol/L) and CPOD (94.4 mmol/L) than for treatment CD (98.5 mmol/L) and DCD (98.1 mmol/L).

From the results obtained in the first experiment, it was concluded that inclusion of PKC and DC in the diet of goats modified the rumen microbial

population by reducing ciliate protozoa and methanogenic archaea; and increasing total bacteria and some species of cellulolytic bacteria.

In the second study, 32 Boer x Kacang crossbred male goats were used in a 100-day experiment. Goats were randomly assigned to one of the four dietary treatments namely, control diet (CD), decanter cake diet (DCD), palm kernel cake diet (PKCD) or control diet plus 5% palm oil (CPOD). The objective was to assess the effects of these diets on growth, carcass quality, fatty acid (FA) content of meat and nitrogen (N) metabolism. Daily weight gain was significantly lower in goats fed DCD (89 g/day) and PKCD (89 g/day) compared to those fed CD (136 g/day) and CPOD (141 g/day).

Slaughter weight, and hot and cold carcass weights were higher in goats fed CPOD (34.4 kg, 16.7 kg, 16.6 kg, respectively) followed by CD (32.9 kg, 16.5 kg, 16.4 kg, respectively), DCD (25.6 kg, 13.3 kg, 13.1 kg, respectively) and PKCD (24.6 kg, 11.5 kg, 11.4 kg, respectively). Nitrogen metabolism was altered in goats received PKCD, where the excretion of N in feaces was the highest ($p<0.05$) in goats fed PKCD (5.1 g/day) and lowest in those fed CPOD (1.6 g/day). Goats fed PKCD had significantly higher C12:0 contents than those fed other diets in all muscles tested. C16:0 and C18:0 were significantly lower in muscles from goats fed CD than those fed other treatments, whereas C18:2 n-6 was highest in the muscles of goats fed CD compared to other diets. Both *longissimus dorsi* (LD) and *infraspinatus* (IS) muscles from goats fed CD had relatively lesser total saturated fatty acid (SFA) proportions; however, SFA

proportions of the muscle *biceps femoris* (BF) was similar in all dietary treatments. Additionally, the proportions of total n-6 polyunsaturated fatty acid (PUFA), n-6: n-3 ratio and PUFA/SFA were higher in the muscles of goats fed CD than those fed other diets. It was concluded that inclusion of PKC and DC in the diet of goats up to 80% resulted in daily gain of ~90 g/day which is within reported values for goats fed such agri-industrial by-products. However, fatty acid composition of meat might be altered.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

PRESTASI PERTUMBUHAN, FEMENTASI RUMEN DAN POPULASI MIKROB, CIRI KARKAS DAN KOMPOSISI ASID LEMAK OTOT KAMBING DIBERI MAKAN DIET BERASASKAN MIL ISIRUNG KELAPA SAWIT DAN KEK DEKANTER

Oleh

ABDELRAHIM ABUBAKR MOHAMMED

Mei 2013

Pengerusi : Profesor Abdul Razak Alimon, PhD

Fakulti: Pertanian

Kekurangan makanan dari segi kuantiti dan kualiti adalah salah satu dari faKtor penting yang membatas pembangunan industri ruminan di kebanyakan negara tropika termasuk Malaysia. Untuk mengatasi masalah ini, penggunaan maksimum bahan makanan tempatan boleh menjadi pendekatan alternative. Tujuan penyelidikan ini adalah untuk mengevaluasi kesan pemberian makanan berasaskan mil isirung kelapa sawit dan kek decanter keatas populasi mikrob rumen, prestasi pertumbuhan dan profil asid lemak otot kambing.

Dalam ujikaji pertama, enam belas kambing kacukan Boer x Kacang, yang di pasang rumen fistula dibahagi kepada empat kumpulan untuk meneliti kesan minyak sawit mentah (PO), hampas isirung kelapa sawit (PKC) dan kek dekanter keatas populasi bacteria selulitik rumen, bilangan protozoa, ciri ciri

fermentasi rumen dan kecernaan nutrient. Kambingdiberi makan salah satu dari empat diet konsentrat (rawatan) iaitu diet control (CD), diet decanter (DCD), diet PKC (PKCD) dan CD + 5% PO (CPOD).

Pemberian diet DCD and PKCD menyebabkan perubahan pada populasi mikrob rumen, meningkatkan DNA copy number jumlah bacteria ($p<0.01$), *Fibrobacter succinogenes* ($P < 0.05$), *Ruminococcus flavefaciens* ($P < 0.05$) dan *Ruminococcus albus* ($P < 0.01$). Min jumlah protozoa siliat adalah lebih tinggi untuk rawatan diet CD (6.2×10^5) daripada rawatan lain (DC, DCD, PKCD dan CPOD (2.1×10^5)) dan menurun dengan cepat antara hari ke 4 dan ke 6 pada kambing rawatan DCD, PKCD dan CPOD. Archea metanogenik rumen menurun secara signifikan pada kambing yang diberi diet PKCD (1.50×10^9) dan CPOD (1.32×10^9) dibandingkan kambing yang diberi CD (2.48×10^9), manakala kambing yang diberi DCD (1.96×10^9) dan CD adalah sama. Ada tren yang menunjukkan penurunan yang ketara pada hari ke 4 dan ke6 selepas permulaan pemberian diet rawatan. Kepekatan Ammonia-N dalam cecair rumen adalah lebih rendah untuk rawatan DCD (35.0 mg/L), PKCD (34.4 mg/L) dan CPOD (33.9 mg/L) dibandingkan dengan rawatan CD (49.9 mg/L), manakala pH adalah rendah sejkali untuk rawatan DCD (6.1) dan tinggi sekali untuk rawatan PKCD (6.4). Kepekatan Total acid lemak meruap adalah lebih rendah untuk rawatan PKCD (94.8 mmol/L) dan CPOD (94.4 mmol/L) dibandingkan dengan rawatan CD (98.5 mmol/L) dan DCD (98.1 mmol/L).

Dari keputusan yang diperolehi dari experiment 1, adalah dirumuskan yang penambahan PKC dan DC dalam diet kambing memodifikasikan populasi bacteria rumen dengan mengurangkan protozoa siliat dan archea metanogenic; dan meningkatkan jumlah bacteria dan beberapa sepsis bacteria selulolitik.

Dalam kajian kedua, 32 ekor kambing jantan kacukan Boer x Kacang digunakan dalam kajian selama 100 hari. Kambing dibahagi kepada empat kumpulan dan diberi diet basal (control, CD), basal dicampur samada kek decanter (DC), isirung kelapa sawit (PKC) atau minyak sawit (PO). Tujuan kajian ini adalah untuk menilai kesan pemberian suplemen ini keatas pertumbuhan, kualiti karkas, kandungan asid lemak (FA) dalam daging dan metabolism nitrogen (N). Peningkatan berat badan harian adalah lebih rendah pada kambing yang diberi DCD(89 g/hari) dan PKCD (89 g/hari) dibandingkan dengan kambing diberi DC (136 g/hari) and PO (141 g/hari).

Berat sembelih, berat karkas panas dan sejuk adalah lebih tinggi pada kambing yang diberi diet PO (masing masing 34.4 kg, 16.7 kg, 16.6 kg) diikuti dengan diet CD (masing masing 32.9 kg, 16.5 kg, 16.4 kg), CD (masing masing 25.6 kg, 13.3 kg, 13.1 kg) and PKC (masing masing 24.6 kg, 11.5 kg, 11.4 kg). Metabolism nitrogen dalam kambing terubah apabila diberi makan PKC pada kadar yang tinggi, dimana pengeluaran N dalam tinja adalah tertinggi ($p<0.05$) dalam kambing yang diberi diet PKC (3.4 g/hari) dan terendah pada kambing yang diberi diet PO (1.6 g/hari). Kambing yang diberi diet PKC asid lemak C12:0 dalam semua daging yang diuji lebih tinggi dari diet yang lain. Asid lemak

C16:0 dan C18:0 adalah lebih rendah dalam otot kambing yang diberi diet CD dibandingkan dengan diet yang lain, manakal C18:2 n-6 adalah lebih tinggi dalam otot kambing yang diberi diet CD dibandingkan dengan lain lain diet. Kedua dua otot *longissmuss dorsi (LD) dan infraspinatus* (IS) dari kambing yang diberi CD mempunyai total asid lemak tepu (SFA) yang rendah, tetapi jumlah SFA dalam otot *biceps femoris* (BF) adalah sama dalam semua rawatan. Proporsi total n-6 asid lemak politaktepu (PUFA), nisbah n-6:n-3 dan nisbah PUFA/SFA adalah lebih tinggi dalam otot kambing yang diberi diet CD dari diet yang lain. Adalah dirumuskan yang pemberian PKC dan DC dalam diet kambing sehingga 80% boleh meningkatkan penambahan berat sehingga 90g/hari iaitu jumlah yang biasa dilaporkan untuk kambing yang diberi makan hasil sampingan pertanian, namun, komposisi asid lemak daging mungkin berubah.

ACKNOWLEDGEMENTS

Abu Hurairah reported: The Prophet Muhammed ﷺ said, "He has not thanked Allah who has not thanked people." [Sunan Abu Dawud, Book 40, Number 4811]. The prophet Mohammed said: who do not thank the people; he does not thank Allah, my sincere thanks to the Almighty Allah for giving me the health and patience to complete this work.

The following work, while individual, benefited from insights and direction of several people. First of all, I wish to thank my supervisor, Prof. Dr. Abdul Razak Alimon, for his constant support and dedication, encouragement, and advice during my studies. I thank him for his patience in guiding me through my work, correcting and reviewing this thesis. Prof. Razak not only provided his kind suggestions on all my ideas and concepts for the current work, but he also guided me to figure out my career. All things he has provided meant a lot to me and made me grow up far more than I expected.

I would also like to express my thanks to the members of my supervisory committee, Prof. Dr. Norhani Abdullah and Dr. Halimatun Yaakub. All the constructive criticism they have offered during our meetings and seminars are valuable to make this thesis even better. Many thanks extended to Dr. Michael Ivan for his helpful efforts during discussions and preparation of paper manuscripts.

Many thanks are extended to the School of Graduate Studies, Universiti Putra Malaysia for providing me a Graduate Research Fellowship (GRF) without which I couldn't complete my study. I would like to extend my thanks and appreciations to the head of the Department, all lecturers and staff members of the Department of Animal Science, Faculty of Agriculture. Exceptional thanks to Prof. Dr. Jothi Malar Panandam for allowing me to use her Laboratory facilities during the extraction of rumen microbial DNA. Also, I would like to acknowledge all staff of the ruminant farm at UPM for their kind cooperation and help in keeping the experimental animals and sample collection during the field study. Special thanks to all staff of laboratory of vaccines and immunotherapeutics, Institute of Bioscience and personally, Dr. Tan Sheau Wei for her kind support and help during the PCR experiments in the laboratory.

Special thanks are due to all friends, Malaysian and international for their fine co-operation and moral support during the hard times, among them, Hytham Hago, Kamal Abu alfath, Mohammed Elshalmani, Anwar, Eeman Noorie, Zeiad, Saeid, Ayisha, and others not mentioned here but their help is fully appreciated. All Sudanese community in UPM were involved in this work in one way or another and their contribution is highly appreciated.

Ultimately, I'm deeply indebted to my family for their continuous and precious supportive encouragement in various aspects during my study in Malaysia.

I certify that a thesis Examination Committee has met on 21th December 2012 to conduct the final examination of ABDELRAIM ABUBAKR MAOHAMMED on his thesis entitled "*GROWTH PERFORMANCE, RUMEN FERMENTATION AND MICROBIAL POPULATION, CARCASS CHARACTERISTICS AND MEAT FATTY ACID COMPOSITION OF GOATS FED DIETS BASED ON OIL PALM KERNEL CAKE AND DECANTER CAKE*" in accordance with Universities and university Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the degree of Doctor of Philosophy (PhD).

