UNIVERSITI PUTRA MALAYSIA

RUMEN METABOLISM, MEAT QUALITY AND GENE EXPRESSION CHANGES ASSOCIATED WITH Nigella sativa L. SEEDS AND Rosmarinus officinalis L. LEAF SUPPLEMENTATION IN DORPER SHEEP

KIFAH ODHAIB JUMAAH

FP 2018 24

RUMEN METABOLISM, MEAT QUALITY AND GENE EXPRESSION CHANGES ASSOCIATED WITH *Nigella sativa* L. SEEDS AND *Rosmarinus officinalis* L. LEAF SUPPLEMENTATION IN DORPER SHEEP

By

KIFAH ODHAIB JUMAAH

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

November 2017

COPYRIGHT

DEDICATION

This thesis is dedicated to

My father and mother

My husband and son

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

RUMEN METABOLISM, MEAT QUALITY AND GENE EXPRESSION CHANGES ASSOCIATED WITH *Nigella sativa* L. SEEDS AND *Rosmarinus officinalis* L. LEAF SUPPLEMENTATION IN DORPER SHEEP

By

KIFAH ODHAIB JUMAAH

November 2017

Chairman : Associate Professor Awis Qurni Sazili, PhD
Faculty : Agriculture

The use of herbs in animal nutrition represents a potent strategy for achieving desired production targets with minimal or no negative impact on animal health and environment. Nonetheless, the impact of herbs on rumen metabolism, growth performance, and product quality is generally less consistent in the published literature. Thus, there is need for additional studies in different production systems to permit tailored decision and informed choices in the utilization of medicinal plants in ruminant nutrition.

The current study examined the effects of *Nigella sativa* (NS) seeds, *Rosmarinus officinalis* (RO) leaves on *in vitro* and *in vivo* rumen metabolism, growth performance, immune response, meat quality and gene expression in Dorper lambs. The study was partitioned into three experiments.

The results in present study are illustrated that the effects of different levels of NS seeds and RO leaves on *in vitro* gas production, rumen fermentation, fatty acids composition and the apparent biohydrogenation of oleic, linoleic and linolenic acids using rumen liquor from Dorper lambs. The NS seeds and RO leaves were supplemented at the rate of 0, 0.5, 1, 1.5 and 2% (w/w) DM of basal substrate [60% forage (urea treated rice straw) and 40% concentrate] and incubated for 24 h at 39°C. Substrates containing RO and NS had greater ($P<0.05$) gas production than the control substrates. The volume of gas produced increased as the levels of RO and NS increased up to 1.5% and decreased afterwards. Supplementation of RO and NS did not affect ($P>0.05$) *in vitro* dry matter digestibility, *in vitro* organic matter digestibility, rumen pH, CH_4 and NH_3-N, total volatile fatty acids (VFA) and the molar proportion of acetate, propionate and butyrate. The RO supplements reduced the ruminal concentration of C18:0 and increased the ruminal concentration of

C18:1n-9 in a dose dependent manner. The supplementation of RO leaves reduced (P<0.05) the apparent biohydrogenation of C18:1n-9 but had no effect (P>0.05) on the apparent biohydrogenation of C18:2n-6 and C18:3n-3.

The results indicated after treatment with *Nigella sativa L.* seeds, *Rosmarinus officinalis L*. leaves and their combination on rumen metabolism, nutrient intake and digestibility, growth performance, immune response and blood metabolites in Dorper lambs. Twenty-four entire male Dorper lambs (18.68±0.6 kg, 4-5 months old) were randomly assigned to a concentrate mixture containing on a dry matter basis either, no supplement (control, T1), 1% *Rosmarinus officinalis* leaves (T2), 1% *Nigella sativa*seeds (T3), or 1% *Rosmarinus officinalis* leaves + 1% *Nigella sativa* seeds (T4). The lambs had *ad libitum* access to urea-treated rice straw (UTRS) and were raised for 90 days. Supplemented lambs had greater (P<0.05) intake of DM and UTRS than the control lambs. Total and daily weight gain were greater (P< 0.05) in T2 lambs than those fed other diets. The T3 and T4 lambs had greater (P< 0.05) ruminal pH than the T1 and T2 lambs. Supplemented lambs improved ruminal total volatile fatty acids, acetate, propionate and reduced NH_3-N, methane gas and C18:0 than the control lambs. Supplemented greater (P< 0.05) serum IgA and IgG compared with the control lambs.

On the other hand, there are detectable evident about ameliorative changes of NS seeds, RO leaves and their combination utilized on carcass attributes, gene expression, lipid oxidation and physicochemical properties of LD, ST and SS muscles in Dorper lambs. The results show that the T2 lambs had greater (P< 0.05) slaughter and cold carcass weights than the control lambs. Meat from supplemented lambs had lower (P<0.05) cooking and drip losses, shear force, lightness, and lipid oxidation and greater (P< 0.05) redness compared with the control meat. *Postmortem* ageing influenced meat quality in Dorper lambs. The impact of dietary supplements on muscle FA varied with muscle type. Furthermore, NS and RO decreased serum total cholesterol, triglycerides, LDL-C and had no effect (P> 0.05) on the expression of SCD and LPL genes in LD and ST muscles in Dorper lambs. The T2 diet up regulated the expression of PRKAA2 gene in LD and ST muscles and up regulated the expression of SREBP1 in LD and ST muscles in Dorper lambs.

Overall, our results concluded that *Nigella sativa* seeds and *Rosmarinus officinalis* leaves variation in the efficacy of in ruminant nutrition. Dietary supplementation of *Nigella sativa* seeds and *Rosmarinus officinalis* leaves had beneficial effects on rumen metabolism, immune response and meat quality in Dorper lambs.

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

PERUBAHAN METABOLISME RUMEN, KUALITI DAGING DAN EKSPRESI GEN BERKAIT DENGAN DENGAN SUPLEMENTASI BIJI *Nigella sativa* L. DAN DAUN *Rosmarinus officinalis* L.PADA BEBIR DORPER

Oleh

KIFAH ODHAIB JUMAAH

November 2017

Pengerusi : Profesor Madya Awis Qurni Sazili, PhD
Fakulti : Pertanian

Penggunaan ramuan herba dalam makanan haiwan meupakan strategi yang berkesan untuk mencapai sasaran pengeluaran, tanpa menjejaskan kesihatan haiwan dan persekitaran. Walau bajaimanapuu, dapatan kajian kesan herba terhadap metabdisme rumen, prestasi tumbesaran kualiti produk adalah tidak konsisten. Sehubunyan itu, kajian lanjutan adalah diperlukan dalam sistem penghasilan yang berbeza bagi memastikan keputusan yang tepat dapat dibuat tentang penggunaan ramuan herba dalam pemakanan ruminan. Kajian ini adalah uatak menilai kesan biji benih *Nigella sativa* (NS), daun *Rosmarinus officinalis* (RO) ke atas metabolisme rumen *in-vitro* dan *in-vivo*, tumbesaran, gerkbalas imun, kualiti daging dan ekspresi gen pada bebiri Dorper. Penyelidikan ini terbahagi kepada tiga eksperimen. Keputusan dalam kajian *in-vitro* ini menunjukkan kesan terhadap tahap yang berbeza dalam biji benih NS dan daun RO dalam penghasilan gas, fermentasi rumen, komposisi asid lemak dan biohidrogenasi asid oleik, linoleik dan linolenik menggunakan fermentasi rumen daripada kambing biri-biri jenis Dorper. Biji benih NS dan daun RO telah ditambah dengan substrat basal pada kadar 0, 0.5, 1, 1.5 and 2% (w/w) bahan kering [60% makananan yang mengandungi (urea dirawat dengan jerami padi) dan kepekatannya pada 40%] dan dibiarkan selama 24 jam pada suhu 39°C. Substrat yang mengandungi RO dan NS mempunyai penghasilan gas lebih besar berbanding substrat terkawal. Isipadu gas yang terhasil meningkat seiring dengan paras RO dan NS yang meningkat pada 1.5% dan menurun kemudiannya. Suplementasi dengan RO dan NS tidak memberikan apa-apa kesan dalam *in-vitro* pencernaan bahan kering, *in-vitro* pencernaan bahan organik, pH rumen, CH_4 dan NH_3-N, jumlah asid lemak meruap (VFA) dan kadaran molar asetat, propionat dan butirat. Suplementasi dengan RO menurunkan kepekatan rumina pada C18:0 dan meningkatkan kepekatan rumina pada C18:1n-9 terhadap dos dependen. Manakala, suplementasi dengan daun RO menurunkan ($P<0.05$) biohidrogenasi dengan ketara pada C18:1n-9 tetapi tiada kesan ($P>0.05$) pada C18:2n-6 and C18:3n-3. Keputusan ini menunjukkan selepas

suplementasi dengan biji benih *Nigella sativa L.*, daun *Rosmarinus officinalis L* dan kombinasi kedua-duanya terhadap metabolisma rumen, pengambilan nutrisi dan pencernaan, prestasi tumbesaran, tindak balas imun dan metabolit darah untuk bebiri jenis Dorper. Dua puluh empat ekor bebiri jantan jenis Dorper (18.68±0.6 kg, berumur 4-5 bulan) telah dipilih secara rawak dan disuplementasikan dengan campuran bahan kering mengandungi sama ada dengan tiada makanan tambahan (kawalan, T1), 1% daun *Rosmarinus officinalis (T2), 1%* biji benih *Nigella sativa (T3),* atau kombinasi 1% daun *Rosmarinus offininalis* + 1% biji benih *Nigella sativa* (T4). bebiri telah diberi makan jerami padi-urea (UTRS) secara *ad libitum* dan dijaga selama 90 hari. Bebiri yang sudah dirawat menunjukkan kesan pengambilan DM dan UTRS yang besar ($P<0.05$) berbanding bebiri terkawal. Jumlah berat harian bebiri T2 menunjukkan perbezaan ketara ($P<0.05$) daripada bebiri yang dirawat dengan makanan tambahan lain. Bebiri T3 dan T4 menunjukkan pH rumina yang ketara berbanding bebiri T1 dan T2. Bebiri yang sudah disuplementasikan dengan makanan tambahan menunjukkan prestasi yang baik terhadap jumlah asid lemak meruap, asetat, propionate dan penurunan NH_3-N, gas metana dan C18:0 berbanding bebiri terkawal. Bebiri yang disuplementasikan juga menunjukkan perbezaan ketara dengan IgA dan IgG serum berbanding bebiri. Selain itu, bukti menunjukkan perubahan yang baik terhadap sifat bangkai, ekspresi genetik, oksidasi lipid dan keadaan fisio-kimia pada otot LD, ST dan SS pada bebiri jenis Dorper dengan suplementasi biji benih NS, RO dan kombinasi kedua-duanya. Keputusan penyembelihan dan berat sejuk bebiri T2 menunjukkan kesan ketara ($P<0.05$) berbanding bebiri. Daging bebiri yang dirawat menunjukkan penurunan pada keadaan dimasak dan keupayaan untuk kehilangan jus daging (*drip losses*), daya ricih (*shear force*), keringanan dan oksida lipid serta perubahan ketara ($P<0.05$) pada warna kemerahan daging berbanding dengan daging bebiri terkawal. Penuaan *postmortem* mempengaruhi kualiti daging bebiri jenis Dorper.

Pengambilan suplemen memberikan kesan terhadap otot lemak asid (FA) dengan jenis otot-otot yang lain. Tambahan pula, NS dan RO menurunkan jumlah kolesterol, trigliserida, LDL-C dalam serum dan tiada kesan ketara ($P> 0.05$) pada ekspresi gen SCD dan LPL dalam otot LD dan ST pada bebiri jenis Dorper. T2 menunjukkan ekspresi gen PRKAA2 dan SREBP1 menaik pada otot LD dan ST kepada bebiri jenis Dorper. Keseluruhannya, keputusan ini telah menunjukkan biji *Nigella sativa* dan daun *Rosmarinus officinalis* memberikan kesan variasi pada nutrisi ruminan. Suplementasi diet biji *Nigella sativa* dan daun *Rosmarinus officinalis* memberikan kesan yang baik pada metabolisma rumen, tindak balas imun dan kualiti daging bebiri.

ACKNOWLEDGEMENTS

First and foremost, I thank the Almighty Allah, my One in All, All in One and All in All. I thank Him for the gift of life, knowledge and good health and for taking me this far.

Special gratitude goes to the Chairman of the supervisory committee, Assoc. Prof. Dr. Awis Qurni Sazili, for his accessibility at all times, patience, indefatigable support, encouragement and guidance throughout my candidature. I am very much indebted to the members of my supervisory committee namely Assoc. Prof. Dr. Anjas Asmara Samsudin, Dr. Shokri Jusoh and I also would like to extend my gratitude to my first supervisor Prof. Dr. Abdul Razak Alimon for his encouragement, constructive criticism, excellent advice, comments, and suggestions in the beginning of the project.

Special thanks to my husband Ali Muhammed and my son (Hussain) for their inexorable love, patience and care. I appreciate the moral and spiritual support of my parents, siblings and friends. Special gratitude goes to the academic and non-academic staffs in the Department of Animal Science, UPM for their support throughout the program.

I certify that a Thesis Examination Committee has met on 3 November 2017 to conduct the final examination of Kifah Odhaib Jumaah on her thesis entitled "Rumen Metabolism, Meat Quality and Gene Expression Changes Associated with *Nigella sativa* L. Seeds and *Rosmarinus officinalis* L. Leaf Supplementation in Dorper Sheep" in accordance with the 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 Doctor of Philosophy.

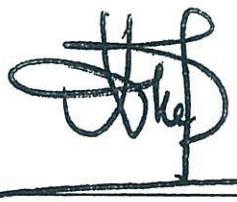
Members of the Thesis Examination Committee were as follows:

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

Goh Yong Meng, PhD
Associate Professor
Faculty of Veterinary Medicine
Universiti Putra Malaysia
(Internal Examiner)

Azhar bin Kassim, PhD
Associate Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Internal Examiner)

Voster Muchenje, PhD
Professor
University of Fort Hare
South Africa
(External Examiner)



NOR AINI AB. SHUKOR, PhD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 28 March 2018

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:

Awis Qurni Sazili, PhD
Associate Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Chairman)

Anjas Asmara @ Ab. Hadi Samsudin, PhD
Associate Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Member)

Shokri Jusoh, PhD
Senior Lecturer
Faculty of Agriculture
Universiti Putra Malaysia
(Member)

ROBIAH BINTI YUNUS, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

Declaration by graduate student

I hereby confirm that:

- this thesis is my original work;
- quotations, illustrations and citations have been duly referenced
- this thesis has not been submitted previously or concurrently for any other degree at any other institutions;
- intellectual property from the thesis and copyright of thesis are fully-owned by Universiti Putra Malaysia, as according to the Universiti Putra Malaysia (Research) Rules 2012;
- written permission must be obtained from the supervisor and the office of the Deputy Vice-Chancellor (Research and Innovation) before thesis is published (in the form of written, printed or in electronic form) including books, journals, modules, proceedings, popular writings, seminar papers, manuscripts, posters, reports, lecture notes, learning modules or any other materials as stated in the Universiti Putra Malaysia (Research) Rules 2012;
- there is no plagiarism or data falsification/fabrication in the thesis, and scholarly integrity is upheld as according to the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) and the Universiti Putra Malaysia (Research) Rules 2012. The thesis has undergone plagiarism detection software.

Signature: _____ Date: _____

Name and Matric No.: Kifah Odhaib Jumaah, GS38784

Declaration by Members of Supervisory Committee

This is to confirm that:

- the research conducted and the writing of this thesis was under our supervision;
- supervision responsibilities as stated in the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) are adhered to.