Members of the Examination Committee are as follows:

Dahlan Bin Ismail, PhD.
Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Chairman)

Mohamed Ali Rajion, PhD
Professor
Faculty of Veterinary Medicine
Universiti Putra Malaysia
(Internal Examiner)

Wan Zuhainis Binti Saad, PhD
Faculty of Biotechnology and Bimolecular Science
Universiti Putra Malaysia
(Internal Examiner)

Hassan Fazaeli Mahmoud, PhD
Professor
Animal Science Research Institute
Karaj, Iran.
(External Examiner)

SEOW HENG FONG, PhD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirements for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

Abdul Razak Alimon, PhD
Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Chairman)

Halimatun Yaakub, PhD
Associate Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Member)

Norhani Abdullah, PhD
Professor
Faculty of Biotechnology and Bimolecular Science
Universiti Putra Malaysia
(Member)

BUJANG BIN KIM HUAT, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

DECLARATION

I declare that the thesis is my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institutions.

ABDELRAHIM ABUBAKR MOHAMMED

Date: 29 May 2013

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

ADF	acid detergent fiber
ADG	average daily gain
ADIN	acid detergent insoluble nitrogen
ADL	acid detergent lignin
BF	biceps femoris
BW	body weight
CD	control diet
CETAB	cetyl trimethylammonium bromide
CP	crude protein
CPOD	control plus palm oil diet
DC	decanter cake
DCD	decanter cake diet
DGGE	denaturing gradient gel electrophoresis
DM	dry matter
DMI	dry matter intake
DNA	deoxyribonucleic acid
EE	ether extract
FA	fatty acid
FAO	food and agriculture organization

FMAE	fatty acid methyl esters
GE	gross energy
HDL	high density lipoprotein
IS	infraspinatus
LD	longissimus dorsi
LDL	low density lipoprotein
MPOB	Malaysian palm oil board
MUFA	mono unsaturated fatty acids
NAN	non-ammonia nitrogen
NCBA	National Cattlemen's Beef Association
NDF	neutral detergent fiber
OM	organic matter
OMD	organic matter digestibility
PF	palm fiber
PKC	palm kernel cake
PKCD	palm kernel cake diet
PKM	palm kernel meal
PO	palm oil
POME	palm oil mill effluent
PUFA	polyunsaturated fatty acid
rRNA	ribosomal ribonucleic acid

RT-PCR	real time polymerase chain reaction
SCFA	short chain fatty acid
SFA	saturated fatty acid
USFA	unsaturated fatty acid
VFA	volatile fatty acid

CHAPTER 1

INTRODUCTION

The development of ruminant livestock industry in Malaysia is commonly limited by the shortage of feed resources and difficulties in providing feed in sufficient quantity and quality throughout the year. The main reason is a limited land area especially during the peak cropping periods when most of the lands are under cultivation. Consequently, the ruminant animal products namely meat and milk are not produced in sufficient amounts and most of the population needs are imported from abroad.

The shortage of feed resources is partially covered by importation of feed ingredients such as corn grain and soybean meal as sources of energy and protein, respectively. This will lead to an increase in the cost of production as feed constitutes more than 70% of the cost in livestock production systems. In addition to economic constraints, competition between human and monogastric animals limit the level of grain inclusion in ruminant diets. Therefore, the major strategy to develop ruminant livestock industry in such areas is to increase the use of available low cost, indigenous feed resources to reduce the cost of imported feed (Goh and Rajion, 2007).

The palm oil industry produces a huge amount of by-products including oil palm frond (OPF), palm press fiber (PPF), palm kernel cake (PKC) and palm oil decanter cake (DC). These by-products can be alternative, readily available and sustainable feed resources for ruminants and other farm animals as their inclusion in feeds can be an effective measure in overcoming the lack of pasture to sustain small ruminant production in palm oil producing countries including Malaysia (Wan Zahari *et al.*, 2012).

The utilization of such by-products in ruminant feeding systems is highly dependent on the nutritional status of the animal which may be affected by the efficiency of by-product fermentation by rumen microbes that yields required nutrients such as volatile fatty acids (VFA) and microbial protein. The rumen is occupied by various types of microbes including bacteria, protozoa and fungi. Bacteria are the most numerous among rumen microorganism and play a major role in the degradation of fiber. *Fibrobacter succinogenes*, *Ruminococcus albus*, and *Ruminococcus flavefaciens* are presently recognized as the major cellulolytic bacterial species found in the rumen (Forster *et al.*, 1997; Shinkai and Kobayashi, 2007). The presence or absence of rumen ciliate protozoa is reported to be associated with change in the composition of the rumen bacterial community (Ozutsumi *et al.*, 2006). The feed type is the most effective factor that can change the microbial activity in the rumen, and understanding the activity and

interaction of these microbes in the rumen of animals fed high levels of palm oil by-products is fundamental to maximize their utilization.

The acceptance of goat meat (Chevon) is increasing around the world over the last few years due to its preferable characteristics to health conscious people. The fatty acid profile of the meat is gaining attention because a high intake of saturated fatty acids is associated with human coronary heart diseases (Hu *et al*., 1999; Givens, 2005). Although the fatty acid profile of meat in ruminants is less affected by dietary fatty acids compared to non-ruminants, there are some evidences stated that different dietary regimens can affect the fatty acid profile of meat (Bas and Morand-Fehr, 2000). Therefore, it is important to evaluate the fatty acid profile of meat produced from animals fed palm oil by-products.

1.1. Research problem

The demand for animal protein is increasing with population growth, income growth and changing consumer preferences. Ruminant livestock industry improvement is always limited by shortage of feed resources in term of quality and quantity. To sustain ruminant livestock production, maximum utilization of indigenous feed ingredients could be an alternative to the high cost imported feeds.

1.2. Research hypothesis

The chemical composition of palm kernel and decanter cake varies significantly depending on oil palm varieties and extraction method. Even though, they could be included in the ration of ruminants to the maximum levels. Due to the relatively high contents of oil in both palm kernel cake and decanter cake, we hypothesized that their inclusion in high levels in the diet of goats might alter the microbial population in the rumen which in turn might affect the nutrient digestion since the rumen microbes are the key factors in the digestion process. Moreover, we hypothesized that the inclusion of high levels of palm kernel cake and decanter cake expected to affect the fat deposition in the carcass of goats and the fatty acid profile in the muscles.

1.3. Objectives

Based on the above mentioned consideration, a study was conducted to evaluate the utilization of palm kernel cake and decanter fed at high levels to local goats. Two experiments were carried out for this purpose. The specific objectives of the research were:

1. To evaluate the fermentation characteristics, microbial population and nutrient digestibility in the rumen of goats fed diets based on palm kernel cake and decanter cake.
2. To evaluate the growth performance, nitrogen metabolism and carcass measurements in goats fed on diets based on palm kernel cake and decanter cake.
3. To evaluate the carcass characteristics and meat muscle fatty acid composition of goats fed diets based on palm kernel cake and decanter cake.

REFERENCES

Abdullah, N. & Hutagalung, R. I. (1988). Rumen fermentation, urease activity and performance of cattle given palm kernel cake-based diet. *Animal Feed Science and Technology*, **20**(1), 79-86.

Abu Hassan, A. R., Azizan, M., Ishida, M. O. & Bakar, C. A. (1993). Oil palm fronds silage as a roughage source for milk production in Sahiwal-Friesian cows. *In: Proceedings of 16th Malaysian Society Animal Production Annual Conference*, Langkawi, Malaysia.

AFRC. (1992). Nutritive requirements for ruminant animals: protein. *Nutritition Abstracts and Reviews*, **62**, 787-835.

Ahmad, H. (1984). Strategy for meat and meat animal development in Pakistan. *World Review of Animal Production*, **20**(2), 63-72S.

Alimon, A. R. (1993). Feed resources in Malaysia. In: *The animal industry in Malaysia*, eds. C. T. N. I. Fatima, A. H. Ramlah & A. R. Bahaman, Faculty of Veterinary medicine and Animal Science, University Putra Malaysia, Malaysia., pp. 13-30.

Alimon, A. R. (2004). The nutritive value of palm kernel cake for animal feed. *Palm Oil Developments*, **40**, 12-14.

Alimon, A. R., Ivan, M. & Jalaludin, S. (2011). Effects of different levels of dietary sulfur and molybdenum on concentrations of copper and other elements in plasma and liver of lambs fed palm kernel cake diets. *British Journal of Nutrition*, **106**(8), 1224-30.

Amann, R. I., Ludwig, W. & Schleifer, K. H. (1995). Phylogenetic identification and in situ detection of individual microbial cells without cultivation. *Microbiology and Molecular Biology Reviews*, **59**(1), 143-169.

Animut, G., Puchala, R., Goetsch, A. L., Patra, A. K., Sahlu, T., Varel, V. H. & Wells, J. (2008). Methane emission by goats consuming diets with different levels of condensed tannins from lespedeza. *Animal Feed Science and Technology*, **144**(3–4), 212-227.

AOAC. (1990). *Official Methods of Analysis, 14th edn.* Association of Official Analytical Chemists, Arlington, VA.

Akin, D. E., Borneman, W. S. & Windham, W. R. (1988). Rumen fungi: morphological types from Georgia cattle and the attack on forage cell walls. *Biosystems*, **21**(3–4), 385-391.

Atasie, V. N. & Akinhanmi, T. F. (2009). Extraction, compositional studies and physico-chemical characteristics of palm kernel oil. *Pakistan Journal of Nutrition*, **8**, 800-803.

Badarina, I. & Soetrisno, E. (2009). The Effect of Concentrate Supplementation Made From Palm Oil Sludge and Several Local Feed Resources to Production Performance of Bali Calves. In *The 1st International Seminar on Animal Industry*. Faculty of Animal Science, Bogor Agricultural University, Indonesia, pp. 130-134.

Baghurst, K. (2004). Dietary fats, marbling and human health. *Australian Journal of Experimental Agriculture*, **44**(7), 635-644.

Baldwin, R. L. (1999). Sheep gastrointestinal development in response to different dietary treatments. *Small Ruminant Research*, **35**(1), 39-47.

Bamikole, M. A. & Babayemi, O. J. (2008). Chemical composition and in sacco dry matter degradability of residue and by-products of palm fruit processing in the rumen of steers. *Animal Science Journal*, **79**(3), 314-321.

Bamikole, M. A. & Ikatua, U. J. (2009). Variety diversity effect on the chemical composition and dry matter degradation characteristics of residue and by-products of oil palm fruits. *Animal Science Journal*, **80**, 239-249.

Banskalieva, V., Sahlu, T. & Goetsch, A. L. (2000). Fatty acid composition of goat muscles and fat depots: a review. *Small Ruminant Research*, **37**(3), 255-268.

Bartoň, L., Marounek, M., Kudrna, V., Bureš, D. & Zahrádková, R. (2008). Growth, carcass traits, chemical composition and fatty acid profile in beef from Charolais and Simmental bulls fed different types of dietary lipids. *Journal of the Science of Food and Agriculture*, **88**(15), 2622-2630.

Bas, P. & Morand-Fehr, P. (2000). Effect of nutritional factors on fatty acid composition of lamb fat deposits. *Livestock Production Science*, **64**, 61-69.

Batubara, L. P. (2003). Potensi integrasi peternakan dengan perkebunan kelapa sawit sebagai simpul agribisnis ruminan. *Wartazoa*, **13**, 83-91.

Bauchop, T. (1981). The anaerobic fungi in rumen fibre digestion. *Agriculture and Environment*, **6**(2–3), 339-348.

Beauchemin, K. A., Kreuzer, M., O'Mara, F. & McAllister, T. A. (2008). Nutritional management for enteric methane abatement: a review. *Australian Journal of Experimental Agriculture*, **48**(2), 21-27.

Bernes, G., Turner, T. & Pickova, J. (2012). Sheep fed only silage or silage supplemented with concentrates: 2. Effects on lamb performance and fatty acid profile of ewe milk and lamb meat. *Small Ruminant Research*, **102**(2–3), 114-124.

Bird, S. H. & Leng, R. A. (1985). Productivity responses to eliminating protozoa from the rumen of sheep. *Review of Rural Science*, **6**, 109-117.

Bonanome, A. & Grundy, S. M. (1988). Effect of Dietary Stearic Acid on Plasma Cholesterol and Lipoprotein Levels. *New England Journal of Medicine*, **318**(19), 1244-1248.

Bryant, M. P. (1959). Bacterial species of the rumen. *Bacteriology Reviews*, **23**, 125–153.

Bryant, M. P. & Robinson., I. M. (1961). Some nutritional requirements of genus Ruminococcus. *Applied Microbiology*, **9**, 91-95.