Signature: _____
Name of Chairman of Supervisory Committee: Associate Professor Dr. Awis Qurni Sazili

Signature: _____
Name of Member of Supervisory Committee: Associate Professor Dr. Anjas Asmara @ Ab. Hadi Samsudin

Signature: _____
Name of Member of Supervisory Committee: Dr. Shokri Jusoh

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ADF	acid detergent fiber
ANOVA	analysis of variance
BH	Biohydrogenation
^{o}C	degrees centigrade
$^{o}C/min$	degrees centigrade per minute
cal	Calorie
CLA	conjugated linoleic acid
cm	Centimetre
cm^2	square centimetre
d	Day
DM	dry matter
FA	fatty acids
FE	feed efficiency
g	Gram
GLM	generalized linear model
h	Hour
Kcal	Kilocalories
L	Liter
LD	*longissimus dorsi*
m	Meter
MDA	Malondialdehyde
min	Minute
mm	Milimeter
mmol/L	milimole per liter
MRA	metmyoglobin reducing activity
µL	Microliter
µ ol/L	micromole per liter
mg	Milligram
mg/L	milligram per lit r
mL	Millilitre

mL/min	millilitre p r minute
MUFA	monounsat rated fatty acids
NS	*Nigella sativa*
n-6/n-3	total n-6 PUFA to total n-3 PUFA ratio
NDF	neutral detergent fib e
PUFA	polyunsaturated fatty acids
RO	*Rosmarinus officinalis*
SEM	standard error of means
SFA	saturated fatty acids
SS	*Supraspinatus*
ST	*semitendinosus*
TBARS	thiobarbituric acid reactive substances
UFA	unsaturated fatty acids
VFA	volatile fatty acids
WHC	water holding capacity

CHAPTER 1

GENERAL INTRODUCTION

Recently, the increase in human population, rapid urbanization and rising incomes have stimulated an increased demand for animal products (Makkar and Beever, 2013). This scenario presents animal scientists with a significant challenge of developing strategies to enhance sustainable animal production to meet the consumers' demand (Adeyemi *et al*., 2015b).

Ruminant production plays a significant role in sustainable livestock production because they can convert plant materials not suitable for human consumption into high quality protein (Wanapat *et al*., 2008). Small ruminant are critical components of production systems throughout the world and they are essential in agricultural systems. Therefore, lambs and goats give rise to large percentage of consumption by global human populace in terms of the dietary protein consumed. About 4% of the meat eaten in the European Union is from ruminant source (EU 2004). Also, in Spain, about 239,500 t of lamb meat is produced yearly occupying the second largest producer of lamb meat (MAPA, 2002). Nonetheless, the pursuit for large-scale animal production to meet the prevailing consumers' demand could compromise animal health and product quality and have negative impact on the environment (Wanapat *et al*., 2008; Vasta and Luciano 2011). Thus, enhancing livestock production without jeopardizing environmental sustainability, animal health and product quality is a continued research endeavor.

The need to improve the productivity of livestock enterprise and animal health lend credence to the use of antibiotics in animal nutrition (Guler *et al*., 2006; Kim *et al*., 2013). Nonetheless, antibiotics could leave residues in animal tissues, which could induce subsequent emergence of resistant strains of microorganisms (Russell and Houlihan 2003; Kim *et al*., 2013) capable of endangering the health of livestock and human. This scenario has given the impetus to explore alternatives to antibiotics in animal nutrition (Guler *et al*., 2006; Kim *et al*., 2013). Consequently, as replacement for the synthetic growth promoters (antibiotics), natural products (herbs and spice) as natural feed additives come to the attention to enhance physiological or pharmacological functions (Ando *et al*., 2003).

Herbs represent an effective substitute for antibiotics in animal nutrition and a potent modifier of rumen metabolism capable of suppressing methanogenesis and improving animal's health, performance and product quality (Yang *et al*., 2007; Vasta and Luciano 2011; Wanapat *et al*., 2013). The manipulation of rumen microbial ecosystem represents an effective strategy for promoting animal health, product quality and the environmental sustainability of ruminant production (Wanapat *et al*., 2013; Adeyemi, 2015). The effects of herbs on ruminants are premised on the chemical nature of the plant secondary metabolites (PSM), the

quantity in the feed, abundance and variety of rumen microflora and ruminant species (McSweeney *et al*., 2001). The scientific literature is replete with studies that have investigated the influence of dietary supplementation of medicinal herbs on rumen metabolism, production performance and product quality in ruminants (Karami *et al*., 2010; Vasta and Luciano 2011; Wanapat *et al*., 2013). Nonetheless, the findings are generally less consistent. Thus, there is need for further research in diverse production systems to allow informed choices and tailored decision in the use of herbs in ruminant nutrition as natural feed additives.

Using *Nigella sativa* (NS) and *Rosmarinus officinalis* (RO) as natural feed additives are examples of medicinal herbs in animal nutrition. *Nigella sativa* and *Rosmarinus officinalis* have been reported as aromatic herbs and they are very rich polyphenols and flavonoids with high antioxidant properties (Michel *et al*., 2011; Sasaki *et al*., 2013; Vatansev *et al*., 2013). In addition, Studies with NS and RO as an option growth booster in livestock production has been established to enhanced carcass trails growth rate and digestibility (Hassan and Hassan 2009; Jordán *et al*. 2010; Nieto *et al*. 2010, 2011; Hassan *et al*. 2011).

Oxidation which is one of the main reason of meat quality impairment as a result of presence of prominent amount of unsaturated lipids, metal catalysts, heme pigments and a range of oxidizing agents in the muscle tissue. Oxidative impairment that occur in any meat sample manifests in form of poor shelf life, off flavor, drip losses, toxic compounds formation, discoloration and nutrient (Contini *et al*., 2014; Palmieri and Sblendorio, 2007). Therefore, enhancing the antioxidant properties of meat could assist to improving meat quality. *Rosmarinus officinalis* and *Nigella sativa* are a medicinal herbs widely used around the world. Of the natural antioxidants, rosemary and *Nigella sativa* have been widely accepted as one of the herbs with the high antioxidant activity (Klančnik *et al*., 2009). The use of these herbs and their by-products as natural antioxidants in feed for ewes could be a simple and interesting opportunity to replace synthetic antioxidants and to improve the quality of lamb meat.

However, feed and animal feeding form one of the basic rock of every livestock. Its enormous role in animal productivity, producer incomes, land use, product quality and safety, health and welfare, water pollution, household security and greenhouse gas emission has been observed (FAO, 2012). In addition, feed accounted for about 70% of the total cost of production regardless of the livestock system either ruminant or non-ruminant and this has placed feed at the fore front in the livestock production sector in order to achieve sustainability (Makkar and Beever, 2013; Buza *et al*., 2014). A question arose as to whether the addition of small amounts of *Nigella sativa* seeds or *Rosmarinus officinalis* leaves to forage or concentrate based diets would result in further improvement of the growth rate of sheep. Therefore, the present study was carried out assess the effects of *Nigella sativa* seeds or *Rosmarinus officinalis* leaves on rumen metabolism, growth performance, meat quality, immune response and gene expression in Dorper lambs. It was hypothesized

that *Nigella sativa* seeds, *Rosmarinus officinalis* leaves and both as natural feed additives would improve rumen metabolism, growth performance, carcass traits, meat quality, immune response and gene expression in Dorper lambs.

Thus, the objectives of the study were:

1. To ascertsin the suitable level of *Nigella sativa* seeds and *Rosmarinus officinalis* leaves on *in vitro* rumen fermentation and apparent biohydrogenation of fatty acids using rumen liquor from Dorper lambs.
2. To determine the effects of *Nigella sativa* seeds, *Rosmarinus officinalis* leaves and their blend on nutrient intake and digestibility, growth performance, and rumen metabolism, some blood parameters and immune response in Dorper lambs.
3. To examine the effects of *Nigella sativa* seeds, *Rosmarinus officinalis* leaves and their combination on carcass traits, fatty acid composition, oxidative stability, quality attributes and gene expression in different muscles in Dorper lambs.

Presentation of the thesis

This thesis consisted of eight chapters. The first two chapters discussed the framework of the experimental research. Chapter 1 provides the justification, hypotheses and the objectives of the study. Chapter 2 presents the review of literature covering the distribution, economic and nutritional importance of sheep, fats and fatty acids in ruminants, rumen ecosystem, uses of medicinal plants to manipulate rumen metabolism, fatty acid composition and meat quality attributes in ruminants. The morphology and medicinal properties of *Nigella sativa* and *Rosmarinus officinalis* and the role of nutrition on gene expression, immune response and meat quality in ruminants were also reviewed. Chapters 3, 4 and 5 present the experimental works for this study. Chapter 6 describes the major findings and highlights the practical importance. Chapter 7 presents the summary, conclusions and recommendations for future studies.

REFERENCES

Aaslyng, M. D., Bejerholm, C., Ertbjerg, P., Bertram, H. C., and Andersen, H. J. (2003). Cooking loss and juiciness of pork in relation to raw meat quality and cooking procedure. *Food Quality and Preference*, 14, 277–288.

Abdel-fattah, A. M., Matsumoto, K., and Watanabe, H. (2000). Antinociceptive effects of *Nigella sativa* oil and its major component, thymoquinone. *European Journal of Pharmacology,* 400, 89–97.

Abdel-Ghaney, D. M., El-Far, A. H., Sadek, K. M., El-Sayed, Y. S., and Abdel-Latif, M. A. (2017). Impact of dietary thyme (*Thymus Vulgaris*) on broiler chickens concerning immunity, antioxidant status, and performance. *Alexandria Journal of Veterinary Sciences* 55: (1), 169-179.

Abdulelah, H.A.A., and Zainal-Abidin, B. A. H. (2007). *In vivo* anti-malarial tests of *Nigella sativa* (Black Seed) different extracts. *American Journal of Pharmacology and Toxicology*, 2(2), 46-50.

Abel-salam, B. K. A. (2012). Immunomodulatory effects of black seeds and garlic on alloxan-induced Diabetes in albino rat. *Allergologia et Immunopathologia*, 40(6), 336–340.

Aberle, E., Forrest, J., Gerrard, D., and Mills, E. (2001). Structure and composition of animal tissues. In E. Aberle *et al*. (Ed.), *Principles of Meat Science*. Dubuque: Kendall/Hunt Publishing Company. (pp. 109-116).

Abu-Dieyeh, Z.H.M., and Abu-Darwish M.S., (2008). Effect of feeding powdered black cumin seeds (*Nigella sativa L.*) on growth performance of 4-8 week-old broilers. *Journal of Animal and Veterinary Advances*, 3, 286-290.

Abul-Fotouh, G.E., Allam, S.M, Shehata, E., and Abdel-Azeem S, N. (1999). Effect of medicinal plants as feed additives on performance of growing sheep. *Egyptian Journal of Nutrition and Feeds,* 2, 79–91.

Acamovic, T., and Brooker, J.D. (2007). Biochemistry of plant secondary metabolites and their effects in animals. *Proceedings of the Nutrition Society*, 64, 403-412.

Achinewhu, S.C., Ogbonna, C.C., and Hart, A.D. (1995). Chemical composition of indigenous wild herbs, spices, fruits, nuts and leafy vegetables used as food. *Plant Foods for Human Nutrition*, 48, 341–348.

Adeyemi, K. D., and Sazili, A. Q. (2014). Efficacy of carcass electrical stimulation in meat quality enhancement: A review. *Asian-Australasian journal of animal sciences*, 27(3), 447.

Adeyemi, K. D (2015). Rumen metabolism, carcass traits and meat quality in goats

fed blend of canola oil and palm oil. PhD Thesis, Universiti Putra Malaysia. Retrieved on 28 December 2015.

Adeyemi, K. D., and Olorunsanya, O. A. (2012). Effect of tomato (lycopersicon esculentum) powder on oxidative stability and sensory characteristics of broiler meat. *African Journal of Food, Agriculture, Nutrition and Development*, 12(6), 6794–6808.

Adeyemi, K. D., Ebrahimi, M., Samsudin, A. A., Alimon, A. R., Karim, R., Karsani, S. A., and Sazili, A. Q. (2015a). Influence of Carotino oil on *in vitro* rumen fermentation, metabolism and apparent biohydrogenation of fatty acids. *Animal Science Journal*, 86(3), 270–278.

Adeyemi, K. D., Ebrahimi, M., Samsudin, A.A., Sabow, A.B., and Sazili, A.Q. (2015b). Carcass traits, meat yield and fatty acid composition of adipose tissues and Supraspinatus muscle in goats fed blend of canola oil and palm oil. *Journal of Animal Science and Technology,* 57 (42), 1-14.

Afonso, M. S., de O Silva, A. M., Carvalho, E. B., Rivelli, D. P., Barros, S. B., Rogero, M. M., Lottenberg, A. M., Torres, R. P., and Mancini-filho, J. (2013). Phenolic compounds from rosemary (*Rosmarinus officinalis L.*) attenuate oxidative stress and reduce blood cholesterol concentrations in diet-induced hypercholesterolemic rats. *Nutrition and Metabolism*, 10(1), 19.

Aggarwal, B.B., (2009). Molecular targets and therapeutic uses of spices. Google Books. p.259. ISBN 978-981-4468-95-4.

Ahmed, M.A., Adeyemi, K.D., Mohamed, Faseleh Jahromi, M.F., Shokri Jusoh, S., Alimon, A.R., and Samsudin, A.A. (2017). Effects of dietary Kleinhovia hospita and Leucaena leucocephala leaves on rumen fermentation and microbial population in goats fed treated rice straw. *Tropical Animal Health and Production*, 49, 1749–1756

Ahmad, Z., and Ghafoor, A. (2007). *Nigella sativa* – A potential commodity in crop diversification traditionally used in healthcare. In: Breeding of Neglected and Under- Utilized Crops, *Spices and Herbs*. (Eds.): S. Ochatt and S.

Ahmad A., Husain A., Mujeeb M., Khan S.A., Najmi A.K., Siddique N.A. , Damanhouri Z.A., and Anwar F.(2013). A review on therapeutic potential of *Nigella sativa*: A miracle herb. *Asian Pacific Journal of Tropical Biomedicine*, 3, 337–352.

Al-Beitawi, N.A, El-Ghousein, S.S., and Nofal, A.H. (2009). Replacing bacitracin methylene disalicylate by crushed *Nigella sativa* seeds in broiler rations and its effects on growth, blood constituents and immunity. *Livestock Science.* 125 (2), 304–307.

Al-Gaby, A. M. A. (1998). Amino acid composition and biological effects of supplementing broad bean and corn proteins with *Nigella sativa* (black

cumin) cake protein. *Nahrung,* 42(5), 290 – 294.

Al-homidan, A., Al-qarawi A.A., Al-waily S.A., and Adam S.E.I. (2002). Response of broiler chicks to dietary *Rhazya stricta* and *Nigella sativa. British Poultry Science*, 43, 291–296.

Ali, B. H., and Blunden, G. (2003). Pharmacological and toxicological properties of *Nigella sativa*. *Phytotherapy Research*, 17(4), 299–305.

Ali, G.H., and Jaafar, Z. E. (2014). Optimization of reflux conditions for total flavonoid and total phenolic extraction and enhanced antioxidant capacity in pandan (*Pandanus amaryllifolius* Roxb.) using response surface methodology. *The Scientific World Journal*, 1, 1–10.

Ali, M.F., Saleh M.S., Eweedah N.M., and Mohmoud S.A. (2005). Effect of using chamomile (*Mtricaria chamomilla*) flowers as feed additives on performance of growing lambs under desertbfarming systems. *Egypt Journal of Nutrition and feeds*, 8, 127-137.

Ali, M.N., Hassan M.S., and Abd El-Ghany F.A. (2007). Effect of strain, type of natural antioxidant and sulphate ion on productive, physiological and hatching performance of native laying hens. *International Journal of Poultry Science*, 6, 539-554.

Al-Jassir, M. (1992). Chemical composition and microflora of black cumin (*Nigella sativa L*) seeds growing in Saudi Arabia. *Food Chemistry*, 45, 239–242.

Al-Kassie, G. A. M. (2008). The effect of anise and rosemary on broiler performance. *International Journal of Poultry Science*, 7(3), 243–245.

Al-Sheyab, F.M. (2012). The effect of rosemary (*Rosmarinus officinalis. L*) plant extracts on the immune response and lipid profile in mice. *Journal of Biology and Life Science,* 3(1), 37–58.

AMSA. (2012). AMSA Meat Color and pH Measurement Guidelines. American Meat Science Association, Illinois, USA.

Anantasook, N., and Wanapat, M. (2012). Influence of rain tree pod meal supplementation on rice straw based diets using *in vitro* gas fermentation technique. *Asian-Australasian Journal of Animal Sciences*, 25(3), 325–334.

Ando, S., Nishida, T., Ishida, M., Hosoda, K., and Bayaru, E. (2003). Effect of peppermint feeding on the digestibility, ruminal fermentation and protozoa. *Livestock Production Science,* 82(2), 245–248.

AOAC. (2007). *Official Methods of Analysis of the Association of Official Analytical Chemists* (18th Ed). Association of Official Analytical Chemists, Washington D.C., USA.

Atta, M. B. (2003). Some characteristics of *Nigella* (*Nigella sativa L.*) seed cultivated in Egypt and its lipid profile. *Food Chemistry*, 83, 63–68.

Babu, U.S., Wiesenfeld, P.L., and Jenkins, M. Y. (1998). Effect of dietary rosemary extract on cell-mediated immunity of young rats. *Plant Foods for Human Nutrition,* 53(2), 169–174.

Bai, N., He, K., Roller, M., Lai, C.-S., Shao, X., Pan, M. H., and Ho, C. T. (2010). Flavonoids and phenolic compounds from Rosmarinus officinalis. *Journal of Agricultural and Food Chemistry*, 58(9), 5363–5367.

Bais, H.P., Walker, T.S., Schweizer, H.P., and Vivanco, J.M., (2002). Root specific elicitation and antimicrobial activity of rosmarinic acid in hairy root cultures of Ocimum basilicum. *Plant Physiology and Biochemistry*, 40, 983–995.

Bañón, S., Méndez, L., and Almela, E. (2012). Effects of dietary rosemary extract on lamb spoilage under retail display conditions. *Meat Science*, 90(3), 579–583.

Bakirel, T., Bakirel, U., Keles, O.U., Ulgen, S.G., and Yardibi, H. (2008). *In vivo* assessment of antidiabetic and antioxidant activities of rosemary (*Rosmarinus officinalis*) in alloxan-diabetic rabbits. *Journal of Ethnopharmacology*.116 (1), 64-73.

Barman K. (2004). *Biodegradation of tanniniferous feeds and their influence on nutrient utilization and productivity of the dairy animals*. Ph.D. The National Dairy Research Institute; Karnal, India

Bauman, D. E., Baumgard, L. H., Corl, B. A., and Griinari, J. M. (2000). Biosynthesis of conjugated linoleic acid in ruminants. *Journal of Animal Science*, 77(E-suppl), 1-15.

Bauman, D.E., Perfield, II, J.W., de Veth, M.J. and Lock, A.L. (2003). New perspectives on lipid digestion and metabolism in ruminants. pp. 175–189, in: Proceedings of the Cornell Nutrition Conference, 2003

Belkhodja, H., Meddah, B., Touil, A. T., and Şekeroğlu, N. (2016). Chemical composition and properties of essential oil of *Rosmarinus officinalis* and populus alba. *World Journal of Pharmacy and Pharmaceutical Sciences*, 5(9), 108–119.

Benchaar, C, and Greathead, H. (2011). Essential oils and opportunities to mitigate enteric methane emissions from ruminants. *Animal Feed Science and Technology*, 166, 338–55

Benchaar, C., Calsamiglia, S., Chaves, A.V., Fraser, G.R., Colombatto, D., McAllister, T.A., and Beauchemin, K. A. (2008). A review of plant-derived essential oils in ruminant nutrition and production. *Animal Feed Science and Technology,* 145, 209–228.

Benchaar, C., Petit, H.V., Berthiaume, R., Ouellet, D.R., Chiquette, J., and Chouinard, P.Y. (2007). Effects of essential oils on digestion, ruminal fermentation, rumen microbial populations, milk production, and milk composition in dairy cows fed alfalfa silage or corn silage. *Journal of Dairy Science*, 90, 886-897.

Beretta, G., Artali, R., Facino, R. M., and Gelmini, F. (2011). The analytical and theoretical approach for the profiling of the antioxidant activity of essential oils: the case of *Rosmarinus officinalis L*. *Journal of Pharmaceutical and Biomedical Analysis*, 55, 1255–1564

Bhattacharya, A., Banu, J., Rahman, M., Causey, J., and Fernandes, G. (2006). Biological effects of conjugated linoleic acids in health and disease. *Journal of Nutritional Biochemistry*, 17(12), 789–810.

Bhutta, Z. (1999). Protein: digestibility and availability. In: Encyclopedia of Human Nutrition. MSadler, J Strain and B. Caballero (Editors). San Diego: Academic Press, 1999. p. 1646-1656.

Bhuiyan, M. S. A., Yu, S. L., Jeon, J. T., Yoon, D., Cho, Y. M., Park, E.W., Kim, N.K., Kim K.S., and Lee, J.H. (2009). DNA polymorphisms in SREBF1 and FASN genes affect fatty acid composition in Korean cattle (Hanwoo). *Asian–Australasian Journal of Animal Sciences*, 22(6), 765–773.

Blatter E, Caius, J.F., and Mhaskar, K.S. (1984). *Indian Medicinal Plants*. In 2nd ed. Allahabad, India: Lalit Mohan Basu. (pp. 11–12).

Blummel, M., Steingass, H., and Becker, K. (1997). The relationship between *in vitro* gas production, in vitro microbial biomass yield and 15N incorporation and its implications for the prediction of voluntary feed intake of roughages. *British Journal of Nutrition*, 77, 911-921.

Blummel, M., and Becker, K. (1997). The degradability characteristics of fifty-four roughages and roughage neutral-detergent fibre as described by in vitro gas production and their relationship to voluntary feed intake. *British Journal of Nutrition*, 77, 757-786.

Bonnet, M., Leroux, C., Faulconnier, Y., Hocquette J., Bocquier F., Martin, P., and Chilliard, Y. (2000). Nutrient-gene expression lipoprotein lipase activity and MRNA are up-regulated by refeeding in adipose tissue and cardiac muscle of sheep. *The Journal of Nutrition*, 130, 749–757.

Boone, C., Mourot J., Gregiore F., and Remacle C. (2000). The adipose conversion process: regulation by extracellular and inb-acellular factors. *Reproduction Nutrition Development*, 40,325-358.

Boonsong, T., Norton L., Chokkalingam K., Jewell K., Macdonald I., Bennett A., and Tsintzas K. (2007). Effect of exercise and insulin on SREBP-1c expression in human skeletal muscle: potential roles for the ERK1/2 and Akt

signalling pathways. *Biochemical Society Transactions*, 35:1310–1311.

Borrás-Linares, I., Pérez-Sánchez, A., Lozano-Sánchez, J., Barrajón-Catalán, E., Arráez-Román, D., Cifuentes, A., Micol V., and Carretero, A. S. (2015). A bioguided identification of the active compounds that contribute to the antiproliferative/cytotoxic effects of rosemary extract on colon cancer cells. *Food and Chemical Toxicology*, 80, 215–222.

Borras-Linares, I., Stojanovic, Z., Quirantes-Pine, R., Arraez-Roman, D., Svarc-Gajic, J., Fernandez-Gutierrez, A., and Segura-Carretero, A. (2014). *Rosmarinus officinalis* leaves as a natural source of bioactive compounds. *International Journal of Molecular Sciences*, 15, 20585–20606.

Boskabady, M., Keyhanmanesh, R., Khameneh, S., Doostdar, Y., and Khakzad, M. (2011). Potential immunomodulation effect of the extract of *Nigella sativa* on ovalbumin sensitized guinea pigs. *Journal of Zhejiang University-Science B (Biomedicine & Biotechnology*, 12(3), 201–209.

Botsoglou, N.A., Govaris, A., Giannenas, I., Botsoglou, E., and Papageorgiou, G. (2007). The incorporation of dehydrated rosemary leaves in the rations of turkeys and their impact on the oxidative stability of the produced raw and cooked meat. *International Journal of Food Sciences and Nutrition*, 58(4), 312-320.

Bozin, B., Mimica-Dukic, N., Samojlik, I., and Jovin, E. (2007). Antimicrobial and antioxidant properties of rosemary and sage (*Rosmarinus officinalis L*. and *Salvia officinalis L*., *Lamiaceae*) essential oils. *Journal of Agricultural and Food Chemistry*, 55(19), 7879–7885.

Brown, M.S., and Goldstein, J.L. (1997) The SREBP pathway: regulation of cholesterol metabolism by proteolysis of a membrane-bound transcription factor. *Cell*, 89, 331– 340.

Brown, W.F., and Pitman, W.D. (1991). Concentration and degradation of nitrogen and fibre fractions in selected tropical grasses and legumes. *Tropical Grassland*, 25, 305-312.

Bryant, M. P. and Robinson, I. M. (1961). An improved nonselective culture medium for ruminal bacteria and its use in determining diurnal variation in numbers of bacteria in the rumen. *Journal of Dairy Science*, 44, 1446-1456.

Budai, C., Gavojdian, D., Kovacs, A., Negrut, F., Olah, J., Cziszter, L.T., Kusza, S., and Javor, A. (2013). Performance and adaptability of the Dorper sheep breed under Hungarian and Romanian rearing conditions. Scientific Papers: *Animal Science Biology*, 46, 344-350.

Buege, C.E., and Aust, S.D., (1978). Microsomal lipid peroxidation. *Methods in Enzymoogyl,* 52, 302–304.

Bunch, T.D., Evans, R.C., Wang, S., Brennand, C.P., Whittier, D.R., and Taylor, B.J., (2004). Feed efficiency, growth rates, carcass evaluation, cholesterol level and sensory evaluation of lambs of various hair and wool sheep and their crosses. *Small Ruminant Research*, 52, 239–245.

Burits, M. and Bucar, F. (2000). Antioxidant activity of *Nigella sativa* essential oil. *Phytotherapy Research*, 328, 323–328.

Busquet, M., Calsamiglia, S., Ferret, A. and Kamel, C. (2006). Plant extracts affect *in vitro* rumen microbial fermentation. *Journal of Dairy Science*, 89(2), 761–771.

Buza, M.H., Holden, L.A., White, R.A., and Ishler, V.A. (2014). Evaluating the effect of ration composition on income over feed cost and milk yield. *Journal of Dairy Science*, 97, 3073–3080.

Calkins, C. R.and Hodgen, J. M. (2007). A fresh look at meat flavor. *Meat Science*, 77, 63–80.

Calsamiglia, S., Cardozo, P. W., Ferret, A., and Bach, A. (2008). Changes in rumen microbial fermentation are due to a combined effect of type of diet and pH. *Journal of Animal Science*, 86, 702–711.

Calsamiglia, S., Busquet, M., Cardozo, P. W., Castillejos, L., and Ferret, A. (2007). Invited Review : Essential oils as modifiers of rumen microbial fermentation. *Journal of Dairy Science*, 90(6), 2580–2595.

Carulla, J.E., Kreuzer, M., Machmüller, A., and Hess, H. (2005). Supplementation of Acacia mearnsii tannins decreases methanogenesis and urinary nitrogen in forage-fed sheep. *Australian Journal of Agricultural Research*, 56, 961–970.

Carberry, C. A., Kenny, D. A., Han, S., McCabe, M S., and Waters, S M. (2012). Effect of phenotypic residual feed intake and dietary forage content on the rumen microbial community of beef cattle. *Applied and Environmental Microbiology*, 78(14), 4949-4985.

Cardinali, R., Cullere, M., Dal Bosco, A., Mugnaid, C., Ruggeri, S., Mattioli, S., Castellini, M. Trabalza Marinucci, M., and Dalle Zotte, A. (2015). Oregano, rosemary and vitamin E dietary supplementation in growing rabbits: Effect on growth performance, carcass traits, bone development and meat chemical composition. *Livestock Science*, 175, 83–89.

Capra, S. (2006). *Nutrient Reference Values for Australia and New Zealand including Recommended Dietary Intakes*. Canberra: Commonwealth Department of Health and Ageing of Australia.

Cartaxo, F.Q., Cezar, M.F., Sousa, W.H., Gonzaga Neto, S., Pereira Filho, J.M., and Cunha, M.G.G., (2009). Características quantitativas da carcac¸ a de

cordeiros terminados em confinamento e abatidos em diferentes condições corporais. *Revista Brasileira de Zoologia*, 38, 697–704.

Cartaxo, F.Q., Sousa, W.H., Cezar, M.F., Gonzaga Neto, S., and Cunha, M.G.G., (2008). Effects of genotype group and of the body condition on the performance of lambs finished in feedlot. *Revista Brasileira de Zoologia*, 37, 1483–1489.

Castillejos, L., Calsamiglia, S., Martín-Tereso, J., and TerWijlen, H. (2008). *In vitro* evaluation of effects of ten essential oils at three doses on ruminal fermentation of high concentrate feedlot-type diets. *Animal Feed Science and Technology* 145, 259–270.

Castillejos, L., Calsamiglia, S., Ferret, A., and Losa, R., (2005). Effects of a specific blend of essential oil compounds and the type of diet on rumen microbial fermentation and nutrient flow from a continuous culture system. *Animal Feed Science and Technology*, 119, 29–41.

Chaturvedi, I., Singh, P. K., and Dutta, T. K. (2013). Effect of herbal feed on goat haematological and biochemical profile. *International Journal of Biotechnology and Bioengineering Research*, 4, 257–262.

Chaves, A.V., He, M.L., Yang, W.Z., Hristov, A.N., McAllister, T.A., and Benchaar, C. (2008). Effects of essential oils on proteolytic, deaminative and methanogenic activities of mixed ruminal bacteria. *Canadian Journal of Animal Science*, 88, 117–122.

Cherif, M., Salema, H.B., and Abidib, S. (2018). Effect of the addition of *Nigella sativa* seeds to low or high concentrate diets on intake, digestion, blood metabolites, growth and carcass traits of Barbarine lamb. *Small Ruminant Research*,158, 1-8.

Cheung, S., and Tai, J. (2007). Anti-proliferative and antioxidant properties of rosemary Rosmarinus officinalis. *Oncology Reports*, 17:(6),1525–1531.

Cheikh-rouhou, S., Besbes, S., Hentati, B., and Blecker, C. (2007). *Nigella sativa L.*: Chemical composition and physicochemical characteristics of lipid fraction. *Food Chemistry*, 101, 673–681.

Chen, G.C, Lv, D.B, Pang, Z., and Liu, Q.F. (2013). Red and processed meat consumption and risk of stroke: a meta-analysis of prospective cohort studies. *European Journal of Clinical Nutrition,* 67, 91-95.