Calder, P. C. (2004). n-3 Fatty acids and cardiovascular disease evidence explained and mechanisms explored. *Clinical Science (London)*, **107**, 1-11.

Cameron, K. C., Hedley, M., Clark, H. & Di, H. J. (2007). Impact of pasture and supplement feeding on the environment. In *Pasture and Supplements for Grazing Animals*, eds. P. V. Rattary, I. M. Brookes & A. M. Nicol, Vol. 14, New Zealand Society of Animal Production. Hamilton, NZ, pp. 287-309.

Carmichael, A. K., Kouakou, B., Gelaye, S., Kannan, G., Lee, J. H. & Terrill, T. H. (2011). Organ mass and composition in growing dairy goat wethers fed different levels of poultry fat and protein. *Small Ruminant Research*, **104** (1), 104-113.

Carvalho, G. G. P. d., Pires, A. J. V., Silva, F. F. d., Veloso, C. M., Silva, R. R., Silva, H. G. d. O., Bonomo, P. & Mendonça, S. d. S. (2004). Comportamento ingestivo de cabras leiteiras alimentadas com farelo de cacau ou torta de dendê. *Pesquisa Agropecuária Brasileira*, **39**, 919-925.

Carvalho, L. P. F., Cabrita, A. R. J., Dewhurst, R. J., Vicente, T. E. J., Lopes, Z. M. C. & Fonseca, A. J. M. (2006). Evaluation of palm kernel meal and corn distillers grains in corn silage-based diets for lactating dairy cows. *Journal of Dairy Science*, **89**(7), 2705-2715.

Carvalho, L. P. F., Melo, D. S. P., Pereira, C. R. M., Rodrigues, M. A. M., Cabrita, A. R. J. & Fonseca, A. J. M. (2005). Chemical composition, in vivo digestibility, N degradability and enzymatic intestinal digestibility of five protein supplements. *Animal Feed Science and Technology*, **119**(1-2), 171-178.

Chanjula, P., Mesang, A. & Pongprayoon, S. (2010). Effect of dietary inclusion of palm kernel cake on nutrient utilization, rumen fermentation characteristics and microbial populations of goats fed *Paspalum plicatulum* hay-based deit. *Songklanakarin Journal of Science and Technology*, **36**(6), 527-536.

Castro, T., Manso, T., Mantecón, A. R., Guirao, J. & Jimeno, V. (2005). Fatty acid composition and carcass characteristics of growing lambs fed diets containing palm oil supplements. *Meat Science*, **69**(4), 757-764.

Chavalparit, O., Rulkens, W. H., Mol, A. P. J. & Khaodhair, S. (2006). Options for environmental sustainability of the crude palm oil industry in Thailand though enhancement of industrial ecosystems. *Environmental, Development and Sustainability*, **8**, 271-287.

Chen, J. & Weimer, W. (2001). Competition among three predominant ruminal cellulolytic bacteria in the absence or presence of non-cellulolytic bacteria. *Microbiology*, **147**, 21-30.

Cheng, K. J., Stewart, C. S., Dinsdale, D. & Costerton, J. W. (1984). Electron microscopy of bacteria involved in the digestion of plant cell walls. *Animal Feed Science and Technology*, **10**(2–3), 93-120.

Chin, F. Y. (2001). Palm Kernel Cake (PKC) as a supplement for fattening and dairy cattle in Malaysia. In *7th Meeting of the Regional Working Group on Grazing and Feed Resources Forage Development in Southeast Asia: Strategies and Impacts*, eds. F. A. Moog, S. G. Reynolds & K. Maaruf. Manado. FAO-University of Sam Rapulangi, Indonesia

Cieslak, A., Szumacher-Strabel, M., Szymankiewicz, E., Piekniewski, M., Oleszak, L., Siwinski, L. & Potkanski, A. (2006). Coconut oil reduces protozoa count and methane release during fermentation in a Rusitec system. *Journal of Animal Feed Science and Technology*, **15 (Suppl. 1)**, 19-22.

Colomer-Rocher, R., Kirton, A. H., Mercer, G. J. K. & Duganzich, D. M. (1992). Carcass composition of New Zealand Saanen goats slaughtered at different weights. *Small Ruminant Research*, **7**, 161-173.

Coltro, W. K., Ferreira, M. M., Macedo, F. A., Oliveira, C. C., Visentainer, J. V., Souza, N. E. & Matsushita, M. (2005). Correlation of animal diet and fatty acid content in young goat meat by gas chromatography and chemometrics. *Meat Science*, **71**, 358-363.

Colucci, P. E., Chase, L. E. & Soest, P. J. V. (1982). Feed intake, apparent diet digestibility, and rate of particulate passage in dairy cattle. *Journal of Dairy Science*, **65**, 1445-1456.

Cornelius, J. A. (1977). Palm oil and palm kernel oil. *Progress in the Chemistry of Fats and other Lipids*, **15**(1), 5-27.

Costa, P., Roseiro, L. C., Bessa, R. J. B., Padilha, M., Partidario, A., Marques de Almeida, J., Calkins, C. R. & Santos, C. (2008). Muscle fiber and fatty acid profiles of Mertolenga-PDO meat. *Meat Science*, **78**(4), 502-512.

Costa, D., Ferreira, G., Araújo, C., Colodo, J., Moreira, G. & de Figueiredo, M. (2010). Intake and digestibility of diets with levels of palm kernel cake in sheep. *Revista Brasileira De Saúde E Produção Animal*, **11**(3), 783-792.

Dahlan, I. (2000). Oil palm frond (OPF): a potential bio-waste material for commercial feed production. *Agro-Search*, **7**(1), 29-34.

Daley, C., Abbott, A., Doyle, P., Nader, G. & Larson, S. (2010). A review of fatty acid profiles and antioxidant content in grass-fed and grain-fed beef. *Nutrition Journal*, **9**(1), 10.

Dannenberger, D., Nuernberg, G., Scollan, N., Schabbel, W., Steinhart, H., Ender, K. & Nuernberg, K. (2004). Effect of Diet on the Deposition of n-3 Fatty Acids, Conjugated Linoleic and C18:1trans Fatty Acid Isomers in Muscle Lipids of German Holstein Bulls. *Journal of Agricultural and Food Chemistry*, **52**(21), 6607-6615.

Davison, T. M., Ehlrich, W. K., N, O. W. & J, A. (1994). Palm kernel expeller as subistitute for grain in dairy cow rations. *Proceedings of Australian Society of Animal Production. 20: 372*.

De Ruiter, J. M., Dalley, D. E., Hughes, T. P., Fraser, T. J. & Dewhurst, R. J. (2007). types of supplements: thier nutritive value and use. In *Pasture and Supplements for Grazing Animals*, eds. P. V. Rattray, I. M. Brookes & A. M. Nicol, Vol. 14, New Zealnd Soceity of Animal Production, Hamilton, NZ, pp. 97-115.

De Smet, S., Raes, K. & Demeyer, D. (2004). Meat fatty acid composition as affected by fatness and genetic factors: a review. *Animal Research*, **53**, 81-98.

de Veth, M. J. & Kolver, E. S. (2001). Diurnal Variation in pH Reduces Digestion and Synthesis of Microbial Protein when Pasture is Fermented in Continuous Culture. *Journal of Dairy Science*, **84**(9), 2066-2072.

Dehority, B. A., Tirabasso, P. A. & Grifo, A. P., Jr. (1989). Most-probable-number procedures for enumerating ruminal bacteria, including the simultaneous estimation of total and cellulolytic numbers in one medium. *Applied and Environmental Microbiology*, **55**(11), 2789-2792.

Dehority, B. A. (1993). Microbial ecology of cell wall fermentation. In *Forage Cell Wall Structure and Digestibility*, eds. H. G. Jung, D. R. Buxton, R. D. Hateld & W. J. Ralph. Madison, American Society of Agronomy, Crop Science Society of America, Soil Science Society of America, pp. 425-453.

Demeyer, D. I. (1992). Biotechnology and the quality of animal products in sustainable agriculture. *Journal of Applied Animal Research*, **1**, 65–80.

Demirel, G., Ozpinar, H., Nazli, B. & Keser, O. (2006). Fatty acids of lamb meat from two breeds fed different forage: concentrate ratio. *Meat Science*, **72**(2), 229-235.

Denke, M. A. & Grundy, S. M. (1992). Comparison of effects of lauric acid and palmitic acid on plasma lipids and lipoproteins. *The American Journal of Clinical Nutrition*, **56**(5), 895-8.

Denke, M. A. (1994). Role of beef and beef tallow, an enriched source of stearic acid, in a cholesterol-lowering diet. *The American Journal of Clinical Nutrition*, **60**(6), 1044S-1049S.

Denman, S. E. & McSweeney, C. S. (2006). Development of a real-time PCR assay for monitoring anaerobic fungal and cellulolytic bacterial populations within the rumen. *FEMS Microbiology Ecology*, **58**(3), 572-582.

Derr, J., Kris-Etherton, P. M., Pearson, T. A. & Seligson, F. H. (1993). The role of fatty acid saturation on plasma lipids, lipoproteins, and apolipoproteins: II. The plasma total and low-density lipoprotein cholesterol response of individual fatty acids. *Metabolism*, **42**(1), 130-134.

Devendra, C. & Lewis, D. D. (1974). Fat in ruminants diets: a review. *Indian Journal of Animal Science*, **44**, 917-938.

Devendra, C., Yeong, S. W. & Ong, H. K. (1981). The potential of palm oil mill effluent (POME) as a feed source for farms animal in Malaysia. *Proceedings of National Workshop on Oil Palm By-product Utilzation*, Kuala Lumphur, Malaysia. December 14-15, pp 63-75.

Devendra, C. (2011). Areview-Rainfed Areas and Animal Agriculture in Asia: The Wanting Agenda for Transforming Productivity Growth and Rural Poverty. *Asian-Australian Journal of Animal Science*, **25**(1), 122-142.

Devendra, C. & Leng, R. A. (2011). -Invited Review - Feed Resources for Animals in Asia: Issues, Strategies for Use, Intensification and Integration for Increased Productivity. *Asian-Australian Journal of Animal Science*, **24**(3), 303-321.

Dias, F. N. (2010). Supplementation of palm kernel expeller to grazing dairy farms in New Zealand, PhD thesis, Massey University. Palmerston North, New Zealand.

Diaz, M. T., Velasco, S., Caneque, V., Lauzurica, S., de Huidobro, F. R. & Perez, C. (2002). Use of concentrate or pasture for fattening lambs and its effect on carcass and meat quality. *Small Ruminant Research*, **43**(3), 257-268.

Dijkstra, J. (1994). Production and absorption of volatile fatty acids in the rumen. *Livestock Production Science*, **39**(1), 61-69.

Dohme, F., Machmüller, A., Estermann, B. L., Pfister, P., Wasserfallen, A. & Kreuzer, M. (1999). The role of the rumen ciliate protozoa for methane suppression caused by coconut oil. *Letters in Applied Microbiology*, **29**(3), 187-192.

DRI. (2005). *Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids (Macronutrients)*. The National Academies Press. Washington, DC.

Dutta, T. K., Agnihotri, M. K. & Rao, S. B. N. (2008). Effect of supplemental palm oil on nutrient utilization, feeding economics and carcass characteristics in post-weaned Muzafarnagari lambs under feedlot condition. *Small Ruminant Research*, **78**(1-3), 66-73.

DVS. (2009). Department of Veterinary Services; Livestock, Livestock products Statistics.

Ebrahimi, M., Rajion, M. A., Goh, Y. M. & Sazili, A. Q. (2012). Impact of different inclusion levels of oil palm (Elaeis guineensis Jacq.) fronds on fatty acid

profiles of goat muscles. *Journal of Animal Physiology and Animal Nutrition*, **96**(6), 962-969.

Elliott, R., Ash, A. J., Calderon-Cortes, F., Norton, B. W. & Bauchop, T. (1987). The influence of anaerobic fungi on rumen volatile fatty acid concentrations in vivo. *The Journal of Agricultural Science*, **109**(01), 13-17.

Enser, M., Hallett, K., Hewitt, B., Fursey, G. A. J. & Wood, J. D. (1996). Fatty acid content and composition of English beef, lamb and pork at retail. *Meat Science*, **42**, 443-456.