Choi, Y., Song, S., Song, Y., and Lee, J.Y. (2013). Consumption of red and processed meat and esophageal cancer risk: meta-analysis. *World Journal of Gastroenterology*, 19, 1020-1029.

Cloete, J.J.E., Cloete, S.W.P., Olivier, J.J., and Hoffman, L.C., (2007). Terminal cross- breeding of Dorper ewes to Ile de France, Merino Landsheep and SA

Mutton Merino sires: ewe production and lamb performance. *Small Ruminant Research,* 69, 28–35.

Cloete, S.W., Snyman, M.A., and Herselman, M.J. (2000). Productive performance of Dorper sheep. *Small Ruminant Research*, 36, 119–135.

Close, W.H., and Menke, K.H. (1986). Selected topics in animal nutrition: a manual prepared for the 3rd Hohenheim Course on Animal Nutrition in the Tropics and the Semi-Tropics. 2nd Ed. Published by Feldafing : DSE, ZEL.Pp.170.

Cobellis, G., Yu Z., Forte, C., Acuti, G., and Trabalza-Marinucci, M. (2016a). Dietary supplementation of *Rosmarinus officinalis L*. leaves in sheep affects the abundance of rumen methanogens and other microbial populations. *Journal of Animal Science and Biotechnology*, 7(27), 1-8.

Cobellis, G., Trabalza-Marinucci, M., and Yu, Z. (2016b). Critical evaluation of essential oils as rumen modifiers in ruminant nutrition. *Science of the Total Environment*, 545,556–68.

Cobellis, G., Acuti, G., Forte, C., Menghini, L., De Vincenzi, S., Orrù, M., A. Valiani A., Pacetti, D., and Trabalza-Marinucci, M. (2015). Use of *Rosmarinus officinalis* in sheep diet formulations: Effects on ruminal fermentation, microbial numbers and in situ degradability. *Small Ruminant Research*, 126, 10-18.

Contini, C., Álvarez, R., O'Sullivan, M., Dowling, D.P., Óg Gargan, S., Frank, J., and Monahan, F.J. (2014). Effect of an active packaging with citrus extract on lipid oxidation and sensory quality of cooked turkey meat. *Meat Science*, 96, 1171–1176.

Costa, R.G., Araújo Filho, J.T., Sousa, W.H., Gonzaga Neto, S., Madruga, M.S., and Fraga, A.B. (2010). Effect of diet and genotype on carcass characteristics of feedlot hair sheep. *Revista Brasileira de Zoologia*, 39, 2763–2768.

Costa, R.G., Almeida, C.C., Pimenta Filho, E.C., Holanda Júnior, E.V., and Santos, N.M. (2007). Characterization of the flocks goat and sheep in the semi-arid region of the State of Paraíba. *Revista Científica de Produção Animal*, 9, 127–136.

Daba, M. H. and Abdel-rahman, M. S. (1998). Hepatoprotective activity of thymoquinone in isolated rat hepatocytes. *Toxicology Letters*, 95, 23–29.

Decker, E., Ivanov, V., and Zhu Band Frei, B. (2001). Inhibition of low-density lipoprotein oxidation by carnosine and histidine. *Journal of Agricultural and Food Chemistry*, 49, 511-516.

Da Costa, N., McGillivray, C., Bai, Q., Wood, J.D., Evans, G., and Chang K. C. (2004). Restriction of dietary energyandprotein induces molecular changes in young porcine skeletal muscles. *Journal of Nutrition*, 134:2191–2199.

Daniel, C.R., Cross, A.J., Koebnick, C., and Sinha, R. (2011). Trends in meat consumption in the USA. *Public Health Nutrition*, 14,575-583.

Dehority, B.A., and Orpin, C.G. (1997). Development of, and natural fluctuations in, rumen microbial populations, p 196–245. In *Hobson PN, Stewart CS (ed),Therumenmicrobial ecosystem. Blackie Academic and Professional, London, United Kingdom.*

Del Baño, M. J., Lorente. J., Castillo, J., Benavente-García, O., del Río, J. A., Ortuño, A., Quirin, K.W., and Gerard, D. (2003). Phenolic diterpenes, flavones, and rosmarinic acid distribution during the development of leaves, flowers, stems, and roots of *Rosmarinus officinalis*. Antioxidant activity. *Journal of Agricultural and Food Chemistry*, 51, 4247–4253.

Department of Standards Malaysia (2009). MS1500:2009: Halal food production, preparation, handling and storage - General guidelines (Second revision).

Dervishi, E., Serrano, C., Joy, M., Serrano, M., Rodellar, C., and Calvo, J.H. (2010). Effect of the feeding system on the fatty acid composition, expression of the Δ^9-desaturase, peroxisome proliferator-activated receptor alpha, gamma, and sterol regulatory element binding protein 1 genes in the semitendinosus muscle of light lambs of the rasa aragonesa breed. *BMC Veterinary Research*, 6, 40, 1–11.

Dervishi, E., Serrano, C., Joy, M., Serrano, M., Rodellar, C., and Calvo, J. H. (2011). The effect of feeding system in the expression of genes related with fat metabolism in semitendinous muscle in sheep. *Meat Science,* 89(1), 91–97.

Descalzo, A. M., and Sancho, A. M. (2008). A review of natural antioxidants and their effects on oxidative status, odor and quality of fresh beef produced in Argentina. *Meat Science*, 79, 423–436.

Dif, N., Euthine, V., Gonnet, E., Laville, M., Vidal, H., and Lefai, E. (2006). Insulin activates human sterol-regulatory-element-binding protein-1c (SREBP-1c) promoter through SRE motifs. *Biochemical Journal*, 400,179–188.

Djenane, D., Yanguela, J., Montanés, L., Djerbal, M., and Roncalés, P. (2011). Antimicrobial activity of Pistacia lentiscus and Satureja montana essential oils agains Listeria monocytogenes CET 935 using laboratory media: efficacy and synergistic potential in minced beef. *Food Control*, 22, 1046–1053.

Dransfield, E. (1985). Evidence of consumer reaction to meat of different origins. The long-term definition of meat quality controlling the variability of quality in beef, veal, pig meat and lamb pp. 45–66. Brussels, Luxemburg: ECS-EEC-EAEC.

Ducluzeau, P. H., Perretti, N., Laville, M., Andreelli, F., Vega, N., Riou, J.P., and Vidal, H. (2001). Regulation by insulin of gene expression in human skeletal muscle and adipose tissue: evidence for specific defects in type 2 diabetes.

Diabetes, 50, 1134–1142.

Ebrahimi, M., Rajion, M. A., and Goh, Y. M. (2014). Effects of oils rich in linoleic and α-linolenic acids on fatty acid profile and gene expression in goat meat. *Nutrients*, 6, 3913–3928.

Eckard, R. J., Grainger, C., and de Klein, C. A. (2010). Options for the abatement of methane and nitrous oxide from ruminant production: A review. *Livestock Science*, 130(1–3), 47–56.

El-Hack, M.E.A., Alagawany, M., Farag, M.R., Tiwari, R., Karthik, K., and Dhama, K. (2016). Nutritional, healthical and therapeutic efficacy of black cumin (*Nigella sativa*) in animals, poultry and humans: Review Article *International Journal of Pharmacology* 12, 232-248.

E1-Kadi, A., and Kandil, O. (1987). The black seed (*N. sativa*) and immunity – its effects on human T-cell subsets. *Federation Proceedings*, 46, 122–126.

Elmowalid, G., Amar, A. M. and Ahmad, A. A. (2013). *Nigella sativa* seed extract : 1. Enhancement of sheep macrophage immune functions *in vitro*. *Research in Veterinary Science*, 95(2), 437–443.

El-Nor, S.A.H., Khattab, H.M., Al-Alamy, H.A., Salem, F. A., and Abdou, M. M. (2007). Effect of some medicinal plants seed in the rations on the productive performance of lactating buffaloes. *International Journal of Dairy Science*, 2(4), 348–355.

Elsa, L., Harshadrai, R., Florian, J. S., Fernando, C.S., Ana, F., Costa, A.R., Antunes, C., André, M.A., Coelho, A.V., and Sales-Baptista, E. (2011). The effect of tannins on mediterranean ruminant ingestive behavior: the role of the oral cavity. *Molecules* 16, 2766-2784.

Estevez, M., Ramírez, R., Ventanas, S., and Cava, R. (2007). Sage and rosemary essential oils versus BHT for the inhibition of lipid oxidative reactions in liver pâté. *LWT-Food Science and Technology,* 40(1), 58–65.

European Commission Directorate-General for Agriculture. (2004). The meat sector in the European Union. http://ec.europa.eu/agriculture/ publi/fact/meat/2004.

Falowo, A. B., Fayemi, P. O., and Muchenje, V. (2014). Natural antioxidants against lipid – protein oxidative deterioration in meat and meat products : A review. *Food Research International,* 64, 171–181.

Fan, Y., Ma, L., Zhang, W., Xu, Y., Suolangzhaxi, Zhi, X., Cui E., and Song X. (2014). Microemulsion can improve the immune-enhancing activity of propolis flavonoid on immunosuppression and immune response. *International Journal of Biological Macromolecules*, 63,126-132.

Faustman, C., Sun, Q., Mancini, R., and Suman, S. P. (2010). Myoglobin and lipid

oxidation interactions : Mechanistic bases and control. *Meat Science*, 86(1), 86–94.

Faulconnier, Y, Bonnet, M., Bocquier, F., Leroux, C., and Chilliard, Y. (2001). Effects of photoperiod and feeding level on adipose tissue and muscle lipoprotein iipase activity and mRNA levelin dry non-pregnant sheep. *British Journal of Nutrition*, 85, 299-306.

Firkins, J.L., Yu, Z., and Morrison, M. (2007). Ruminal nitrogen metabolism: perspectives for integration of microbiology and nutrition for dairy. *Journal of Dairy Science*, 90, 1–16.

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

Food and Agricultural Organization of the United Nations. Food outlook. Biannual report on global food markets. October 2015. http://www.fao.org/ giews/ [accessed 20.05.16].

Food Agriculture and Organization of the United Nations (2014). FAO world food outlook Retrieved Accessed: March, 10, 2015, from http://www.fao.org/ag/againfo/themes/en/meat/home.html.

Food Agriculture and Organization (FAO). (2012). Impact of animal nutrition on animal welfare—Expert Consultation 26–30 September 2011—FAO, Rome, Italy. Animal Production and Health Report No. 1, Rome, Available at: http://www.fao.org/docrep/017/i3148e/i3148e00.pdf (accessed 23.07.14).

Food and Agricultural Organization (FAO). (2007). In: Rischkowsky, B., Pilling, D. (Eds.), The State of the World's Animal Genetic Resources for Food and Agriculture. Food and Agricul- tural Organization of the United Nations, Rome, Italy, pp. 77–99.

Forouzanfar, F., Bazzaz, B.C.F., and Hosseinzadeh, H. (2014). Black cumin (*Nigella sativa*) and its constituent (thymoquinone): a review on antimicrobial effects. *Iranian Journal of Basic Medical Sciences*, 17(12),929.

Frank, D., Joo, S. T., and Warner, R. (2016). Consumer acceptability of intramuscular fat. *Korean journal for food science of animal resources*, 36(6), 699.-708

Frankel, E.N., Huang, S., Aeschbach, R., and Prior E. (1996). Antioxidant activity of rosemary extract and its constituents, carnosic acid, carnosol, and rosmarinic acid, in bulk oil and oil-in-water emulsion. *Journal of Agricultural and Food Chemistry*, 44, 131–135.

Friedewald, W.T., Levy, R.I., and Fredrickson, D.S., (1972). Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of

the preparative ultracentrifuge. *Clinical Chemistry,* 18: 499-502.

Frutos, P., Hervás, G., Giráldez, F. J., and Mantecón, A. R. (2004). Review. Tannins and ruminant nutrition. *Spanish Journal of Agricultural Research*, 2(2), 191-202.

Furtado, R. A., Araújo, R., Resende, A., Cunha, W. R., and Tavares, D. C. (2010). Protective effect of rosmarinic acid on V79 cells evaluated by the micronucleus and comet assays. *Journal of Applied Toxicology*, 30, 254–259.

Galvani, D.B., Pires, A.V., Susin, I., Gouvêa, V.N., Berndt, A., Chagas, L.J., Dórea, J.R.R., Abdalla, A.L., and Tedeschi, L.O. (2014). Energy efficiency of growing ram lambs fed concentrate-based diets with different roughage sources. *Journal of Animal Science*, 92, 250–263

Gallo, S.B., Merlin, F.A., Macedo, C.M., and Silveira, R.D.O. (2014). Whole grain diet for feedlot lambs. *Small Ruminant Research*, 120, 185–188.

Garg, S.K , Makkar, H.P., Nagal, K.B., Sharma, S.K., Wadhwa, D.R., and Singh, B. (1992). Oak (*Quercus incana*) leaf poisoning in cattle. *Veterinary and Human Toxicology*, 34, 161-164.

Getachew, G., Blummel, M., Makkar, H.P.S., and Becker, K. (1998). *In vitro* gas measuring techniques for assessment of nutritional quality of feeds: a review. *Animal Feed Science and Technology*, 72, 261-281.

Ghazalah, A. A., and Ali, A. M. (2008). Rosemary leaves as a dietary supplement for growth in broiler chickens. *International Journal of Poultry Science,* 7, 234–239.

Ghrabi, Z. (2005). A guide to medicinal plants in North Africa. *Malaga: IUCN Centre for Mediterranean Cooperation,*

Gilani, A.H., Jabeen, A., and Khan, M.A.U. (2004). A review of medicinal uses and pharmacological activities of *Nigella sativa*. *Pakistan Journal of Biological Sciences*, 7, 441–451.

Gladine, C., Rock, E., Morand, C., Bauchart, D., Durand, D. (2007). Bioavail- ability and antioxidant capacity of plant extracts rich in polyphenols, given as a single acute dose, in sheep made highly susceptible to lipoperoxidation. *British Journal of Nutrition*, 98, 691–701.

González-Trujano, M.E., Peña, E.I., Martínez, A.L., Moreno, J., Guevara-Fefer, P., Déciga-Campos, M. and López-Muñoz, F.J. (2007). Evaluation of the antinociceptive effect of *Rosmarinus officinalis L*. using three different experimental models in rodents. *Journal of Ethnopharmacology*, 111(3), 476-482.

González-Calvo, L., Joy, M., Blanco, M., Dervishi, E., Molino, F., Sarto, P., Ripoll, G., Serrano, M., and Calvo, J.H. (2015). Effect of vitamin E supplementation or alfalfa grazing on fatty acid composition and expression of genes related to lipid metabolism in lambs. *Journal of Animal Science*, 93, 3044-3054.

Górski, K., and Saba, L. (2012). Changes in the level of selected haematological and biochemical parameters in the blood of dairy cows in central-eastern Poland. *Acta Veterinaria*, 62(4), 421–428.

Greathead, H. (2003). Plants and plant extracts for improving animal productivity. *Proceedings of the Nutrition Society*, 62, 279-290.

Griinari, J.M., Corl, B. A., Lacy, S. H., Chouinard, P. Y., Nurmela, K. V. V., and Bauman, D. E. (2000). Conjugated linoleic acid is synthesized endogenously in lactating dairy cows by Δ9- desaturase. *The Journal of Nutrition*, 130, 2285–2291.

Guerrero, A., Valero, M. V., Campo, M. M., and Sañudo, C. (2013). Some factors that affect ruminant meat quality : from the farm to the fork. Review. *Acta Scientiarum. Animal Sciences,* 35(4), 335–347.

Gupta, K.K., Taneja, S.C., Dhar, K.L., and Atal, C.K. (1983). Flavonoids of *Andrographis paniculata*. Phyfochemrsrry, pnated 3rd great bntam. Pergamon Press Ltd, 22(1), 314−315.

Güler, T., Dalkılıç, B., Ertas, O.N., and Ciftci, M. (2006). The effect of dietary black cumin seeds (*Nigella sativa L.*) on the performance of broilers. *Asian-Australasian Journal of Animal Sciences*, 19, 425-430.

Gunun, P, Wanapat, M, and Anantasook, N. (2013).Effects of physical form and urea treatment of rice straw on rumen fermentation, microbial protein synthesis and nutrient digestibility in dairy steers. *Asian-Australasian Journal of Animal Sciences,* 26: (12), 1689-1697

Guillet-Deniau, I., Mieulet, V., Le Lay, S., Achouri, Y., Carre, D., Girard, J., Foufelle, F., and Ferre, P. (2002). Sterol regulatory element binding protein-1c expression and action in rat muscles: insulin-like effects on the control of glycolytic and lipogenic enzymes and UCP3 gene expression. *Diabetes*, 51, 1722–1728.

Habeeb, A.A.M., and El-Tarabany, A.A., (2012). Effect of *Nigella sativa* or curcumin on daily body weight gain, feed intake and some physiological functions in growing Zaraibi goats during hot summer season. *Arab Journal of Nuclear Sciences and Applications*, 45(3), 238-249.

Hassan, M. and El-Dakhakhny, M. (1992). Effect of some *Nigella sativa* constituents on chemical carcinogenesis in hamster cheek pouch. *Journal of the Egyptian Society of Pharmacology and Experimental Therapeutics,* 11, 675–677.

Hassan, S.A., and Hassan. K. (2009). Effect of different levels of rumen undegradable nitrogen and *Nigella sativa* on daily intake, live weight gain, feed conversion ratio and some blood parameters of karadi lambs. *Iraqi Journal of Agricultural Science*, 40, 168–178.

Hassan, A. S., Hassan, M. K., and Al-rubeii, A. (2010). Carcass characteristics of Karadi lambs as affect by different levels of dietary supplement of rumen degradable nitrogen fed with *Nigella sativa*. *African Journal of Biotechnology*, 9(27), 4295–4299.

Hassan, A. S., Hassan, M. K., and Al-rubeii, A. (2011). Carcass yield and characteristics of Karadi lambs as affected by dietary supplement of rumen undegradable nitrogen fed with *Nigella sativa*. *African Journal of Biotechnology*, 10(8), 1491–1495.

Hassim, H.A., Lourenço, M., Goh, Y.M., Baars, J.J., and Fievez, V. (2012). Rumen degradation of oil palm fronds is improved through pre-digestion with white rot fungi but not through supplementation with yeast or enzymes. *Canadian Journal of Animal Science*, 92(1), 79-87.

Hess, H.D., Beuret, R.A., Lotscher, M., Hindrichsen, K.I., Machmuller, A., Carulla, J.E., Lascano, C.E., and Kreuzer, M. (2004). Ruminal fermentation, methanogensis and nitrogen utilization of sheep receiveing tropical grass hay-concentrate diet offered with Sapindus saponaria fruits and Cratylia argentea foliage. *Journal of Animal Science*, 79, 177–189.

Hocquette, J. F., Gondret, F., Baza, E., M., dale, F., Jurie, C., and Pethick, D. W. (2010) Intramuscular fat content in meat- producing animals: Development genetic and nutritional con- trol and identification of putative markers. *Animal*, 4, 303-319.

Hocquette, J.F., Graulet, B., and Olivecrona, T. (1998). Lipoprotein lipase activity and RNA levels in bovine tissues. *Comparative Biochemistry and Physiology part B: Biochemistry and Molecular Biology*, 121(2), 201 -212.

Hopkins, D. L., Hall, D. G., Channon, H. A., and Holst, P. J. (2001). Meat quality of mixed sex lambs grazing pasture and supplemented with, roughage, oats or oats and sunflower meal. *Meat Science*, 59, 277–283.

Horton, J.D., Shah, N.A., Warrrington, J.A., Anderson, N.N., Park, S.W., Brown, M.S. and Goldstein, J.L. (2003) Combined analysis of oligonucleotide microarray data from transgenic and knockout mice identifies direct SREBP target genes. *Proceedings National Academy of Science* 100, 27–32.

Houghton, P. J., Zarka, R., de les Heras, B. and Hoult, J.R. (1995). Fixed oil of *Nigella sativa* and derived thymoquinone inhibit ficosanoid generation in leukocytes and membrane lipid peroxidation. *Planta Medica*, 61, 33–36.

Jacob, R.H., and Pethick, D.W. (2014). Animal factors affecting the meat quality of

Australian lamb meat. *Meat Science*, 96, 1120–1123

Islam, S.N., Begum, P., Ahsan, T., Huque, S., and Ahsan, M. (2004). Immunosuppressive and cytotoxic properties of *Nigella sativa*. *Phytotherapy Research*, 18, 395-398.

Jama, N., Muchenje, V., Chimonyo, M., Strydom, P. E., Dzama, K., and Raats, J. G. (2008). Cooking loss components of beef from Nguni, Bonsmara and Angus steers. *African Journal of Agricultural Research*, 3(6), 416–420.

Jayaprakasha, G. K., and Rao, L. J. (2000). Phenolic Constituents from the Lichen Parmotrema stuppeum (Nyl .) Hale and their antioxidant activity. *Zeitschrift für Naturforschung* 55, 1018–1022.

Jayanegara, A., Marquardt, S., Kreuzer, M., and Leiber, F. (2011). Nutrient and energy content, in vitro ruminal fermentation characteristics and methanogenic potential of alpine forage plant species during early summer. *Journal of the Science of Food and Agriculture*, 91, 1863-1870.

Jeleníková, J., Pipek, P., and Miyahara, M. (2008). The effects of breed, sex, intramuscular fat and ultimate pH on pork tenderness. *European Food Research and Technology*, 227, 989–994.

Jeremiah, L. E. (1982). A review of factors influencing consumer selection and acceptability of meat purchases. *Journal of Consumers Studies and Home Economics*, 6, 137–154.

Jiang, Y., Wu, N., Fu, Y., Wang, W., Luo, M., Zhao, C.J., Zu, Y.G., and Liu, X.L. (2011). Chemical composition and antimicrobial activity of the essential oil of rosemary. *Environmental Toxicology and Pharmacology*, 32(1), 63–68.

Jitkamol, T., Surasak, J., Somkiat, K., and Theera R. (2010). Fatty acid profile of ruminal fluid, plasma and milk fat of dairy cows fed soybean and sunflower oil-rich diets, without effects on milk production. *Kasetsart Journal (Natural Science)*, 44, 837-849.

Johan, A.M., and Jamaludin, A.B. (1996). The development of small ruminant industry in Malaysia: experiences in the transfer of technology. *In workshop on Small Ruminant Production: Recommendations for South Asia, Parapat (Indonesia), May 12-15,1996*. Small Ruminant Collaborative Research Support Program.

John, Q. Z., Bryan, S., Melissa, M.L., Heidi, L.M., Agce, Y.S., Richard, H.C., Marilyn, J.K., and Tom R.T. (2002). Changes in LPL and reverse cholesterol transport variables during 24-h postexercise period. *American Journal of Physiology- Endocrinology Metabolism*, 283(2), E267-E214

Jordán, M.J., Castillo, J., Bañón, S., Martínez-Conesa, C., and Sotomayor, J.A. (2014). Relevance of the carnosic acid/carnosol ratio for the level of

rosemary diterpene transfer and for improving lamb meat antioxidant status. *Food Chemistry*, 151, 212–218.

Jordán, M. J., Lax, V., Rota, M. C., Lorán, S., and Sotomayor, J. A. (2013). Effect of the phenological stage on the chemical composition, and antimicrobial and antioxidant properties of *Rosmarinus officinalis L* essential oil and its polyphenolic extract. *Industrial Crops and Products*, 48, 144–152.

Jordán, M. J., Lax, V., Rota, M., Lorán, S., and Sotomayor, J. (2012). Relevance of carnosic acid, carnosol, and rosmarinic acid concentrations in the *in vitro* antioxidant and antimicrobial activities of *Rosmarinus officinalis* (*L.*) methanolic extracts. *Journal of Agricultural and Food Chemistry*, 60, 9603-9608.

Jordán, M. J., Moñino, M. I., Martínez, C., Lafuente, A., and Sotomayor, J. A. (2010). Introduction of distillate rosemary leaves into the diet of the murciano-granadina goat : transfer of polyphenolic compounds to goats'milk and the plasma of suckling goat kids. *Journal of Agricultural and Food Chemistry*, 58, 8265–8270.

Juárez, M., Aldai, N., López-Campos, O., Dugan, M. E. R., Uttaro, B., and Aalhus, J. L. (2012). Beef texture and juiciness. *Handbook of meat and meat processing*, 9, 177-206.

Kamra, D.N., Singh, R., Agarwal, N., and Pathak, N.N. (2000). Soapnut (Reetha) as natural defaunating agent its effect on rumen fermentation and in sacco degradability of jowar hay in buffaloes. *Buffalo Journal*, 16, 99-104.

Kang, M. G., Kim, H. J., Lee, H. J., Jang, A. R., Yun, G. S. and Jo, C. R. (2011). Effect of dietary kocetin TM on meat quality of Hanwoo loin. *Journal of Animal Science and Technology,* 53(6), 541–548.

Kang, M.G., Kim, H.J., Jang, A.R., Gam, D. K., Yun, G. S., and Jo, C. R. (2012). Effect of dietary supplementation of quercetin on antioxidant activity and meat quality of beef cattle. *Korean Journal of Agricultural Science*, 39(1), 61-68.

Kanner, J. (1994). Oxidative processes in meat and meat products : quality implications. *Meat Science,* 36, 169–189.

Kanner, J. (2007). Review dietary advanced lipid oxidation endproducts are risk factors to human health. *Molecular Nutrition & Food Research*, 51, 1094–1101.

Karaca, S., Yılmaz, A., Kor, A., Bingöl, M., Cavido˘glu, I., and Ser, G. (2016).The effect of feeding system on slaughter-carcass characteristics, meat quality, and fatty acid composition of lambs. *Archives Animal Breeding,* 59,121-129.

Karami, M., Alimon, A. R., and Goh, Y. M. (2011a). Effect of vitamin E,

Andrographis paniculata and turmeric as dietary antioxidant supplementation on lipid and color stability of goat meat. *Small Ruminant Research*, 97, 67–71.

Karami, M., Alimon, A. R., Sazili, A. Q., Goh, Y. M. and Ivan, M. (2011b). Effects of dietary antioxidants on the quality, fatty acid profile, and lipid oxidation of *longissimus* muscle in Kacang goat with aging time. *Meat Science*, 88(1), 102-108.

Karami, M., Alimon, A. R, Goh, Y. M., Sazili, A. Q. and Ivan, M. (2010). Effects of dietary herbal antioxidants supplemented on feedlot growth performance and carcass composition of male goats. *American Journal of Animal and Veterinary Sciences*, 5(1), 33–39.

Karawya, M. S., Hashim, E. M., Abde1-Wahab, S. M., E1-Deeb, K. S., Soliman, S. N., Salam, I. A., Mokhtar, N., and El-Hossiny, Y. (1994). Essential oil and lipids of *Nigella sativa* seed and their biological activity. *Zagazig Journal of Pharmaceutical Sciences*, 3, 49–55.

Kariuk I.W., and Norton B.W. (2008). The digestion of dietary protein bound by condensed tannins in the gastro-intestinal tract of sheep. *Animal Feed Science and Technology,* 142, 197-209.

Kerth, C. R. (2013). Meat Tenderness. In C. R. Kerth. The Science of Meat Quality. Oxford: John Wiley and Sons Inc. (pp. 99–117).

Khan, S.H., Anjum, M.A., Parveen, A., Khawaja, T., and Ashraf, N.M. (2013). Effects of black cumin seed (*Nigella sativa L*.) on performance and immune system in newly evolved crossbred laying hens. *Veterinary Quarterly,* 33, 13–19.

Khan, A.M. (1999). Chemical composition and medicinal properties of *Nigella sativa* linn. *Inflammopharmacolog*, 7(1), 15–35.

Khiaosa-Ard, R., Bryner, S.R., Scheeder, M.R.L., Wettstein, H.R., Leiber, F., Kreuzer, M., and Soliva, C.R. (2009). Evidence for the inhibition of the terminal step of ruminal α-linolenic acid biohydrogenation by condensed tannins. *Journal of Dairy Science*, 92,177–188.

Kim, D. H., Kim, K. H., Nam, I. S., Lee, S. S., Choi, C. W., Kim, W. Y., Kwon, E. J., Lee, K. Y., Lee M. J., and Oh, Y. K. (2013). Effect of indigenous herbs on growth, blood metabolites and carcass characteristics in the late fattening period of hanwoo steers. *Asian- Australasian Journal of Animal Sciences*, 26(11), 1562–1568.

Kingston-Smith, A. H., Marshall, A. H., and Moorby, J. M. (2013). Breeding for genetic improvement of forage plants in relation to increasing animal production with reduced environmental footprint. *Animal*, 7, 79–88.

King, J.C. (2007). An evidence-based approach for establishing dietary guidelines. Journal of Nutrition, 137, 480-483.

Klančnik, A., Guzej, B., Hadolin Kolar, M., Abramovič, H., and Smole Mózina, S. (2009). *In vitro* antimicrobial and antioxidant activity of commercial rosemary extract formulations. *Journal of Food Protection*. 72, 1744–1752.

Klurfeld, D.M. (2015). Research gaps in evaluating the relationship of meat and health. *Meat Science*, 109, 86–95.

Knights, R. (2010). Dorper sheep and the production of lean lamb in arid Australia. *International ISS Institute/DEEWR Trades Fellowship.*

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

Koşar, M., Göger, F., Hüsnü, K., and Can Baser (2008). *In vitro* antioxidant properties and phenolic composition of *Salvia virgata* jacq from turkey. *Journal of Agricultural and Food Chemistry*, 56, 2369–2374.

Kosgey, I.S. (2004). Breeding Objectives and Breeding Strategies for Small Ruminants in the Tropics. Ph.D. Thesis. Wageningen University, The Netherlands, p. 272.

Kotzka, J., Muller-Wieland, D., Roth, G., KremerL., Munck, M., Schurmann, S., Knebel B., and Krone, W. (2000). Sterol regulatory element binding proteins (SREBP)-1a and SREBP-2 are linked to the MAP-kinase cascade. *Journal of Lipid Research*, 41, 99–108.

Lanza, M., Barbagallo, M. B. D., Fasone, V., Finocchiaro, L., and Priolo, A. (2003). Effect of partially or totally replacing soybean meal and maize by chickpeas (Cicer arietinum L.) in lamb diets: growth performances, carcass and meat quality. *Animal Research*, 52, 263−270.

Laura, O.F., Garzon, M.T., and Vicente, M. (2010). Relationship between the antioxidant capacity and effect of rosemary (*Rosmarinus officinalis L.*) polyphenols on membrane phospholipid order. *Journal of Agricultural and Food Chemistry*, 58 (1), 161–171.

Lawrie, R., and Ledward, D. (2006). Lawrie's Meat Science. Cambridge: Woodhead Publishing Ltd.