Enser, M., Hallett, K. G., Hewett, B., Fursey, G. A. J., Wood, J. D. & Harrington, G. (1998). Fatty acid composition of UK beef and lamb muscle in relation to production system and implication for human nutrition. *Meat Science*, **49**, 329-341.

Ensminger, M. E. (2002). *Sheep and Goat Science, 6th ed.* Interstate Publisher, Inc., Danville, Illinois.

Erwin, E. S., Marco, G. J. & Emery, E. M. (1961). Volatile Fatty Acid Analyses of Blood and Rumen Fluid by Gas Chromatography. *Journal of Dairy Science*, **44**(9), 1768-1771.

FAO. (2011). FAOSTAT, Food and Agriculture Organization of the United Nations. Rome, Italy.

Fenner, H. (1965). Method for determining total volatile bases in rumen fluid by steam distillation. *Journal of Dairy Science*, **48**(2), 249-251.

Field, R. A., Rule, D. C. & Riley, M. L. (1992). Characteristics of fat from heavy lams fed 90% corn diet or alfalfa pellets. *Sheep Research Journal*, **8**, 77-80.

Firkins, J. L., Yu, Z. & Morrison, M. (2007). Ruminal nitrogen metabolism: perspectives for integration of microbiology and nutrition for dairy. *Journal of Dairy Science*, **90**, E1-E16.

Fraser, G. E. (1999). Associations between diet and cancer, ischemic heart disease, and all-cause mortality in non-Hispanic white California Seventh-day Adventists. *The American Journal of Clinical Nutrition*, **70**(3), 532s-538s.

Folch, J., Lees, M. & Stanley, G. H. S. (1957). A simple method for the isolation and purification of total lipids from animal tissues *Journal of Biological Chemistry*, **226**(1), 497-509.

Fonty, G. & Grenet, E. (1994). Effects of diet on the fungal population of the digestive tract of ruminants. In *Anaerobic Fungi: Biology, Ecology and Function*, eds. D. O. Mountfort & C. G. Orpin, Marcel Dekker. New York, pp 229-239.

Forster, R. J., Gong, J. & Teather, R. M. (1997). Group-specific 16S rRNA hybridization probes for determinative and community structure studies of Butyrivibrio fibrisolvens in the rumen. *Applied and Environmental Microbiology*, **63**(4), 1256-1260.

Girard, V. & Hawke, J. C. (1978). The role of holotrichs in the metabolism of dietary linoleic acid in the rumen. *Biochemistry Biophysics Acta* **528**, 17-27.

Givens, D. I. (2005). The role of animal nutrition in improving the nutritive value of animal-derived foods in relation to chronic disease. *Proceedings of the Nutrition Society*, **64**, 395-402.

Goh, Y. M. (2002). Dietary manipulation of using oil palm (Elaeis Guineensis) frond to increase the unsaturated fatty acid content of mutton under tropical conditions. In *Universiti Putra Malaysia, Malaysia*, Ph.D thesis pp. 354.

Goh, Y. M. & Rajion, M. A. (2007). Oil palm in ruminant nutrition: Opportunities and challenges. In *Symposium on Current Research on Feeds and Feeding of Ruminants in Tropical Countries*. Kasetsart University, Bangkhen Campus, Bangkok, Thailand, pp. 19-23.

Gonthier, C., Mustafa, A. F., Berthiaume, R. & Petit, H. V. (2004). Feeding micronized and extruded flaxseed to dairy cows: effects on digestion and ruminal biohydrogenation of long-chain fatty acids. *Canadian journal of animal science.*, **84**(4), 705-711.

Gonthier, C., Mustafa, A. F., Ouellet, D. R., Chouinard, P. Y., Berthiaume, R. & Petit, H. V. (2005). Feeding Micronized and Extruded Flaxseed to Dairy Cows: Effects on Blood Parameters and Milk Fatty Acid Composition. *Journal of Dairy Science*, **88**(2), 748-756.

Griffith, G. W., Ozkose, E., Theodorou, M. K. & Davies, D. R. (2009). Diversity of anaerobic fungal populations in cattle revealed by selective enrichment culture using different carbon sources. *Fungal Ecology*, **2**(2), 87-97.

Grenet, E., Breton, A., Barry, P. & Fonty, G. (1989). Rumen anaerobic fungi and plant substrate colonization as affected by diet composition. *Animal Feed Science and Technology*, **26**(1–2), 55-70.

Grummer, R. R. (1988). Influence of Prilled Fat and Calcium Salt of Palm Oil Fatty Acids on Ruminal Fermentation and Nutrient Digestibility. *Journal of Dairy Science*, **71**(1), 117-123.

Grundy, S. M. & Denke, M. A. (1990). Dietary influences on serum lipids and lipoproteins. *Journal of Lipid Research*, **31**(7), 1149-72.

Grundy, S. M. (1994). Influence of stearic acid on cholesterol metabolism relative to other long-chain fatty acids. *The American Journal of Clinical Nutrition*, **60**(6), 986S-990S.

Grundy, S. M., Cleeman, J. I., Merz, C. N. B., Brewer, H. B., Clark, L. T., Hunninghake, D. B., Pasternak, R. C., Smith, S. C., Stone, N. J., Program, f. t. C. C. o. t. N. C. E., Endorsed by the National Heart, L., Blood Institute, A. C. o. C. F. & Association, A. H. (2004). Implications of Recent Clinical Trials for the National Cholesterol Education Program Adult Treatment Panel III Guidelines. *Circulation*, **110**(2), 227-239.

Hadad, S. G. & Younis, H. M. (2004). The effect of adding ruminally protected fat in fattening diets on nutrient intake, digestibility and growth performance of Awassi lambs. *Animal Feed Science and Technology*, **113**, 61-69.

Halim. (1993). Forages for ruminants. In *The Animal Industry in Malaysia*, eds. C. T. N. I. Fatima, A. H. Ramlah & A. R. Bahaman, Faculty of Veterinary medicine and Animal Science, University Putra Malaysia, Malaysia., pp. 7-12.

Harfoot, C. G. & Hazlewood, G. P. (1997). Lipid metabolism in the rumen. 2nd ed. In *The Rumen Microbial Ecosystem*, eds. N. Hobson & C. S. Stewart., Chapman and Hall. London, UK, pp. 382-426.

HMSO. (1994). Nutritional aspects of the cardiovascular disease. Report of health and social subjects No. 46. London: Her Majesty's Stationery Office.

Hegarty, R. S. (1999). Reducing rumen methane emissions through elimination of rumen protozoa. *Australian Journal of Agricultural Research*, **50**(8), 1321-1328.

Hess, H. D., Monsalve, L. M., Lascano, C. E., Carulla, J. E., Díaz, T. E. & Kreuzer, M. (2003). Supplementation of a tropical grass diet with forage legumes and Sapindus saponaria fruits: Effects on *in vitro* ruminal nitrogen turnover and methanogenesis. *Australian Journal of Agricultural Research*, **54**(7), 703-713.

Hindle, V. A., Steg, A., van Vuuren, A. M. & Vroons-de Bruin, J. (1995). Rumen degradation and post-ruminal digestion of palm kernel by-products in dairy cows. *Animal Feed Science and Technology*, **51**(1-2), 103-121.

Ho, Y. W., Wong, H. K., Abdullah, N. & Tajuddin, Z. A. (1991). Recent advanced on the nutrition of herbivores. *Malasian society of animal production, 300 pp*.

Hook, S. E., Dijkstra, J., Wright, A. D. G., McBride, B. W. & France, J. (2012). Modeling the distribution of ciliate protozoa in the reticulo-rumen using linear programming. *Journal of Dairy Science*, **95**(1), 255-265.

Hristov, A. N., Grandeen, K. L., Ropp, J. K. & McGuire, M. A. (2004). Effect of Sodium Laurate on Ruminal Fermentation and Utilization of Ruminal Ammonia Nitrogen for Milk Protein Synthesis in Dairy Cows. *Journal of Dairy Science*, **87**(6), 1820-1831.

Hristov, A. N., Ivan, M. & McAllister, T. A. (2004a). *In vitro* effects of individual fatty acids on protozoal numbers and on fermentation products in ruminal fluid from cattle fed a high-concentrate, barley-based diet. *Journal of Animal Science*, **82**(9), 2693-2704.

Hristov, A. N., Vander Pol, M., Agle, M., Zaman, S., Schneider, C., Ndegwa, P., Vaddella, V. K., Johnson, K., Shingfield, K. J. & Karnati, S. K. R. (2009). Effect of lauric acid and coconut oil on ruminal fermentation, digestion, ammonia losses from manure, and milk fatty acid composition in lactating cows. *Journal of Dairy Science*, **92**(11), 5561-5582.

Hu, F. B., Stampfer, M. J., Manson, J. E., Rimm, E., Colditz, G. A., Rosner, B. A., Hennekens, C. H. & Willett, W. C. (1997). Dietary Fat Intake and the Risk of Coronary Heart Disease in Women. *New England Journal of Medicine*, **337**(21), 1491-1499.

Hu, F. B., Stampfer, M. J., Manson, J. E., Aschiero, A., Colditz, G. A. & Speizer, F. E. (1999). Dietary saturated fats and their food sources in relation to the risk of coronary heart disease in women. *American Journal of Clinical Nutrition*, **70**, 1001-1008.

Hungate, E. R. (1966). *The Rumen and its Microbes. Academic Press, New York.*

Hungate, R. E. (1969). A rool tube method for cultivation of strict anaerobes. In *Methods in Microbiology*, ed. J. R. N. a. D. W. Ribbons, Vol. 3B, Academic Press,. London and New York, pp. 117-132.

Hutagulung, R. I. & Mahyuddin, M. D. (1985). Nutritive values and feeding systems on palm kernel cake and palm press fiber for ruminants.

Proceedings 3rd Asian-Australasian Association of Animal Production Societies, Volume 2. 983-985.

Islam, M., Dahlan, I., Rajion, M. A. & Jelan, Z. A. (2000). Rumen pH and Ammonia Nitrogen of cattle fed different levels of oil palm (Elaeis guineensis) fronds based diets and dry matter degradation of fractions of oil palm fronds. *Asian-Australian Journal of Animal Science*, **13**, 941-947.

Ivan, M., Hidiroglou, M. & Petit, H. V. (1991). Duodenal flow of nitrogen following protozoal inoculation of fauna-free sheep fed a diet supplemented with casein or soybean meal. *Canadian Journal of Animal Science*, **71**, 793-801.

Ivan, M., Daynellde, M. S., Mahadevan, S. & Hidiroglou, M. (1992). Effect of bentonite on wool growth and nitrogen metabolism in fauna free and faunated sheep. *Journal of Animal Science*, **70**, 3194–3202.

Ivan, M., Entz, T., Mir, P. S., Mir, Z. & McAllister, T. A. (2003). Effects of sunflower seed supplementation and different dietary protein concentrations on the ciliate protozoa population dynamics in the rumen of sheep *Canadian Journal Animal Science*, **83** (4), 673-685

Ivan, M., Koenig, K. M., Morgavi, D. P., Rode, L. M., Newbold, C. J. & Entz, T. (2006). Duodenal flow and digestibility in fauna-free sheep and in sheep monofaunated with Entodinium caudatum or Polyplastron multivesiculatum. *British Journal of Nutrition*, **95**(3), 469-476.

Ivan, M. (2009). Comparison of duodenal flow and digestibility in fauna-free sheep inoculated with Holotrich protozoa, Entodinium monofauna or total mixed protozoa population. *British Journal of Nutrition*, **101**, 34-40.

Ivan, M., Chiquette, J., Petit, H. V. & Alimon, A. R. (2009). Effects of dietary linoeic and linolenic acids on the rumen population of cellulolytic bacteria and ciliate protozoa in dairy cows. . *Ruminant physiology, Digestion, metabolism and effects of nutrition on reproduction and welfare.* Proceedings Of the XIth International Symposium on Ruminant Physiology. Wageningen Academic Publ. 220-221.

Ivan, M., Petit, H. V., Chiquette, J. & Wright, A.-D. G. (2013). Rumen fermentation and microbial population in lactating dairy cows receiving diets containing oilseeds rich in C-18 fatty acids. *British Journal of Nutrition*, **109**(07), 1211-1218.

Jalaludin, S., Jelan, Z. A., Abdullah, N. & Ho, Y. W. (1991). Recent developments in the oil palm by-product based ruminant feeding system. *Proceedings 3rd*

International Symposium Nutrition Herbivores Malaysian Society Animal Production. 35-44.

Jelan, Z. A. (2005). Recent advances in animal nutrition in Malaysia: its relevance and importance for farming system in Indonesia. In *National Seminar on Animal Husbandry and Veterinary Technology, 12-13 September*. Bogor, Indonesia.

Jenkins, T. C. & Palmquist, D. L. (1984). Effect of Fatty Acids or Calcium Soaps on Rumen and Total Nutrient Digestibility of Dairy Rations. *Journal of Dairy Science*, **67**(5), 978-986.

Jenkins, T. C. (1993). Lipid Metabolism in the Rumen. *Journal of Dairy Science*, **76**(12), 3851-3863.

Jenkins, T. C., Wallace, R. J., Moate, P. J. & Mosley, E. E. (2008). Recent advances in biohydrogenation of unsaturated fatty acids within the rumen microbial ecosystem. *Journal of Animal Science*, **86**, 397-412.

Dijkstra, J., Ellis, J. L., Kebreab, E., Strathe, A. B., López, S., France, J. & Bannink, A. (2012). Ruminal pH regulation and nutritional consequences of low pH. *Animal Feed Science and Technology*, **172**(1–2), 22-33.

Joblin, K. N. (1981). Isolation, Enumeration, and Maintenance of Rumen Anaerobic Fungi in Roll Tubes. *Applied and Environmental Microbiology*, **42**(6), 1119-1122.

Johnson, D. D., Eastridge, J. S., Neubauer, D. R. & McGowan, C. H. (1995). Effect of sex class on nutrient content of meat from young goat. *Journal of Animal Science* **73**, 296-301.

Jouany, J. P. (1994). Manipulation of microbial activity in the rumen. *Archiv fur Tierernaehrung*, **46**(2), 133 - 153.

Jouany, J.-P. (1996). Effect of Rumen Protozoa on Nitrogen Utilization by Ruminants. *Journal of Nutrition*, **126**(4_Suppl), 1335S-1346.

Judd, J., Baer, D., Clevidence, B., Kris-Etherton, P., Muesing, R. & Iwane, M. (2002). Dietary cis and trans monounsaturated and saturated FA and plasma lipids and lipoproteins in men. *Lipids*, **37**(2), 123-131.

Katan, M. B., Zock, P. L. & Mensink, R. P. (1994). Effects of fats and fatty acids on blood lipids in humans: an overview. *American Journal of Clinical Nutrition*, **60**(suppl), 10117S-1022S.

Khejornsart, P., Wanapat, M. & Rowlinson, P. (2011). Diversity of anaerobic fungi and rumen fermentation characteristic in swamp buffalo and beef cattle fed on different diets. *Livestock Science*, **139**(3), 230-236.

Kelemen, L. E., Kushi, L. H., Jacobs, D. R. & Cerhan, J. R. (2005). Associations of Dietary Protein with Disease and Mortality in a Prospective Study of Postmenopausal Women. *American Journal of Epidemiology*, **161**(3), 239-249.

Kingsbury, K. J., Morgan, D. M., Stovold, R., Brett, C. G. & Anderson, J. (1969). Polyunsaturated fatty acids and myocardial infarction. Follow up of patients with aortoiliac and femoropopoliteal atheroschlerosis. *Lancet*, **294**, 1325-1329.

Kitessa, S., Flinn, P. C. & Irish, G. G. (1999). Comparison of methods used to predict the *in vivo* digestibility of feeds in ruminants. *Australian Journal of Agricultural Research*, **50**(5), 825-842.

Koenig, K. M., Newbold, C. J., McIntosh, F. M. & Rode, L. M. (2000). Effects of protozoa on bacterial nitrogen recycling in the rumen. *Journal of Animal Science*, **78**(9), 2431-2445.

Koike, S. & Kobayashi, Y. (2001). Development and use of competitive PCR assays for the rumen cellulolytic bacteria: Fibrobacter succinogenes, Ruminococcus albus and Ruminococcus flavefaciens. *FEMS Microbiology Letters*, **204**(2), 361-366.

Koike, S. & Kobayashi, Y. (2009). Fibrolytic rumen bacteria: their ecology and functions. *Asian-Australian Journal of Animal Science*, **22**, 131-138.

Kongmun, P., Wanapat, M., Pakdee, P. & Navanukraw, C. (2010). Effect of coconut oil and garlic powder on *in vitro* fermentation using gas production technique. *Livestock Science*, **127**(1), 38-44.

Kongmun, P., Wanapat, M., Pakdee, P., Navanukraw, C. & Yu, Z. (2011). Manipulation of rumen fermentation and ecology of swamp buffalo by coconut oil and garlic powder supplementation. *Livestock Science*, **135**(1), 84-92.

Kontogianni, M. D., Panagiotakos, D. B., Pitsavos, C., Chrysohoou, C. & Stefanadis, C. (2008). Relationship between meat intake and the development of acute coronary syndromes: the CARDIO2000 case-control study. *European Journal of Clinical Nutrition*, **62**, 171-177.

Krause, D. O. & Russell., J. B. (1996). How many ruminal bacteria are there? *Journal of Dairy Science*, **79** 1467-1475.

Kris-Etherton, P. M., Derr, J., Mitchell, D. C., Mustad, V. A., Russell, M. E., McDonnell, E. T., Salabsky, D. & Pearson, T. A. (1993). The role of fatty acid saturation on plasma lipids, lipoproteins, and apolipoproteins: I. Effects of whole food diets high in cocoa butter, olive oil, soybean oil, dairy butter, and milk chocolate on the plasma lipids of young men. *Metabolism*, **42**(1), 121-129.

Kromhout, D., Menotti, A., Bloemberg, B., Aravanis, C., Blackburn, H., Buzina, R., Dontas, A. S., Fidanza, F., Giaipaoli, S., Jansen, A., Karvonen, M., Katan, M., Nissinen, A., Nedeljkovic, S., Pekkanen, J., Pekkarinen, M., Punsar, S., Rasanen, L., Simic, B. & Toshima, H. (1995). Dietary Saturated and transFatty Acids and Cholesterol and 25-Year Mortality from Coronary Heart Disease: The Seven Countries Study. *Preventive Medicine*, **24**(3), 308-315.

Kudo, H., Cheng, K. J. & Costerton, J. W. (1987). Interactions between *Treponema bryantii* and cellulolytic bacteria in the *in vitro* digestion of straw cellulose. *Canadian Journal of Microbiology*, **33**, 241-248.

Kumar, S., Puniya, A., Puniya, M., Dagar, S., Sirohi, S., Singh, K. & Griffith, G. (2009). Factors affecting rumen methanogens and methane mitigation strategies. *World Journal of Microbiology and Biotechnology*, **25**(9), 1557-1566.

Laureles, L. R., Rodriguez, F. M., Reaño, C. E., Santos, G. A., Laurena, A. C. & Mendoza, E. M. T. (2002). Variability in Fatty Acid and Triacylglycerol Composition of the Oil of Coconut (Cocos nucifera L.) Hybrids and Their Parentals. *Journal of Agricultural and Food Chemistry*, **50**(6), 1581-1586.

Leaf, A., Xiao, Y.-F., Kang, J. X. & Billman, G. E. (2003). Prevention of sudden cardiac death by n−3 polyunsaturated fatty acids. *Pharmacology & Therapeutics*, **98**(3), 355-377.

Lee, J. H., Kouakou, B. & Kannan, G. (2008). Chemical composition and quality characteristics of chevon from goats fed three different post-weaning diets. *Small Ruminant Research*, **75**, 177–184.

Liu, H., Vaddella, V. & Zhou, D. (2011). Effects of chestnut tannins and coconut oil on growth performance, methane emission, ruminal fermentation, and microbial populations in sheep. *Journal of Dairy Science*, **94**(12), 6069-6077.

Liu, S. J., Bu, D. P., Wang, J. Q., Liu, L., Liang, S., Wei, H. Y., Zhou, L. Y., Li, D. & Loor, J. J. (2012). Effect of incremental levels of fish oil supplementation

on specific bacterial populations in bovine ruminal fluid. *Journal of Animal Physiology and Animal Nutrition*, **96**(1), 9-16.

Lough, D. S., Solomon, M. B., Rumsey, T. S., Kahl, S. & Slyter, L. L. (1993). Effects of high-forage diets with added palm oil on performance, plasma lipids, and carcass characteristics of ram and ewe lambs. *Journal of Animal Science*, **71**, 1171– 1176.

Lough, D. S., Solomon, M. B., Rumsey, T. S., Kahl, S. & Slyter, L. L. (1994). The effects of high-forage diets with added palm oil on performance, plasma lipids, and carcass characteristics of ram lambs with initially high or low plasma cholesterol. *Journal of Animal Science*, **72**, 330– 336.

Ma, A. N. (2000). Management of palm oil industrial effluents. In *Advances in Oil Palm Research*, eds. Y. Basiron, B. S. Jalani & K. W. Chan, Vol. II, pp. 1439–1461.

Machmuller, A. & Kreuzer, M. (1999). Methane suppression by cocconut oil and associated effects on nutrient and energy bablnce in sheep. *Canadian Journal of Animal Science*, **79**, 65-72.

Machmüller, A. (2006). Medium-chain fatty acids and their potential to reducemethanogenesis in domestic ruminants. *Agriculture, Ecosystems & Environment*, **112**(2-3), 107-114.

Maczulak, A. E., Dehority, B. A. & Palmquist, D. L. (1981). Effects of Long-Chain Fatty Acids on Growth of Rumen Bacteria. *Applied Environmental Microbiology*, **42**(5), 856-862.

Mahgoub, O., Khan, A. J., Al-Maqbaly, R. S., Al-Sabahi, J. N., Annamalai, K. & Al-Sakry, N. M. (2002). Fatty acid composition of muscle and fat tissues of Omani Jebel Akhdar goats of different sexes and weights. *Meat Science*, **61**, 381-387.

Mahgoub, O., Kadim, M. I. T., Al-Busaidi, H., Annamalai, K. & Al-Saqri, N. M. (2007). Effects of feeding ensiled date palm fronds and a by-product concentrate on performance and meat quality of Omani sheep. *Animal Feed Science and Technology*, **135**, 210-221.

Mahyuddin, M. D. (1993). Areview of the Malaysian Livestock industry. In *The Animal industry in Malaysia*, eds. C. T. N. I. Fatima, A. H. Ramlah & A. R. Bahaman, Faculty of Veterinary medicine and Animal Science, University Putra Malaysia, Malaysia., pp. 1-6.

Maia, M. R. G., Chaudhary, L. C., Figueres, L. & Wallace, R. J. (2007). Metabolism of polyunsaturated fatty acids and their toxicity to the microflora of the rumen. *Antonie Van Leeuwenhoek*, **91**(4), 303-314.

Maia, M., Chaudhary, L., Bestwick, C., Richardson, A., McKain, N., Larson, T., Graham, I. & Wallace, R. (2010). Toxicity of unsaturated fatty acids to the biohydrogenating ruminal bacterium, Butyrivibrio fibrisolvens. *BMC Microbiology*, **10**(1), 52.

Malaysian Standard MS 1500. (2004). Halal food - Production, Preparation, Handling and Storage - General guidelines. First revision, Department of standards Malaysia.

Manso, T., Castro, T., Mantecón, A. R. & Jimeno, V. (2006). Effects of palm oil and calcium soaps of palm oil fatty acids in fattening diets on digestibility, performance and chemical body composition of lambs. *Animal Feed Science and Technology*, **127**(3-4), 175-186.

Manso, T., Bodas, R., Castro, T., Jimeno, V. & Mantecon, A. R. (2009). Animal performance and fatty acid composition of lambs fed with different vegetable oils. *Meat Science*, **83**(3), 511-516.

Martin, C., Morgavi, D. P. & Moreau, D. (2010). Methane mitigation in ruminants: From microbe to the farm scale. *Animal*, **4**, 351–365.

Mapiye, C., Aldai, N., Turner, T. D., Aalhus, J. L., Rolland, D. C., Kramer, J. K. G. & Dugan, M. E. R. (2012). The labile lipid fraction of meat: From perceived disease and waste to health and opportunity. *Meat Science*, **92**(3), 210-220.