Lecomte, V., Meugnier, E., Euthine, V., Durand, C., Freyssenet, D., Nemoz, G., Rome, S., Vidal, H., and Lefai, E. (2010). New role for sterol regulatory element binding protein1 transcription factors in the regulation of muscle mass and muscle cell differentiation. *Molecular and Cellular Biology*, 30, 1182–1198.

Lee, H.Y., Choi, B.H., Lee, J.S., Jang, G.W., Lee, K.T., Chung, H.Y., Jeon, J.T., Cho, B.W., Lee, J.H. and Kim, T.H. (2007). Molecular characterization and chromosomal mapping of the porcine AMP-activated protein kinase α2 (PRKAA2) gene. *Asian-Australasian Journal of Animal Sciences,* 20, 615-621.

Lehnert, S. A., Byrne, K.A., Reverter, A., Nattrass, G.S., Greenwood, P.L., Wang, Y.H., Hudson N.J., and Harper G.S. (2006). Gene expression profiling of bovine skeletal muscle in response to and during recovery from chronic and severe undernutrition. *Journal of Animal Science*, 84,3239–3250.

Leng, R.A. (1990) Factors affecting the utilization of 'poor-quality' forages by ruminants particularly under tropical conditions. *Nutrition Research Reviews*, 3 (1), 277-303.

Lii, L., Ji, C., Luo, X. G., Liu, B. and Yu, S. X. (2004). Effect of supplemental manganese on carcass traits, meat quality, and relative enzyme activities in broilers. *Scientia Agricultura Sinica*, 37, 1917- 1924.

Liss, B. (2002). Improved quantitative real-time RT–PCR for expression profiling of individual cells. *Nucleic Acids Research*, 30 (17), 89–97.

Lichtenstein, A. H., Appel, L. J., Brands, M., Carnethon, M., Daniels, S., Franch, H. A., Franklin, B., Kris-Etherton, P., Harris W.S., Howard, B., Karanja, N., Lefevre, M., Rudel L., Sacks, F., Van Horn, L., Winston, M., and Wylie-Rosett, J. (2006). Diet and lifestyle recommendations revision. *Circulation*, 114: (1), 82–96.

Lila, Z.A., Mohammed, N., Kanda, S., Kurihara, M., and Itabashi, H. (2005). Sarsaponin effects on ruminal fermentation and microbes, methane production, digestibility and blood matabolites in steers. *Asian-Australasian Journal of Animal Sciences*, 12, 1746.

Lila, Z.A., Mohammed, N., Kanda, S., Kamada, T., and Itabashi, H., (2003). Effect of sarsaponin on ruminal fermentation with particular reference to methane production *in vitro*. *Journal of Dairy Science*, 86, 3330–3337.

Livak, K. J., and Schmittgen, T. D. (2001). Analysis of relative gene expression data using realtime quantitative PCR and the 2-ΔΔCT method. *Methods*, 25, 402–408.

Lokman, N.S., Sabow, A.B., Abubakar, A.A., Adeyemi, K.D., and Sazili, A.Q. (2017). Comparison of carcass and meat quality in goats subjected to preslaughter head-only electrical stunning or slaughtered without stunning. *Cyta – Journal of Food*, 15, 99-104.

Lucarini, R., Bernardes, W. A., Ferreira, D. S., Tozatti, M. G., Furtado, R., Bastos, J. K.,and Janua, A. H. (2013). *In vivo* analgesic and anti-inflammatory activities of *Rosmarinus officinalis* aqueous extracts, rosmarinic acid and its acetyl

ester derivative. *Pharmaceutical Biology*, 51(9), 1087–1090.

Mahgoub, A.A. (2003). Thymoquinone protects against experimental colitis in rats. Toxicology Letters, 143, 133–143.

Makkar, H. P.and Beever, D.(2013). Optimization of feed use efficiency in ruminant production systems. FAO Symposium Proceedings, Bangkok, Thailand, 27 November 2012. *FAO Animal Production and Health Proceedings*. (16).

Makkar, H.P.S., Francis, G., and Becker, K. (2007). Bioactivity of phytochemicals in some lesser-known plants and their effects and potential applications in livestock and aquaculture production systems. *Animal*, 1 (9), 1371–1391.

Makkar, H. P. S., Blummel, M., Borowy, N. K., and Becker, K. (1993). Gravimetric Determination of Tannins and their Correlations with Chemical and Protein Precipitation Methods. *Journal of the Science of Food and Agriculture*, 61, 161–165.

Matkowski, A., Tasarz, P., and Szypula, E. (2008). Antioxidant activity of herb extracts from five medicinal plants from Lamiaceae, subfamily Lamioideae. *Journal of Medicinal Plants Research*, 2, 321–330.

Mancini, S., Paci, G., Pisseri, F., and Preziuso, G. (2016). Effect of turmeric (Curcuma longa L.) powder as dietary antioxidant supplementation on pig meat quality. *Journal of Food Processing and Preservation*. 41(1)

Mansour, M. A., Nagi, M. N., El-khatib, A. S., and Al-bekairi, A. M. (2002). Effects of thymoquinone on antioxidant enzyme activities, lipid peroxidation and DT-diaphorase in different tissues of mice : a possible mechanism of action. *Cell Biochemistry and Function*, 20, 143–151.

Mansour, M. A., Ginawi, O.T., El-Hadiyah, T., El-Khatib, A. S., Al-Shabanah, O.A., and Al- Sawaf, H. A. (2001). Effects of volatile oil constituents of *Nigella sativa* on carbontetrachloride-induced hepatotoxicity in mice: evidence for antioxidant effects of thymoquinone. *Research communications in molecular pathology and pharmacology*, 110, 239–251.

MAPA, Ministerio de Agricultura Pesca y Alimentación. (2002). La alimentación en España 2001. Madrid: Secretaría General de Agricultura y Alimentación.

Martínez, A. L, González-Trujano, M. E, Chávez, M., and Pellicer, F. (2012). Antinociceptive effectiveness of triterpenes from rosemary in visceral nociception. *Journal of Ethnopharmacol*, 142, 28–34.

Matthaus, B., and Özcan, M. M. (2011). Fatty Acids, Tocopherol, and sterol contents of some Nigella species seed oil. *Czech Journal of Food Sciences*, 29(2), 145–150.

McAfee, A. J., Mcsorley, E. M., Cuskelly, G. J., Moss, B. W., Wallace, J. M. W.,

Bonham, M. P., and Fearon, A. M. (2010). Red meat consumption : An overview of the risks and benefits. *Meat Science*, 84(1), 1–13.

McBride, N. T. M., Hogan, S. A., and Kerry, J. P. (2007). Comparative addition of rosemary extract and additives on sensory and antioxidant properties of retail packaged beef. *International Journal of Food Science and Technology*, 42, 1201–1207.

McCormick, R. J. (2009). Collagen. In M. Du and R. J. McCormick. *Applied Muscle Biology and Meat Science*. New York: CRC Press. (pp 129-148).

McSweeney, C. S., Palmer, B., Mcneill, D. M., and Krause, D. O. (2001). Microbial interactions with tannins : nutritional consequences for ruminants. *Animal Feed Science and Technology*, 91, 83–93.

Medjekal, S., Bodas, R., Bousseboua, H., and López S. (2017). Evaluation of three medicinal plants for methane production potential, fiber digestion and rumen fermentation *in vitro*. *Energy Procedia* 119, 632–641.

Meziti, A., Meziti, H., Boudiaf, K., Mustapha, B., and Bouriche, H. (2012). Polyphenolic Profile and Antioxidant Activities of *Nigella Sativa* seed extracts *in vitro* and *in vivo*. *International Journal of Biotechnology and Bioengineering*, 6(4), 109-117.

Menke, K.H., and Steingass, H. (1988). Estimation of the energetic feed value obtained by chemical analysis and *in vitro* gas production using rumen fluid. *Animal Research Development*, 28, 7–55.

Michel, C. G., El-Sayed, N. S., Moustafa, S. F., Ezzat, S. M., Nesseem, D. I., and El-Alfy, T. S. (2011). Phytochemical and biological investigation of the extracts of *Nigella sativa L*. seed waste. *Drug Test Analysis,* 3: 245–254.

Milne, C. (2000). The history of Dorper sheep. *Small Ruminant Research*, 36, 99-101.

Min, B. R., Attwood, G. T., Reilly, K., Sun, W., Peters, J. S., Barry, T. N., and Mcnabb, W. C. (2002). Lotus corniculatus condensed tannins decrease *in vivo* populations of proteolytic bacteria and affect nitrogen metabolism in the rumen of sheep. *Canadian Journal of Microbiology,* 48, 911–921.

Min, B.R, Solaiman, S., Terrill, T., Ramsay A. and Mueller-Harvey, I. (2015). The effects of tannins-containing ground pine bark diet upon nutrient digestion, nitrogen balance, and mineral retention in meat goats. *Journal of Animal Science and Biotechnology*, 6(25), 4–11.

Minokoshi, Y., Kim, Y. B., Peroni, O. D., Fryer, L. G. D., Carling, D., and Kahn, B.B. (2002). Leptin stimulates fatty-acid oxidation by activating AMP-activated protein kinase. *Nature,* 415,339-343.

Mir Ishtiyak, A., Kumar, R., Sharma, R.K., and Barman, K. (2010). Effect of addition of herbs on *in vitro* digestibility of feed with rumen liquor of goat. *Indian Journal of veterinary Resesrch*. 19(1), 13-18.

Mohamed, A.H., Nadia, M., and Abd-El-Bar, I. K. (2005). Influence of some medicinal plants supplementation. 2. Lambs performance, carcass properties and mutton meat quality. *Egyption Journal of Nutrition Feed*, 8(1), 445–460.

Moñino, M. I., Martínez, C., Sotomayor, J. A., LafuenteJordán, A., and Jordán, M. J. (2008). Polyphenolic transmission to segureno lamb meat from ewes'diet supplemented with the distillate from rosemary (*Rosmarinus officinalis*) leaves. *Journal of Agricultural and Food Chemistry,* 56, 3363–3367.

Morán, L., Andrés, S., Bodas, R., Prieto, N., and Giráldez, F. J. (2012). Meat texture and antioxidant status are improved when carnosic acid is included in the diet of fattening lambs. *Meat Science*, 91,430–434.

Morand- Fehr, P., Araba, A., Bas, P., and El Aich, A. (2012). Effects of feeding system and diet on body lipid composition of young goats. In O. Maghoub *et al* (Ed.), Goat meat production and quality. Cambridge: CABI Publisher (pp. 337–354).

Moreno, S., Catalina, T., Romano, S., and Vojnov, A.A., (2006). Antioxidant and antimicrobial activities of rosemary extracts linked to their polyphenol composition. *Free Radical Research*, 40(2), 223–231.

Morsi, N.M. (2000). Antimicrobial effect of crude extracts of *Nigella sativa* on multiple antibiotic resistant bacteria. *Acta microbiologica Polonica*, 49 (1), 63–74.

Moss, A. R., Jean-Pierre, J. P., and Newbold, J. (2000). Methane production by ruminants: its contribution to global warming. *Annales. Zootechnie*. 49, 231–253.

Moujahed, N., Bouaziz, Y., and Khelfa, A. (2013). Effects of essential oils from Rosmarinus officinalis and Thymus capitatus on *in vitro* rumen fermentation in sheep. In *Feeding and management strategies to improve livestock productivity, welfare and product quality under climate change. H. Ben Salem and A. López Francos (eds). Zaragoza: CIHEAM/INRAT/OEP/IRESA/FAO. Options Méditerranéennes, Se ries A: Mediterranean Seminars* (Vol. 107, pp. 35-38).

Mozaffari, F. S., Ghorbanli, M., Babai, A., and Farzami, M. (2000). The effect of water stress on the seed oil of *Nigella sativa L.* *Journal of Essential Oil Research*, 12, 36–38.

Muchenje, V., Dzama, K., Chimonyo, M., Raats, J.G., and Strydom, P. E. (2008). Meat quality of Nguni, Bonsmara and Aberdeen Angus steers raised on natural pasture in the Eastern Cape, South Africa. *Meat Science*, 79, 20–28.

Muchenje, V., Dzama, K., Chimonyo, M., Strydom, P. E., Hugo, A., and Raats, J. G. (2009). Some biochemical aspects pertaining to beef eating quality and consumer health : A review. *Food Chemistry*, 112, 279–289.

Murphy, M.M., Spungen, J.H., Bi, X., and Barraj, L.M. (2011). Fresh and fresh lean pork are substantial sources of key nutrients when these products are consumed by adults in the United States. *Nutrition Research*, 31, 776–783.

Muir, P.D., Deaker, J.M., and Bown, M.D. (1998). Effects of forage- and grain-based feeding systems on beef quality: A reviewNew. *Zealand Journal of Agricultural Researc*h, 41, 623–635.

Nadeau, K. J., Leitner, J.W., Gurerich, I., and Draznin, B. (2004). Insulin regulation of sterol regulatory element-binding protein-1 expression in L-6 muscle cells and 3T3 L1 adipocytes. *Journal of Biological Chemistry*, 279, 34380–34387.

Nadia, L.R., Hassan, R.A., Qota, E.M., and Fayek, H.M. (2008). Effect of natural antioxidant on oxidative stability of eggs and productive and reproductive performance of laying hens. *International Journal of Poultry Science*, 7,134-150.

Nagaraja, T.G. (2016). Microbiology of the Rumen. In *Rumenology* (pp 39-61). Springer international publishing.

Nagi, M. N., Alam, K., Badary, O. A., Al-shabanah, O. A., Al-sawaf, H. A., and Al-bekairi, A. M. (1999). Thymoquinone protects against carbon tetrachloride hepatotoxicity in mice via an antioxidant mechanism. *Biochemistry and Molecular Biology International*, 47(1), 153–159.

Nakatani, N. (2000). Phenolic antioxidants from herbs and spices. *Biofactors*, 13, 141–146.

Nakyinsige, K., Fatimah, A., Aghwan, Z.A., Zulkifli, I., Goh, Y.M., and Sazili, A.Q. (2014). Bleeding efficiency and meat oxidative stability and microbiological quality of New Zealand White rabbits subjected to halal slaughter without stunning and gas stun-killing. *Asian Australasian Journal of Animal Sciences*, 27, 406–413.

Narimani-rad, M., Nobakht, A., Shahryar, H. A., and Kamani, J. (2011). Influence of dietary supplemented medicinal plants mixture (Ziziphora, Oregano and Peppermint) on performance and carcass characterization of broiler chickens. *Journal of Medicinal Plants Research*, 5(23), 5626–5629.

Nangia, O. P., and Shrivastava, P. N. (1989). Effect of presence or absence of protozoa on rumen digestive functions in buffaloes on straw-based diets. *Asian-Australasian Journal of Animal Sciences*, 2, 493–496.

National Research Council (NRC) (1985). Nutrient requirements of sheep. Nat Acad Press, Washington, DC, 6th rev. ed.

National Research Council (NRC). (2007). Nutrient requirements of small ruminant (6th ed.). Washington, D. C., USA:

Nergiz, C. and Ötleş S. (1993). Chemical composition of *Nigella sativa L* . seeds. *Food Chemistry*, 48, 259–261.

Nickavar, B., Mojab, F., and Javidnia, K. (2003). Chemical composition of the fixed and volatile oils of *Nigella sativa L. Zeitschrift für Naturforschung C*., 58, 629–631.

Nieto, G., Díaz, P., Bañón, S., and Garrido, M. D. (2010). Dietary administration of ewe diets with a distillate from rosemary leaves (*Rosmarinus officinalis L.*): Influence on lamb meat quality. *Meat Science*, 84(1), 23–29.