Matsumoto, M., Kobayashi, T., Takenaka, A. & Itabashi, H. (1991). Defaunation effects of medium-chain fatty acids and their derivatives on goat rumen protozoa. *Journal of General and Applied Microbiology*, **37**, 439-445.

McSweeney, C. S. & Denman, S. E. (2007). Effect of sulfur supplements on cellulolytic rumen micro-organisms and microbial protein synthesis in cattle fed a high fibre diet. *Journal of Applied Microbiology*, **103**(5), 1757-1765.

Meissner, H. H., Koster, H. H., Nieuwoudt, S. H. & Coetze, R. J. (1991). Effects of energy supplementation on intake and digestion of early and mid-season ryegrass and Panicum/Smuts finger hay, and on in sacco disappearance of various forage species. *South African Journal of Animal Science*, **21**, 33–42.

Mensink, R. P., Zock, P. L., Kester, A. D. M. & Katan, M. B. (2003). Effects of dietary fatty acids and carbohydrates on the ratio of serum total to HDL cholesterol and on serum lipids and apolipoproteins: A meta-analysis of 60 controlled trials. *American Journal of Clinical Nutrition*, **77**, 1146-1155.

Merchen, N. R. (2002). Nutrients, Digestion and Absortion - Fermentation in the rumen. In *Encyclopedia of Diary Sciences*, eds. H. Roginski, J. Fuquay & P. Fox, Elsevier Siecnce, pp. 2112-2120.

Miettinen, T. A., Naukkarinen, V., Huttunen, J. K., Mattila, S. & Kumlin, T. (1982). Fatty-acid composition of serum lipids predicts myocardial infarction. *British Medical Journal*, **285**(6347), 993-996.

Minson, D. J. (1990). *Forage in Ruminant Nutrition, 1st edn.Academic Press, New York.* .

Mir, P. S., Mir, Z., Kuber, P. S., Gaskins, C. T., Martin, E. L., Dodson, M. V., Elias Calles, J. A., Johnson, K. A., Busboom, J. R., Wood, A. J., Pittenger, G. J. & Reeves, J. J. (2002). Growth, carcass characteristics, muscle conjugated linoleic acid (CLA) content, and response to intravenous glucose challenge in high percentage Wagyu, Wagyu × Limousin, and Limousin steers fed sunflower oil-containing diets. *Journal of Animal Science*, **80**(11), 2996-3004.

Mir, P. S., McAllister, T. A., Zaman, S., Morgan Jones, S. D., He, M. L., Aalhus, J. L., Jeremiah, L. E., Goonewardene, L. A., Weselake, R. J. & Mir, Z. (2003). Effect of dietary sunflower oil and vitamin E on Beef cattle performance, carcass characteristics and meat quality. *Canadian Journal of Animal Science*, **83**(1), 53-66.

Morand-Fehr, P. (2005). Recent developments in goat nutrition and application: a review. *Small Ruminant Research*, **60**, 25-43.

Mosoni, P., Martin, C., Forano, E. & Morgavi, D. P. (2011). Long-term defaunation increases the abundance of cellulolytic ruminococci and methanogens but does not affect the bacterial and methanogen diversity in the rumen of sheep. *Journal of Animal Science*, **89**(3), 783-791.

Moss, A. R. & Givens, D. I. (1994). The chemical composition, digestibility, metabolisable energy content and nitrogen degradability of some protein concentrates. *Animal Feed Science and Technology*, **47**, 335-351.

MPOB. (2010). Production of palm kernel cake for the month of December 2009.

Mould, F. L. & Ørskov, E. R. (1983). Manipulation of rumen fluid pH and its influence on cellulolysis in *in sacco*, dry matter degradation and the rumen microflora of sheep offered either hay or concentrate. *Animal Feed Science and Technology*, **10**(1), 1-14.

Mushi, D. E., Thomassen, M. S., Kifaro, G. C. & Eik, L. O. (2010). Fatty acid composition of minced meat, longissimus muscle and omental fat from Small East African goats finished on different levels of concentrate supplementation. *Meat Science*, **86**(2), 337-342.

Mustafa, M. & Kamal, H. (1982). A study of goat production under two systems of management. In: Animal production and Animal health in the tropics. *first Asian-Austaralian Animal Science Congress*, Serdang, 329-332.

Naik, P. K., Saijpaul, S. & Rani, N. (2009). Effect of ruminally protected fat on *in vitro* fermentation and apparent nutrient digestibility in buffaloes (Bubalus bubalis). *Animal Feed Science and Technology*, **153**(1-2), 68-76.

Najafi, M. H., Zeinoaldini, S., Ganjkhanlou, M., Mohammadi, H., Hopkins, D. L. & Ponnampalam, E. N. (2012). Performance, carcass traits, muscle fatty acid composition and meat sensory properties of male Mahabadi goat kids fed palm oil, soybean oil or fish oil. *Meat Science*, **92**(4), 848-854.

NCBA. (2008). National Cattlemen's Beef Association. Beef lipids in perspective. http://www.beefresearch.org/CMDocs/BeefResearch/Beef%20Lipids.

Newbold, C. J. & Chamberlain, D. G. (1988). Lipids as rumen defaunating agents. *Proceedings of Nutrition Society*, **47**, 154A.

Nicolosi, R. J., Wilson, T. A., Rogers, E. J. & Kritchevsky, D. (1998). Effects of specific fatty acids (8:0,14:0, cis-18:1, trans-18:1) on plasma lipoproteins, early atherogenic potential, and LDL oxidative properties in the hamster. *Journal of Lipid Research*, **39**(10), 1972-1980.

Nicolosi, R., Stucchi, A., Kowala, M., Hennessy, L., Hegsted, D. & Schaefer, E. (1990). Effect of dietary fat saturation and cholesterol on LDL composition and metabolism. In vivo studies of receptor and nonreceptor-mediated catabolism of LDL in cebus monkeys. *Arteriosclerosis, Thrombosis, and Vascular Biology*, **10**(1), 119-128.

Nigdi, M. E., Loerch, S. C., Fluharly, F. L. & Palmquist, D. L. (1990). Effects of calcium soaps of long chain fatty acids on feedlot performance, carcass characteristics and animal metabolism of steer. *Journal Animal Science*, **68**, 2555-2565

Noakes, M. N., Nestle, P. J. & Clifton, T. M. (1996). Modifying the fatty acids profile of dairy products through feedlot technology lowers plasma cholesterol of humans consuming the products. *American Journal of Clinical Nutrition*, **63**, 42-46.

Noci, F., O'Kiely, P., Monahan, F. J., Stanton, C. & Moloney, A. P. (2005). Conjugated linoleic acid concentration in *M. Longissimus dorsi* from heifers offered sunflower oil-based concentrates and conserved forages. *Meat Science*, **69**(3), 509-518.

Noci, F., Monahan, F. J., Scollan, N. D. & Moloney, A. P. (2007). The fatty acid composition of muscle and adipose tissue of steers offered unwilted or wilted grass silage supplemented with sunflower oil and fish oil. *British Journal of Nutrition*, **97**, 502-513.

Nuernberg, K., Dannenberger, D., Nuernberg, G., Ender, K., Voigt, J., Scollan, N. D., Wood, J. D., Nute, G. R. & Richardson, R. I. (2005). Effect of a grass-based and a concentrate feeding system on meat quality characteristics and fatty acid composition of longissimus muscle in different cattle breeds. *Livestock Production Science*, **94**(1–2), 137-147.

Oshibe, M., Wan Zahari, M., Nor Ismail, S., Subramaniam, K. & Hayakawa, H. (2000). Effects of varying levels of oil palm fronds on intake and growth performance of beef cattle. *In: Proceedings of 22nd Malaysian Society of Animal Production Annual Conference*, Kota Kinabalu, Malaysia.

O'Mara, F. P., Mulligan, F. J., Cronin, E. J., Rath, M. & Caffrey, P. J. (1999). The nutritive value of palm kernel meal measured in vivo and using rumen fluid and enzymatic techniques. *Livestock Production Science*, **60**, 305-316.

Ozutsumi, Y., Tajima, K., Takenaka, A. & Itabashi, H. (2006). Real-Time PCR Detection of the Effects of Protozoa on Rumen Bacteria in Cattle. *Current Microbiology*, **52**(2), 158-162.

Paepatung, N., Nophatatana, N. & Songkasiri, W. (2009). Biomethane potential of biological solid and agricultural wastes. *Asian Journal on Energy and Environment*, **10**, 19-27.

Palmonari, A., Stevenson, D. M., Mertens, D. R., Cruywagen, C. W. & Weimer, P. J. (2010). pH dynamics and bacterial community composition in the rumen of lactating dairy cows. *Journal of Dairy Science*, **93**(1), 279-287.

Paillard, D., McKain, N., Chaudhary, L., Walker, N., Pizette, F., Koppova, I., McEwan, N., Kopency, J., Vercoe, P., Louis, P. & Wallace, R. (2007). Relation between phylogenetic position, lipid metabolism and butyrate

production by different Butyrivibrio-like bacteria from the rumen. *Antonie Van Leeuwenhoek*, **91**(4), 417-422.

Panyakaew, P., Goel, G., Lourenço, M., Yuangklang, C. & Fievez, V. (2013). Medium-chain fatty acids from coconut or krabok oil inhibit *in vitro* rumen methanogenesis and conversion of non-conjugated dienoic biohydrogenation intermediates. *Animal Feed Science and Technology* (accepted).

Park, W. Y. & Washington, A. C. (1993). Fatty acid composition of goat organ and muscle meat of Alpine and Nubian breeds. *Journal of Food Science*, **58**, 245-253.

Partida, J. A., Olleta, J. L., Sanudo, C., Alberti, P. & Campo, M. M. (2007). Fatty acid composition and sensory traits of beef fed palm oil supplements. *Meat Science*, **76**, 444-454.

Patra, A. (2012). Enteric methane mitigation technologies for ruminant livestock: a synthesis of current research and future directions. *Environmental Monitoring and Assessment*, **184**(4), 1929-1952.

Patra, A. K. & Yu, Z. (2013). Effects of coconut and fish oils on ruminal methanogenesis, fermentation, and abundance and diversity of microbial populations *in vitro*. *Journal of Dairy Science* (accepted).

Peña, F., Juárez, M., Bonvillani, A., Garcia, P., Polvillo, O. & Domenech, V. (2011). Muscle and genotype effects on fatty acid composition of goat kid intramuscular fat. *Italian Journal of Animal Science*, **10**, 212-216.

Petri, R. M., Forster, R. J., Yang, W., McKinnon, J. J. & McAllister, T. A. (2012). Characterization of rumen bacterial diversity and fermentation parameters in concentrate fed cattle with and without forage. *Journal of Applied Microbiology*, **112**(6), 1152-1162.

Pilajun, R. & Wanapat, M. (2013). Microbial population in the rumen of swamp buffalo (Bubalus bubalis) as influenced by coconut oil and mangosteen peel supplementation. *Journal of Animal Physiology and Animal Nutrition*, **97**(3), 439-445.

Pimpa, B., Ruengsuwan, S. & Pimpa, O. (2009). Physical and chemical characteristics of by-products from palm oil mill for ruminant feed. *Proceeding of 11th Agriculture Conference, Khon Kaen University*, Khon Kaen, February1 -3, 2009. 221-223. (in Thai).

Potu, R., AbuGhazaleh, A., Hastings, D., Jones, K. & Ibrahim, S. (2011). The effect of lipid supplements on ruminal bacteria in continuous culture fermenters varies with the fatty acid composition. *The Journal of Microbiology*, **49**(2), 216-223.

Prins, R., Van Nevel, C. & Demeyer, D. (1972). Pure culture studies of inhibitors for methanogenic bacteria. *Antonie Van Leeuwenhoek*, **38**(1), 281-287.

Raes, K., Haak, L., Balcaen, A., Claeys, E., Demeyer, D. & De Smet, S. (2004). Effect of linseed feeding at similar linoleic acid levels on the fatty acid composition of double-muscled Belgian Blue young bulls. *Meat Science*, **66**(2), 307-315.

Rahman, M., Abdullah, R., Wan Embong, W., Nakagawa, T. & Akashi, R. (2012). Effect of palm kernel cake as protein source in a concentrate diet on intake, digestibility and live weight gain of goats fed Napier grass. *Tropical Animal Health and Production.* (in press. accepted).