Nieto, G., Estrada, M., José, M., Dolores, M., and Bañón, S. (2011). Effects in ewe diet of rosemary by-product on lipid oxidation and the eating quality of cooked lamb under retail display conditions. *Food Chemistry*, 124, 1423–1429.

Nieto, G., Ban, S., and Garrido, M. D. (2012). Administration of distillate thyme leaves into the diet of Segureña ewes: effect on lamb meat quality. *Animal*, 6, 2048–2056.

Nishimura, T. (2010). The role of intramuscular connective tissue in meat texture. *Animal Science Journal,* 81, 21–27.

Ntambi, J. M., and Miyazaki, M. (2004). Regulation of stearoyl-CoA desaturases and role in metabolism. *Progress in Lipid Research*, 43(2), 91–104.

Nute, G., Richardson, R., Wood, J., Hughes, S., Wilkinson, R., Cooper, S., and Sinclair, L. (2007). Effect of dietary oil source on the flavour and the colour and lipid stability of lamb meat. *Meat Science*, 77, 547–555.

Offer, G. and Knight, P. (1988). The structural basis of water-holding in meat part 2: Drip losses. In Lawrie, R., (Ed.). In Developments in Meat Science. UK: Elsevier Science publishers (Vol. 4, pp. 173–243).

O'Grady, M.N, Maher, M, Troy, D.J, Moloney, A.P., and Kerry, J.P. (2006). An assessment of dietary supplementation with tea catechins and rosemary extract on the quality of fresh beef. *Meat Science* 73, 132–143.

Okamura, N., Fujimoto, Y., Kuwabara, S. and Yagi, A. (1994). High-performance liquid chromatographic determination of carnosic acid and carnosol in *Rosmarinus oficinalis* and Salvia oficinalis. *Journal of Chromatography*, 679, 381–386.

Okoh, O. O., Sadimenko, A. P., and Afolayan, A. J. (2010). Comparative evaluation of the antibacterial activities of the essential oils of *Rosmarinus officinalis L.* obtained by hydrodistillation and solvent free microwave extraction methods.

Food Chemistry, 120(1), 308–312.

Okuda, T. (2005). Systematics and health effects of chemically distinct tannins in medicinal plants. *Phytochemistry*, 66, 2012- 2031.

Ono, K., Hasegawa, K., Naiki, H., and Yamada, M. (2004). Curcumin has potent anti-amyloidogenic effects for alzheimer's β-amyloid fibrils *in vitro*. *Journal of Neuroscience Research,* 75,742–750.

Ørskov, E.R. and Ryle, M. (1990). Energy Nutrition in Ruminants, 2nd ed. Elsevier, New York, NY.

Ørskov, E., and McDonald, I. (1979). The estimation of protein degradability in the rumen from incubation measure- ments weighted according to rate of passage. *The Journal of Agricultural Science,* 92, 499–503.

Ortuño, J., Serrano, R., and Bañón, S. (2015). Antioxidant and antimicrobial effects of dietary supplementation with rosemary diterpenes (carnosic acid and carnosol) vs vitamin E on lamb meat packed under protective atmosphere. *Meat Science*, 110, 62–69.

Ortuño, J., Serrano, R., Jordán, M.J., and Bañón, S. (2014). Shelf life of meat from lambs given essential oil-free rosemary extract containing carnosic acid plus carnosol at 200 or 400 mg kg^{-1}. *Meat Science*, 96(4), 1452–1459.

Osakabe, N., Yasuda, A., Natsume, M., and Yoshikawa T. (2004). Rosmarinic acid inhibits epidermal inflammatory responses : anticarcinogenic effect of Perilla frutescens extract in the murine two-stage skin model. *Carcinogenesis*, 25(4), 549–557.

Osman, A.M.A., and El-Barody M.A. (1999). Growth performance and immune response of broiler chicks as affected by diet density and *Nigella sativa* seeds supplementation. *Egyptian Poultry Science Journal*, 19, 619-634.

Palmieri, B., and Sblendorio, V. (2007). Oxidative stress tests: Overview on reliability and use Part II. *European Review for Medical and Pharmacological Sciences*, 11,383–399.

Patra, A.K, and Yu, Z. (2015). Effects of adaptation of *in vitro* rumen culture to garlic oil, nitrate and saponin and their combinations on methanogenesis, fermentation, and abundances and diversity of microbial populations. *Frontiers Microbiology*, 6, 1434.

Patra, A.K., and Yu, Z. (2012). Effects of essential oils on methane production and fermentation by, and abundance and diversity of, rumen microbial populations. *Applied Environmental Microbiology*, 78, 4271–4280.

Patra, A.K., and Saxena, J. (2010). A new perspective on the use of plant secondary metabolites to inhibit methanogenesis in the rumen. *Phytochemistry*, 71,

1198-222.

Pereira, P.M., and Vicente, A.F. (2013). Meat nutritional composition and nutritive role in the human diet. *Meat Science*, 93, 586–592.

Petersen, M, and Simmonds M.S. (2003). Rosmarinic acid. *Phytochemistry*, 62, 121–5.

Petiwala, S. M., Puthenveetil, A. G., and Johnson, J. J. (2013). Polyphenols from the Mediterranean herb rosemary (*Rosmarinus officinalis*) for prostate cancer. *Front Pharmacol*, 4, 1–4.

Philip, A K. (1997). Potential role of TNFa and lipoprotein lipase as candidate genes for obesity. *American Society for Nutritional Sciences*, 127, 1917-1922.

Piras, A, Rosa, A., Marongiu, B., Porcedda, S., Falconieri, D., Dessì, M.A., Ozcelik, B., and Kocae, U. (2013). Chemical composition and *in vitro* bioactivity of the volatile and fixed oils of *Nigella sativa* L. extracted by supercritical carbon dioxide. *Industrial Crops and Products*, 46, 317– 323.

Platel, K., and Srinivasan, K. (2001). Studies on the influence of dietary spices on food transit time in experimental rats. *Nutrition Research*, 21, 1309-1314.

Ponnampalam, E. N., Norng, S., Burnett, V. F., Dunshea, F. R., Jacobs, J. L., and Hopkins, D. L. (2014). The synergism of biochemical components controlling lipid oxidation in lamb muscle. *Lipids*, 49, 757–766.

Popkin, B.M., Adair, L.S., and Ng, S.W. (2012). Global nutrition transition and the pandemic of obesity in developing countries. *Nutrition reviews*, 70, 3-21.

Popova, T., Marinova, P., Vasileva, V., Gorinov, Y., and Lidji, K. (2009). Oxidative changes in lipids and proteins in beef during storage. *Archiva Zootechnica*, 12, 30-8.

Prain, D. (1988). Bangal Plants, 4th Edition, Botanical Survey of India, Calcutta, India.

Priolo, A., Micol, D., Agabriel, J., Prache, S. and Dransfield, E., (2002). Effect of grass or concentrate feeding systems on lamb carcass and meat quality. *Meat Science*, 62, 179-185.

Priolo, A., Waghorn, G.C., Lanza, M., Biondi, L., and Pennisi, P. (2000). Polyethylene glycol as a means for reducing the impact of condensed tannins in carob pulp: Effects on lamb growth performance and carcass and meat quality. *Journal of Animal Science*, 78, 810-816.

Priola, A., Micol, D. and Agabriel, J. (2001). Effects of grass feeding systems on ruminant meat color and flavour. A review. *Animal Research*, 50, 185–200.

Puertollano, M. A., Puertollano, E., Alvarez de Cienfuegos, G., and A de Pablo, M.

(2011). Dietary antioxidants : Immunity and host defense. *Current Topics in Medicinal Chemistry*, 11, 1752–1766.

Purslow, P. P. (2014). New developments on the role of intramuscular connective tissue in meat toughness. *annual review of Food Science and Technology*, 5, 133–153.

Purslow, P. P. (2005). Intramuscular connective tissue and its role in meat quality. *Meat Science*, 70, 435–447.

Purchas, R., and Busboom, J. (2005). The effect of production system and age on levels of iron, taurine, carnosine, coenzyme Q10, and creatine in beef muscles and lover. *Meat Science*, 70, 589-596.

Purchas, R., Rutherfurd, S., Pearce, P., Vather, R., and Wilkinson, B.H. (2004). Concentrations in beef and lamb of taurine, carnosine, coenzyme Q10, and creatine. *Meat Science*, 66, 629-637.

Qwele, K., Hugo, A., Oyedemi, S. O., Moyo, B., Masika, P. J., and Muchenje, V. (2013). Chemical composition , fatty acid content and antioxidant potential of meat from goats supplemented with Moringa (*Moringa oleifera*) leaves , sunflower cake and grass hay. *Meat Science*, 93(3), 455–462.

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

Ramin, AG., Hashemi, M., Asri-Rezaie, S., Batebi, E., Tamadon, A. and Ramin, S. (2011). Prediction of traumatic pericarditis in cows using some serum biochemical and enzyme parameters. *Acta Veterinaria*, 61(4), 383–390.

Reed, J. D., Soller, H., and 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(1), 39–50.

Remond, B., Brugere, H., Poncet, C, Baumont, R. Le contenu du réticulo-rumen.(1995). In: *Nutrition des Ruminants Domestiques*. Editors. Jarrige R, Ruckebusch Y, Demarquilly C, Farce MH, Journet M, INRA, Paris ; 1995.p 253-298.

Rhee, K. S. (2007). Fatty acids in meats and meat products. In *C. K. Chow (Ed.), Fatty acids in foods and their health implication*. New York: Marcel Dekker, Inc. (pp.1281).

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., and 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.

Ripoll, G., Albertí, P., and Joy, M., (2012). Influence of alfalfa grazing-based feeding systems on carcass fat colour and meat quality of light lambs. *Meat Science*. 90, 457-464.

Russell, J.B., and Houlihan, A.J. (2003). Ionophore resistance of ruminal bacteria andits potential impact on human health. *FEMS Microbiology Reviews*, 27, (1), 65-74.

Sabow, A.B., Sazili, A.Q., Zulkifli, I., Goh, Y.M., Ab Kadir, M.A.Z., and Adeyemi, K.D. (2015). Physicochemical characteristics of longissimus lumborum muscle in goats subjected to halal slaughter and anesthesia (halothane) pre-slaughter. *Animal Science Journal*, 86, 981–991.

Sahraei, M., Pirmohammadi, R., and Payvastegan, S. (2014). The effect of rosemary (*Rosmarinus officinalis L.*) essential oil on digestibility, ruminal fermentation and blood metabolites of Ghezel sheep fed barley-based diets. *Spanish Journal of Agricultural Research*, 12 (2), 448-454.

Salem, M. L. (2005). Immunomodulatory and therapeutic properties of the *Nigella sativa L*. seed. *International Immunopharmacology*, 5, 1749–1770.

Salem, A., López, S., Ranilla, M.J., and González ,J.S. (2013). Short- to medium-term effects of consumption of quebracho tannins on saliva production and composition in sheep and goats. *Journal of Animal Science*, 91, 1341–1349.

Salem, M. L., and Hossain, M. S. (2000). Protective effect of black seed oil from *Nigella sativa* against murine cytomegalovirus infection. *International Journal of Immunopharmacology*, 22, 729–740.

Sampels, S. (2013). Oxidation and antioxidants in fish and meat from farm to fork. *In Food industry*. In Tech.

Samsudin, A. A., Evans, P. N., Wright, A. G., and Al Jassim, R. (2011). Molecular diversity of the foregut bacteria community in the dromedary camel (*Camelus dromedarius*). *Environmental Microbiology*, 13(11), 3024–3035.

Sanudo, C., Sánchez, A., and Alfonso, M. (1998). Small ruminants production systems and factors affecting lamb meat quality. *Meat Science*, 49, 29–64.

Santé-Lhoutellier, V., Engel, E., and Gatellier, P.h. (2008). Assessment of the influence of diet on lamb meat oxidation. *Food Chemistry*, 109(3), 573–579

Sarker, M. R., Mazumder, M. E., and Rashid H. (2011). *In vitro* enhancement of polyclonal IgM production by ethanolic extract of *Nigella sativa L*. Seeds in whole spleen cells of female BALB / c Mice. *Bangladesh Pharmaceutical Journal*, 14(1), 73–77.

SAS. (2003). Statistical Analysis System package (SAS) Version 9.2 software. SAS Institute Inc., Cary, NC, USA.

Sasaki, K., El, A., Kondo, S., Han, J., and Isoda, H. (2013). *Rosmarinus officinalis* polyphenols produce anti-depressant like effect through monoaminergic and cholinergic functions modulation. *Behavioural Brain Research*, 238, 86–94.

Sazili, A. Q., Parr, T., Sensky, P. L., Jones, S. W., Bardsley, R. G., and Buttery, P. J. (2005). MEAT The relationship between slow and fast myosin heavy chain content , calpastatin and meat tenderness in different ovine skeletal muscles. *Meat Science*, 69, 17–25.

Schaäfer, A., Rosenvold, K., Purslow, P. P., Andersen, H. J., and Henckel, P. (2002). Physiological and structural events post mortem of importance for drip loss in pork. *Meat Science*, 61(4), 355–366.

Schmittgen, T. D., and Zakrajsek, B. A. (2000). Effect of experimental treatment on housekeeping gene expression : validation by real-time, quantitative. *Journal of Biochemical and Biophysical Methods*, 46(1), 69–81.

Schmid, A., Collomb, M., Sieber, R., and Bee, G. (2006). Conjugated linoleic acid in meat products: A review. *Meat Science*, 73(1), 29–41.

Semenkovich, C.F., Chen S.H., Wims, M., Luo, C.C., Li, W.H, and Chan, L. (1989). Lipoprotein lipase and hepatic lipase mRNA tissue specific expression, development regulations and evolution. *Journal of Lipid Research*, 30,423-431.

Sener, B, Kusmenoglu, S., Mutlugil, A., and Bingol F. (1985). A study with seed oil of *N.sativa*. *Journal of Faculty of Pharmacy of Gazi University*, 2, 1–7.

Serrano, R., Ortuño, J., and Bañón, S. (2014). Improving the sensory and oxidative stability of cooked and chill-stored lamb using dietary rosemary diterpenes. *Journal of Food Science*, 79(9), 1805–1810.

Shahidi, F., Janitha, P. K., and Wanasundara, P. D. (1992). Phenolic antioxidants. *Critical Reviews in Food Science and Nutrition*, 32(1), 67–103.

Shan, T. Z., Wang, Y. Z., and Li, M. (2006). Cloning of lipoprotein lipase (LPL) gene of swine and the difference of LPL gene expression at different avoirdupois stages. *Journal of Agricultural Biotechnology*, 14, 151-155.

Shi H., Luo J., Zhu J., Jun Li, Sun Y., Lin X., Zhang L., Yao D., and Shi H. (2013). PPARγ Regulates Genes Involved in Triacylglycerol Synthesis and Secretion in Mammary Gland Epithelial Cells of Dairy Goats. *PPAR Research* 2013.

Shimano, H. (2002) Sterol regulatory element binding protein family as global regulators of lipid synthetic genes in energy metabolism. *Vitamins and Hormones*, 65, 167–194.

Shokrollahi, B., Amini, F., Fakour, S., and Andi, M.A. (2015). Effect of rosemary (*Rosmarinus officinalis*) extract on weight, hematology and cell-mediated

immune response of newborn goat kids. *Journal of Agriculture and Rural Development in the Tropics and Subtropics* 116, 91–97.