Rahman, N. N. A., Al-Rawi, S. S., Ibrahim, A. H., Ben Nama, M. M. & Ab Kadir, M. O. (2012). Supercritical carbon dioxide extraction of the residual oil from palm kernel cake. *Journal of Food Engineering*, **108**(1), 166-170.

Rajion, M. A., McLean, J. G. & Cahill, R. N. (1985). Essential fatty acids in the fetal and newborn lamb. *Australian Journal of Biological Sciences*, **38**, 33-40.

Rajion, M. A., Alimon, A. R. & Davis, M. P. (1993). Goat and Sheep production. In *The Animal Industry in Malaysia*, eds. C. T. N. I. Fatima, A. H. Ramlah & A. R. Bahaman, Faculty of Veterinary Medicine and Animal Science, Universiti Putra Malaysia, Malaysia, pp. 51-68.

Rajion, M. A., Goh, Y. M., Dahlan, I. & Abdullah, S. (2001). Dietary manipulation and increase in plasma unsaturated fatty acids in sheep. *Asian-Australian Journal of Animal Science*, **14**, 1073-1077.

Reed, J., Soller, H. & Woodward, A. (1990). Fodder tree and straw diets for sheep: intake, growth, digestibility and the effects of phenolics on nitrogen utilisation. *Animal Feed Science and Technology*, **30**, 39-50.

Rhee, K. S., Waldron, D. F., Ziprin, Y. A. & Rhee, K. C. (2000). Fatty acid composition of goat diets vs. intramuscular fat. *Meat Science*, **54**, 313-318.

Ribeiro, R. D. X., Oliveira, R. L., Macome, F. M., Bagaldo, A. R., Silva, M. C. A., Ribeiro, C. V. D. M., Carvalho, G. G. P. & Lanna, D. P. D. (2011). Meat quality of lambs fed on palm kernel meal, a by-product of biodiesel production. *Asian-Australian Journal of Animal Sciences*, **24**(10), 1399-1406.

Robertson, J. B. & Van Soest, P. J. (1981). The detergent system of analysis and its application in human foods. In *Analysis of Dietary Fiber in Food*, eds. W. P. T. James & O. Theander, T. Marcell Dekker Inc. New York, N.Y., Basel, pp. 123–158.

Rosli, A., Mohd-Bsari, W. & Arrifin, D. (2001). Integration of livestock in palntation crops. *proceedings of the 2nd International Congress/13th Veterinary Association Malaysia (VAM) Scientific Congress and CVA-Australian/Oceania regional Symposium* 27-30 August Kuala Lumpur, Malaysia. 35-44.

Russo, C., Preziuso, G., Casarosa, L., Campodoni, G. & Cianci, D. (1999). Effect of diet energy source on the chemical–physical characteristics of meat and depot fat of lambs carcasses. *Small Ruminant Research*, **33**, 77-85.

Sackmann, J. R., Duckett, S. K., Gillis, M. H., Realini, C. E., Parks, A. H. & Eggelston, R. B. (2003). Effects of forage and sunflower oil levels on ruminal biohydrogenation of fatty acids and conjugated linoleic acid formation in beef steers fed finishing diets. *Journal of Animal Science*, **81**(12), 3174-3181.

Sadeghi, A. A., Nikkhah, A., Shawrang, P. & Shahrebabak, M. M. (2006). Protein degradation kinetics of untreated and treated soybean meal using SDS-PAGE. *Animal Feed Science and Technology*, **126**(1–2), 121-133.

Santos-Silva, J., Bessa, R. J. B. & Santos-Silva, F. (2002). Effect of genotype, feeding system and slaughter weight on the quality of light lambs: II. Fatty acid composition of meat. *Livestock Production Science*, **77**(2–3), 187-194.

Santra, A. & Karim, S. A. (2000). Growth performance of faunated and defaunated Malpura weaner lambs. *Animal Feed Science and Technology*, **86** 251–260.

Santra, A. & Karim, S. A. (2002). Nutrient utilization and growth performance of defaunated and faunated lambs maintained on complete diets containing varying proportion of roughage and concentrate. *Animal Feed Science and Technology*, **101**, 87-99.

Santra, A., Chaturvedi, O. H., Tripathi, M. K., Kumar, R. & Karim, S. A. (2003). Effect of dietary sodium bicarbonate supplementation on fermentation characteristics and ciliate protozoal population in rumen of lambs. *Small Ruminant Research*, **47**(3), 203-212.

Santra, A., Karim, S. A. & Chaturvedi, O. H. (2007). Rumen enzyme profile and fermentation characteristics in sheep as affected by treatment with sodium lauryl sulfate as defaunating agent and presence of ciliate protozoa. *Small Ruminant Research*, **67**(2-3), 126-137.

SAS. (2003). SAS User's Guide: Statistics. 9.1 ed, SAS Institute Inc. Cary, NC.

Satter, L. D. & Slyter, L. L. (1974). Effect of ammonia concentration on rumen microbial protein production *in vitro*. *British Journal of Nutrition*, **32**, 199-208.

Scerra, M., Caparra, P., Foti, F., Cilione, C., Zappia, G., Motta, C. & Scerra, V. (2011). Intramuscular fatty acid composition of lambs fed diets containing alternative protein sources. *Meat Science*, **87**(3), 229-233.

Scollan, N. D., Choi, N. J., Kurt, E., Fisher, A. V., Enser, M. & Wood, J. D. (2001). Manipulating the fatty acid composition of muscle and adipose tissue in beef cattle. *British Journal of Nutrition*, **85** 115-124.

Seephueak, W., Ngampongsai, W. & Chanjula, P. (2011). Effects of palm oil sludge in concentrate on nutrient utilization and rumen ecology of thai native cattle fed with hay. *Songklanakarin Journal of Science and Technology*, **33**(3), 271-280.

Shekelle, R. B., Shryock, A. M., Paul, O., Lepper, M., Stamler, J., Liu, S. & Raynor, W. J. (1981). Diet, Serum Cholesterol, and Death from Coronary Heart Disease. *New England Journal of Medicine*, **304**(2), 65-70.

Shinkai, T. & Kobayashi, Y. (2007). Localization of Ruminal Cellulolytic Bacteria on Plant Fibrous Materials as Determined by Fluorescence In Situ Hybridization and Real-Time PCR. *Applied and Environmental Microbiology*, **73**(5), 1646-1652.

Silva, H. G. O., Pires, A. J. V., Silva, F. F., C. M. Veloso, Carvalho, G. G. P., Cezário, A. S. & Santos, C. C. (2005). Apparent digestibility of diets containing cocoa meal and palm kernel cake in lactating goats. *Pesquisa Agropecuária Brasileira*, **40**(4), 405-411.

Simon, J. A., Hodgkins, M. L., Browner, W. S., Neuhaus, J. M., Bernert, J. T. & Hulley, S. B. (1995). Serum Fatty Acids and the Risk of Coronary Heart Disease. *American Journal of Epidemiology*, **142**(5), 469-476.

Simopoulos, A. P. (1999). Essential fatty acids in health and chronic disease. *American Journal of Clinical Nutrition*, **70**, 506S-509S.

Skillman, L. C., Toovey, A. F., Williams, A. J. & Wright, A.-D. G. (2006). Development and Validation of a Real-Time PCR Method To Quantify Rumen Protozoa and Examination of Variability between Entodinium Populations in Sheep Offered a Hay-Based Diet. *Applied and Environmental Microbiology*, **72**(1), 200-206.

Smith, G. C., Carpenter, Z. L. & Shelton, M. (1978). Effect of age and quality level on the palatability of goat meat. *Journal of Animal Science*, **46**, 1229-1235.

Soliva, C. R., Hindrichsen, I. K., Meile, L., Kreuzer, M. & Machmüller, A. (2003). Effects of mixtures of lauric and myristic acid on rumen methanogens and methanogenesis *in vitro*. *Letters in Applied Microbiology*, **37**(1), 35-39.

Solomon, M. B., Lynch, G. P., Paroczay, E. & Norton, S. (1991). Influence of rapeseed meal, whole rapeseed and soybean meal on fatty acid composition and adipose tissue from ram lambs. *Journal of Animal Science*, **69**, 4055-4061.

Solomon, M. B., Lynch, G. P. & Lough, D. S. (1992). Influence of dietary palm oil supplementation on serum lipid metabolites, carcass characteristics, and lipid composition of carcass tissues of growing ram and ewe lambs. *Journal of Animal Science*, **70**, 2746-2751.

Spady, D. K. & Dietschy, J. M. (1985). Dietary saturated triacylglycerols suppress hepatic low density lipoprotein receptors in the hamster. *Proceedings of National Academy of Science USA*, **82**(13), 4526-4530.

Steel, R. G. & Torrie, J. H. (1980). *Principles and Procedures of Statistics: A biometric Approach*. *2nd ed*. McGraw-Hill Book, New York.

Sundram, K., Hayes, K. C. & Siru, O. H. (1994). Dietary palmitic acid results in lower serum cholesterol than does a lauric-myristic acid combination in normolipemic humans. *The American Journal of Clinical Nutrition*, **59**(4), 841-6.

Sutton, J. D., Knight, R., McAllan, A. B. & Smith, R. H. (1983). Digestion and synthesis in the rumen of sheep given diets supplemented with free and protected oils. *British Journal of Nutrition*, **49**(03), 419-432.

Sylvester, J. T., Karnati, S. K. R., Yu, Z., Morrison, M. & Firkins, J. L. (2004). Development of an Assay to Quantify Rumen Ciliate Protozoal Biomass in Cows Using Real-Time PCR. *The Journal of Nutrition*, **134**(12), 3378-3384.

Talebzadeh, R., Alipour, D., Saharkhiz, M. J., Azarfar, A. & Malecky, M. (2012). Effect of essential oils of *Zataria multiflora* on *in vitro* rumen fermentation, protozoal population, growth and enzyme activity of anaerobic fungus isolated from Mehraban sheep. *Animal Feed Science and Technology*, **172**(3–4), 115-124.

Talpur, F. N., Bhanger, M. & Sherazi, S. (2008). Intramuscular fatty acid profile of longissimus dorsi and semitendinosus muscle from Pateri goats fed under traditional feeding system of Sindh, Pakistan. *Meat Science*, **80**, 819-922.

Tan, H. Y., Sieo, C. C., Abdullah, N., Liang, J. B., Huang, X. D. & Ho, Y. W. (2011). Effects of condensed tannins from Leucaena on methane production, rumen fermentation and populations of methanogens and protozoa *in vitro*. *Animal Feed Science and Technology*, **169**(3–4), 185-193.

Tas, B. M. (2006). Nitrogen utilization of perenial ryegrass in daory cows. In *Fresh Herbage for Dairy cattle*, eds. A. Elggersma, J. Dijkstra & S. Tamminga, Springer. Wageningen, Netherlands, pp. 125-140.

Theodorou, M. K., Lowe, S. E. & Trinci, A. P. J. (1992). Anaerobic fungi and the rumen ecosystem. In *The Fungal Community: Its Organisation and Role in the Ecosystem*, eds. G. C. Carroll & D. T. Wicklow, Marcel Dekker Inc, New York, pp 43-71.

Tholstrup, T., Marckmann, P., Jespersen, J. & Sandström, B. (1994). Fat high in stearic acid favorably affects blood lipids and factor VII coagulant activity in comparison with fats high in palmitic acid or high in myristic and lauric acids. *The American Journal of Clinical Nutrition*, **59**(2), 371-7.

Todaro, M., Carrao, A., Alicata, M. L., Schinelli, R., Giaccone, P. & Priolo, A. (2004). Effect of litter size and sex on meat quality traits of kid meat. *Small Ruminant Research*, **54**, 191-196.

Tolera, A. & Sundstol, F. (2000). Supplementation of graded levels of *Desmodium intortum* hay to sheep feeding on maize stover harvested at three stages of maturity: 2. Rumen fermentation and nitrogen metabolism. *Animal Feed Science and Technology*, **87**(3-4), 215-229.

Trinci, A. P. J., Davies, D. R., Gull, K., Lawrence, M. I., Bonde Nielsen, B., Rickers, A. & Theodorou, M. K. (1994). Anaerobic fungi in herbivorous animals. *Mycological Research*, **98**(2), 129-152.

Tripathi, M., Chaturvedi, O., Karim, S., Singh, V. & Sisodiya, S. (2007). Effect of different levels of concentrate allowances on rumen fluid pH, nutrient

digestion, nitrogen retention and growth performance of weaner lambs. *Small Ruminant Research*, **72**, 178-186.

Turner, T. D., Karlsson, L., Mapiye, C., Rolland, D. C., Martinsson, K. & Dugan, M. E. R. (2012). Dietary influence on the m. *longissimus dorsi* fatty acid composition of lambs in relation to protein source. *Meat Science*, **91**(4), 472-477.

Utomo, B. N. & Widjaja., E. (2004). Limbah padat pengolahan minyak sawit sebagai sumber nutrisi ternak ruminansia. *Jurnal Libang Pertanian*, **23**, 22-28.

Vaithiyanathan, S., Bhatta, R., Mishra, A. S., Prasad, R., Verma, D. L. & Singh, N. P. (2007). Effect of feeding graded levels of Prosopis cineraria leaves on rumen ciliate protozoa, nitrogen balance and microbial protein supply in lambs and kids. *Animal Feed Science and Technology*, **133**(3-4), 177-191.

Van Harten, S., Almeida, A. M., Morais, Z., Schwalbach, L. M., Greyling, J. P., de Waal, H. O. & Cardoso, L. A. (2003). Free fatty acids and fatty acids of triacylglycerols profiles in muscle and plasma of fed and underfed Boer goats. *Nutrition Research*, **23**, 1447-1452.

Van Niekerk, W. A. & Casey, N. H. (1988). The Boer goat. II. Growth, nutrient requirements, carcass and meat quality. *Small Ruminant Research*, **1**, 355-368.

Van Soest, P. J., Robertson, J. B. & Lewis, B. A. (1991). Methods for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition. *Journal of Dairy Science*, **74**, 3583-3597.

Van Soest, P. J. (1994). *Nutritional ecology of the ruminant, 2nd edition*. Cornell University Press, Ithaca, New York.

Van Zyl, J. H. M., Von la Chevallerie, M. & Skinner, J. D. (1969). A note on the dressing percentage in the springbok (Antidorcas marsupialis, Zimmerman) and impala (Aepyceros melampus). *Proceedings of South African Society of Animal Production*, **8**, 199–200.

Veira, D. M., Ivan, M. & Jui, P. Y. (1983). Rumen Ciliate Protozoa: Effects on Digestion in the Stomach of Sheep. *Journal of Dairy Science*, **66**(5), 1015-1022.

Vicenti, A., Ragni, M., Ginnico, F., Vonghia, G. & Zezza, L. (2001). Omega-3 fatty acid supplementation I bottle feeling for rearing kids. 2. Effects on the

chemical composition and fatty acid profile of meat. *Zootecnia e nutrizione animale*, **27**, 23-32.

Vogels, G. D., Hoppe., W. F. & Stumm., C. K. (1980). Association of methanogenic bacteria with rumen ciliates. *Applied and Environmental Microbiology*, **40**, 608-612.

Wallace, R. J., Broderick, G. A. & Brammall, M. L. (1987). Microbial protein and peptide metabolism in rumen fluid from faunated and ciliate-free sheep. *British Journal of Nutrition*, **58**(01), 87-93.

Wallace, R. J., McEwan, N. R., MacIntosh, F. M., Teferedegne, B. & Newbold, C. J. (2002). Natural products as manipulators of rumen fermentation. *Asian-Australian Journal of Animal Science*, **10**, 1458-1468.

Wallace, R. J., Chaudhary, L. C., McKain, N., McEwan, N. R., Richardson, A. J., Vercoe, P. E., Walker, N. D. & Paillard, D. (2006). Clostridium proteoclasticum: a ruminal bacterium that forms stearic acid from linoleic acid. *FEMS Microbiology Letters*, **265**(2), 195-201.

Wanapat, M., Ngarmsang, A., Korkhuntot, S., Nontaso, N., Wachirapakorn, C., Beakes, G. & Rowlinson, P. (2000). A comparative study on the rumen microbial population of cattle and swamp buffalo raised under traditional village conditions in the northeast of Thailand. *Asian-Australian Journal of Animal Science*, **13**, 478-482.

Wanapat, M. & Khampa., S. (2006). Effect of mineralized solid palm fat and feeding pattern on ruminal ecology and digestibility of nutrients in dairy steers fed on urea-treated rice straw. *Pakistan Journal of Nutrition*, **5**, 319-324.

Wanapat, M. & Cherdthong, A. (2009). Use of Real-Time PCR Technique in Studying Rumen Cellulolytic Bacteria Population as Affected by Level of Roughage in Swamp Buffalo. *Current Microbiology*, **58**(4), 294-299.

Wan Zahari, M., Alimon, A. R. & Wong, H. K. (2012). Utilization of oil palm co-products as feeds for livestock in Malaysia. In *Biofuel co-products as livestock feed: Opportunities and challenges*, ed. H. P. S. Makkar, FAO. Rome, Italy, pp. 243.

Wattanachant, C. (1999). Systems approach to evaluate growth and meat production of sheep under two production systems, Vol. Ph.D thesis, Univesity Putra Malaysia, Malaysia, pp. 268.

Webb, E. C., Casey, N. H. & Simela, L. (2005). Goat meat quality. *Small Ruminant Research*, **60**(1-2), 153-166.

Weiss, W. P. & Wyatt, D. J. (2004). Digestible Energy Values of Diets with Different Fat Supplements when Fed to Lactating Dairy Cows. *Journal of Dairy Science*, **87**(5), 1446-1454.

Weimer, P. J., Waghorn, G. C., Odt, C. L. & Mertens, D. R. (1999). Effect of Diet on Populations of Three Species of Ruminal Cellulolytic Bacteria in Lactating Dairy Cows. *Journal of Dairy Science*, **82**(1), 122-134.

Welkie, D. G., Stevenson, D. M. & Weimer, P. J. (2010). ARISA analysis of ruminal bacterial community dynamics in lactating dairy cows during the feeding cycle. *Anaerobe*, **16**(2), 94-100.

Werdi Pratiwi, N. M., Murray, P. J. & Taylor, D. G. (2007). Feral goats in Australia: A study on the quality and Nutritive value of their meat. *Meat Science*, **75**, 168-177.

Williams, A. G. (1989). Metabolic activities of rumen protozoa. In: *The Roles of protozoa and fungi in ruminant digestion.*, ed. J. V. Nolan, Leng, R.A., Demeyer, D.I., Penambul Books. Armidale, Australia, pp. 97-126.

Williams, A. G. & Coleman., G. S. (1992). *The rumen protozoa.* . Springer-Verlag., New York.

Williams, V. & Withers, S. E. (1993). Changes in the rumen microbial population and its activities during refaunation period after the reintroduction of ciliate protozoa into the rumen of defaunated sheep. *Canandian Journal of Microbiology*, **39**, 17-36.

Williams, A. G. & Coleman., G. S. (1997). The rumen protozoa. In *the Rumen Microbial Ecosystem.*, eds. P. N. Hobson. & C. S. Stewart., Blackie Academic and Professional,. London, UK., pp. 73–139

Wintzingerode, V. F., Göbel, U. B. & Stackebrandt, E. (1997). Determination of microbial diversity in environmental samples: pitfalls of PCR-based rRNA analysis. *FEMS Microbiology Reviews*, **21**(3), 213-229.

Wolin, M. J. & Miller, T. L. (1988). Microbe-microbe interactions. In *The Rumen Microbial Ecosystem*, ed. P. N. Hobson, Elsevier Scientific Publishers, London, UK., pp. 527.

Wong, H. K. & Wan Zahari, M. (1992). Characterization of oil-palm by-products as feed for ruminants. *In: Proceedings of the 15th Annual Conference of the Malaysian Society of Animal Production, Kuala Terengganu*, 58–60.

Wood, J. D. & Enser, M. (1997). Factors influencing fatty acids in meat and the role of antioxidants in improving meat quality. *British Journal of Nutrition*, **78**, S49-S60.

Woods, V. B., O'Mara, F. P. & Moloney, A. P. (2003a). The nutritive value of concentrate feedstuffs for ruminant animals: Part I: In situ ruminal degradability of dry matter and organic matter. *Animal Feed Science and Technology*, **110**(1-4), 111-130.

Woods, V. B., Moloney, A. P. & O'Mara, F. P. (2003b). The nutritive value of concentrate feedstuffs for ruminant animals: Part II: In situ ruminal degradability of crude protein. *Animal Feed Science and Technology*, **110**(1-4), 131-143.

Woods, V. B., Moloney, A. P., Calsamiglia, S. & O'Mara, F. P. (2003c). The nutritive value of concentrate feedstuffs for ruminant animals: Part III. Small intestinal digestibility as measured by *in vitro* or mobile bag techniques. *Animal Feed Science and Technology*, **110**(1-4), 145-157.

Woodward, S. L., Waghorn, G. C., Lassey, K. R. & Laboyrie, P. G. (2002). Does feeding sulla (Hedysarum coronarium) reduce methane emissions from dairy cows. *Proceedings of New Zealand Society Animal Production*, **62**, 227–230.

Wright, A.-D. G., Williams, A. J., Winder, B., Christophersen, C. T., Rodgers, S. L. & Smith, K. D. (2004). Molecular Diversity of Rumen Methanogens from Sheep in Western Australia. *Applied and Environmental Microbiology*, **70**(3), 1263-1270.

Yabuuchi, Y., Matsushita., Y., Otsuka., H., Fukamachi., K. & Kobayashi., Y. (2006). Effects of supplemental lauric acid-rich oils in high-grain diet on *in vitro* rumen fermentation. *Animal Science Journal.*, **77**, 300-307.

Yanez Ruiz, D. R., Martin Garcia, A. I., Moumen, A. & Molina Alcaide, E. (2004). Ruminal fermentation and degradation patterns, protozoa population and urinary purine derivatives excretion in goats and wethers fed diets based on olive leaves. *Journal of Animal Science*, **82**(10), 3006-3014.

Yang, S. L., Bu, D. P., Wang, J. Q., Hu, Z. Y., Li, D., Wei, H. Y., Zhou, L. Y. & Loor, J. J. (2009). Soybean oil and linseed oil supplementation affect profiles of ruminal microorganisms in dairy cows. *Animal*, **3**(11), 1562-1569.

Yokoyama, M. T. & Johnson., K. A. (1988). Microbiology of the rumen and intestine. In *The ruminant animal – Digestive physiology and nutrition*, ed. D. C. Church, Waveland Press, Inc., Prospect Heights. Illinois, pp. 125 -144.

Yu, S., Derr, J., Etherton, T. D. & Kris-Etherton, P. M. (1995). Plasma cholesterol-predictive equations demonstrate that stearic acid is neutral and monounsaturated fatty acids are hypocholesterolemic. *The American Journal of Clinical Nutrition*, **61**(5), 1129-39.

Yu, Z., Michel, F. C., Hansen, G., Wittum, T. & Morrison, M. (2005). Development and Application of Real-Time PCR Assays for Quantification of Genes Encoding Tetracycline Resistance. *Applied and Environmental Microbiology*, **71**(11), 6926-6933.

Zhang, C. M., Guo, Y. Q., Yuan, Z. P., Wu, Y. M., Wang, J. K., Liu, J. X. & Zhu, W. Y. (2008). Effect of octadeca carbon fatty acids on microbial fermentation, methanogenesis and microbial flora *in vitro*. *Animal Feed Science and Technology*, **146**(3–4), 259-269.

Zhou, M., Hernandez-Sanabria, E. & Guan, L. L. (2010). Characterization of Variation in Rumen Methanogenic Communities under Different Dietary and Host Feed Efficiency Conditions, as Determined by PCR-Denaturing Gradient Gel Electrophoresis Analysis. *Applied and Environmental Microbiology*, **76**(12), 3776-3786.

Zock, P. L. & Katan, M. B. (1992). Hydrogenation alternatives: effects of trans fatty acids and stearic acid versus linoleic acid on serum lipids and lipoproteins in humans. *Journal of Lipid Research*, **33**(3), 399-410.

Zock, P., de Vries, J. & Katan, M. (1994). Impact of myristic acid versus palmitic acid on serum lipid and lipoprotein levels in healthy women and men. *Arteriosclerosis, Thrombosis, and Vascular Biology*, **14**(4), 567-575.