Simitzis, P. E., Deligeorgis, S. G., Bizelis, J. A., and Dardamani, A. (2008). Effect of dietary oregano oil supplementation on lamb meat characteristics. *Meat Science*, 79, 217–223.

Simitzis, P.E, Deligeorgis, S.G., Bizelis, J.A., Dardamani, A., Theodosiou, I., and Fegeros, K. (2007). Effect of dietary oregano oil supplementation on lamb meat characteristics. *Meat Science*, 79, 217–223

Srinivasan, K. (2005). Spices as influencers of body metabolism: An overview of three decades of research. *Food Research International*, 38, 77-86.

Sivakumaran, S., Molan, A.L., Meagher, L.P., Kolb, B., Foo, L.Y., Lane, G.A., Attwood, G.A., Fraser, K., and Tavendale, M. (2004). Variation in antimicrobial action of pro-anthocyanidins from Dorycnium rectum against rumen bacteria. *Phytochemistry*. 65, 2485-2497.

Smeti, S., Hajji, H., Mekki, I., Mahouachi, M., and Atti, N. (2018). Effects of dose and administration form of rosemary essential oils on meat quality and fatty acid profile of lamb. *Small Ruminant Research,* 158, 62–68

Smeti, S., Atti, N., Mahouachi, M., and Muñoz, F. (2013). Use of dietary rosemary (*Rosmarinus officinalis L.*) essential oil to increase the shelf life of Barbarine light lamb meat. *Small Ruminant Research*, 113,340–345.

Soladoye, O., Juárez, M., Aalhus, J., Shand, P., and Estévez, M. (2015). Protein oxidation in processed meat : mechanisms and potential implications on human health. *Comprehensive Reviews in Food Science and Food Safety*, 14, 106–122.

Solorzano L. (1969). Determination of ammonia in natural waters by the phenolhypochlorite method. *imnology and Oceanography,*14, 799-801.

Sorisky, A. (1999). From Preadipocyte to adipocyte : Differentiation-directed signals of insulin from the cell surface to the nucleus. *Critical Reviews in Clinical Laboratory Sciences*, 36(1), 1–34.

Sousa, W.H., Cartaxo, F.Q., Cezar, M.F., Gonzaga Neto, S., Cunha, M.G.G., and Santos, N.M., (2008). Desempenho e características de carcaça de cordeiros terminados em confinamento com diferentes condições corporais. *Revista Brasileira de Saúde e Produção Animal*, 9, 795–803.

Souza, D.A., Selaive-Villarroel, A.B., Pereira, E.S., Osório, J.C.S., and Teixeira, A. (2013). Growth performance, feed efficiency and carcass characteristics of lambs produced from Dorper sheep crossed with Santa Inês or Brazilian Somali sheep. *Small Ruminant Research*, 114, 51–55.

Soycan-önenç, S. (2016). Effect of *Vitex agnus-castus* on *in vitro* digestibility in ruminant. *African Journal of Agricultural Research*, *11*(23), 2058–2063.

Stahl, A.B. (2014). Plant-food processing: implications for dietary quality. In In: Harris DR, Hillman GC, editors. Foraging and farming. The evolution of plant exploitation. New York: Routledge; (Pp. 171–94.).

Suresh, D., and Srinivasan, K. (2007). Studies on the *in vitro* absorption of spice principles – curcumin, capsaicin and piperine in rat intestines. *Food Chemical Toxicology*, 45, 1437-1442.

Swamy, S. M. K., and Tan, B. K. H. (2000). Cytotoxic and immunopotentiating effects of ethanolic extract of *Nigella sativa L.* seeds. *Journal of Ethnopharmacology*, 70, 1-7.

Sylvester, J. T., Karnati, S. K. R., Yu, Z., Morrison, M., and 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.

Takruri, H. M. H., and Dameh, M. A. F. (1998). Study of the nutritional value of black cumin seeds (*Nigella sativa L.*). *Journal of the Sciences of Food Agriculture*, 76, 404–410.

Tavassoli, S.K., Mousavi, S.M., Emam-Djomeh, Z., and Razavi, S.H., (2011). Chemical composition and evaluation of antimicrobial properties of *Rosmarinus officinalis L.* essential oil. *African Journal of Biotechnology*, 10, 13895–13899.

Teicher, B.A. (2002). *In vivo* tumor response end point In: In Tumor Models in Cancer Research. (Ed.): B.A. Ticher. Humana Press Inc. Totowa, New Jersey. (p. 593–616).

Tilley J.M., and Terry R.E. (1963). A two-stage technique for in vitro digestion of forage crops. *Grass and Forage Science,* 18, 104-111.

Tu, Z., Moss-pierce, T., Ford, P., and Jiang, T. A. (2013). Rosemary (*Rosmarinus officinalis L.*) Extract Regulates Glucose and Lipid Metabolism by Activating AMPK and PPAR Pathways in HepG2 Cells. *Journal of Agricultural and Food Chemistry*, *61*, 2803−2810.

Tudor, G. D. A., Coupar, F. J. A., and Pethick, D. W. B. (1996). Effect of silage diet on glycogen concentration in the muscle of yearling cattle. *Proceedings of the Australian Society of Animal Production*, 21, 451.

Ultee, A., Kets, E. P., and Smid E. J. (1999). Mechanisms of action of carvacrol on the food-borne pathogen bacillus cereus. *Applied and Environmental Microbiology*, 65(10), 4606–4610.

Valenzuela-Grijalva N.V., Pinelli-Saavedra A., Muhlia-Almazan A., Domínguez-

Díaz D., and González-Ríos, H. (2017). Dietary inclusion effects of phytochemicals as growth promoters in animal production. *Journal of Animal Science and Technology*, 59(8), 1–17.

Van Elswyk, M. E., and McNeill, S. H. (2014) Impact of grass/ forage feeding versus grain finishing on beef nutrients and sensory quality: The US experience. *Meat Science,* 96, 535-540.

Van Nevel, C., and Demeyer, D. I. (1988). Manipulation of rumen fermentation. In H. D. Hobson. The rumen microbial ecosystem New York: Elsevier Science. (pp. 387–343).

Van Soest, P. J., Robertson, J. B., and Lewis, B. A. (1991). Methods for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition. *Journal of Dairy Science*, 74(10), 3583–3597.

Váradyová, Z., Kišidayová, S., Siroka, P., and Jalč, D. (2007). Fatty acid profiles of rumen fluid from sheep fed diets supplemented with various oils and effect on the rumen ciliate population. *Czech Journal of Animal Science*, 52(11), 399–406.

Vasta, V., and Luciano, G. (2011). The effects of dietary consumption of plants secondary compounds on small ruminants' products quality. *Small Ruminant Research*, 101(1), 150–159.

Vasta, V., Mele, M., Serra, A., Scerra, M., Luciano, G., Lanza, M., and Priolo, A. (2009). Metabolic fate of fatty acids involved in ruminal biohydrogenation in sheep fed concentrate or herbage with or without tannins. *Journal of Animal Science*,87, 2674–2684.

Vatansev, H., Ciftci, H., Ozkaya, A., Ozturk, B., Evliyaoglu, N., and Kiyici, A. (2013). Chemical composition of *Nigella sativa* l. seeds used as a medical aromatic plant from east Anatolia region, turkey. *Asian journal of chemistry*, 25(10), 5490.

Vaughan, J.G., and Geissler, C.A. (1997). *The new Oxford book of food plants.* Oxford university press.

Venkatachallam, S.K.T., Pattekhan, H., Divakar S., and Kadimi U.S. (2010). Chemical composition of *Nigella sativa L*. seed extracts obtained by supercritical carbon dioxide. *Journal Food Science and Technology*, 47(6), 598–605.

Viollet, B., Andreelli F., Jorgensent B., Perrin C., Flamez D., Mu J.,Wojtaszewski J.F.P., Schuit F.C., Birnbaum M., Richter E., Burcelin R., and Vaulont S. (2003). Physiological role of AMP- activated protein kinase (AMPK): insights from knockout mouse models. *Biochemical Society Transactions*, 31, 216-219.

Wallace, R. J. (2004). Antimicrobial properties of plant secondary metabolites. *Proceedings of the Nutrition Society*, 63, 621–629.

Wanapat, M., Cherdthong, A., Pakdee, P., and Wanapat, S. (2008). Manipulation of rumen ecology by dietary lemongrass (*Cymbopogon citratus* stapf) powder supplementation. *Journal of Animal Science*, 86(12), 3497–3503.

Wanapat, M., Kang, S., Khejornsart, P., and Wanapat, S. (2013). Effects of plant herb combination supplementation on rumen fermentation and nutrient digestibility in beef cattle. *Asian-Australasian Journal of Animal Sciences*, 26(8), 1127–1136.

Wang, R. J., Li, D., and Steve, B. (1998). Can 2000 years of herb medicine history help us solve problems in the year 2000. In: *Biotechnology in the feed industry* (Ed. T. P. Lyons and K. A. Jacques). Nottingham University Press. pp. 271-291.

Wang ,Y., McAllister, T.A., Yanke, L.J., Xu, Z.J., Cheeke, P.R., and Cheng, K.-J. (2000). *In vitro* effects of steroidal saponins from *Yucca schidigera* extract on rumen microbial protein synthesis and ruminal fermentation. *Journal of the Science of Food and Agriculture*, 80, 2114–2122.

Warriss, P. D. (2010). Meat Science: An Introductory Text. Cambridge: CABI publishing.

Waylan, A.T, Dunn, J.D., Johnson, B.J., and Sissom, E.K. (2004). Effect of supplementation and growth promotants on lipoprotein lipase and glycogenin messenger RNA concentrations in finishing cattle. *Journal of Animal Science*, 82, 1868-1875.

Webb, E.C., and O'Neill, H.A. (2008). The animal fat paradox and meat quality *Meat Science,* 80 28–36.

Weinstock, P. H., Levak-Frank, S., Hudgins, L.C., Radner, H., Friedman, J. M., Zechner, R., and Breslow L.J. (1997). Lipoprotein lipase controls fatty acid entry into adipose tissue, but fat mass is preserved by endogenous synthesis in mice deficient in adipose tissue lipoprotein lipase. *Proceedings of the National Academy of Sciences,* 94(19), 10261–10266.

Wiklund, E., Stevenson-Barry, J. M., Duncan, S. J., and Littlejohn, R. P. (2001). Electrical stimulation of red deer (Cervus elaphus) carcasses — effects on rate of pH-decline, meat tenderness, colour stability and water-holding capacity. *Meat Science*, 59(2), 211-220.

Wood, J. D., Enser M., Fisher A. V., Nute, G. R., Sheard, P. R., Richardson, R. I., Hughes S. I., and Whittington, F. M. (2008). Fat deposition, fatty acid composition and meat quality : A review. *Meat Science*, 78, 343–358.

Worthen, D.R, Ghosheh O.A., and Crooks P.A. (1998). The *in vitro* anti-tumour

activity of some crude and purified components of black seeds, *Nigella sativa L*. *Anticancer Research*, 18(3A), 1527–1532.

Xu, G.S., Ma, T., Ji, S.K., Deng, K.D., Tu, Y., Jiang, C.G., and Diao, Q.Y. (2015). Energy requirements for maintenance and growth of early-weaned Dorper crossbred male lambs. *Livestock Science,* 177, 71–78.

Xu, X, Yu, E., Gao, X., Song, N., Liu, L., Wei, X., Zhang, W., and Fu, C. (2013). Red and processed meat intake and risk of colorectal adenomas: a meta-analysis of observational studies. *International Journal of Cancer*, 132, 437-448.

Yan, M., Li, G., Petiwala, S. M., and Householter, E. (2015). Standardized rosemary (*Rosmarinus officinalis*) extract induces Nrf2 / sestrin-2 pathway in colon cancer cells. *Journal of Functional Foods*, 13, 137–147.

Yan, C., Wang, K., Chen, L., He, Y.M., and Tang, Z.X. (2012). Effects of feeding an herbal preparation to sows on immunological performance of offspring. *Journal of Animal Science*, 90, 3778–3782.

Yang, W. Z., Benchaar, C., Ametaj, B. N., Chaves, A. V, He, M. L., and Mcallister, T. A. (2007). Effects of garlic and juniper berry essential oils on ruminal fermentation and on the site and extent of digestion in lactating cows. *Journal of Dairy Science*, 90(12), 5671–5681.

Yesilbag, D., Eren, M., Agel, H., Kovanlikaya, A., and Balci, C. (2011). Effects of dietary rosemary, rosemary volatile oil and vitamin E on broiler performance, meat quality and serum SOD activity. *British Poultry Science*, 52, 472–482.

Yesil-Celiktas, O., Sevimli, C., Bedir, E., and Vardar-Sukan, F. (2010). Inhibitory effects of rosemary extracts, carnosic acid and rosmarinic acid on the growth of various human cancer cell lines. *Plant Foods for Human Nutrition*, 65(2), 158– 163.

Yusuf, A. L. (2014). Growth performance, rumen fermentation and meat quality of Boer goats fed diets containing different parts of king of bitters (*Andrographis paniculata* (Burm.f.) Wall. Ex nees). PhD thesis, Universiti Putra Malaysia. Retrieved on 25 January 2015

Yusuf, A. L., Goh, Y. M., Samsudin, A. A., Alimon, A. R., and Sazili, A. Q. (2014). Growth performance, carcass characteristics and meat yield of Boer goats fed diets containing leaves or whole parts of *Andrographis paniculata*. *Asian-Australasian Journal of Animal Sciences,* 27(4), 503–510.

Yusuf, A. L., Ebrahimi M., Goh, Y. M., Samsudin, A. A., Idris, A.R., Alimon, A. R., and Sazili, A. Q. (2012). *In vitro* Digestibility of Diets Containing Different Parts of Andrographis paniculata Using Rumen Fluid from Goats. *Journal of animal and veterinary advances,* 11(21), 3921-3927.

Zanouny, A. I., Abd-el-Moty, A. K. I., Sallam, M. T., El-Barody, M. A. A., and Abd-el-Hakeam, A. A. (2013). Effect of supplementation with *Nigella sativa* seeds on nutritive values and growth performance of Ossimi sheep. *Egyptian Journal of Sheep and Goat Sciences*, 8(1), 57–63.

Zhao, W., Hu, S., Yu, K., Wang, H., Wang, W., and Loor, J. (2014). Lipoprotein lipase, tissue expression and effects on genes related to fatty acid synthesis in goat mammary epithelial cells. *International Journal of Molecular Sciences*, 15, 22757–22771.

Zheng, M. Q., Cao, H. H, Li, H. B., and Wen, J. (2001). The current research situation of lipoprotein lipase (LPL) gene. *Animal Science Abroad*, 2, 27-31.

Zhang, Y., Smuts, J.P., Dodbiba, E., Rangarajan, R., Lang, J.C., and Armstrong, D.W., (2012). Degradation study of carnosic acid, carnosol, rosmarinic acid, and rosemary extract (*Rosmarinus officinalis L.*) assessed using HPLC. *Journal of Agricultural and Food Chemistry*, 60, 9305–9314.

LIST OF PUBLICATIONS

Odhaib, K.J., Sazili, A.Q., and A.L. Alimon (2015). The effect of *Nigella sativa* and *Rosmarinus officinalis* on in vitro rumen fermentation. Green technology farming for sustainable livestock production. Proceeding of the 2nd ASEAN Regional Conference on Animal production and 36th Annual Conference of the Malaysian Society of Animal Production 2015. 1-3 June, Port Dickson, Negeri Sembilan, Malaysia.

Odhaib K.J., Adeyemi, K. D., Ahmed, M.A., Jahromi, M.F., Jusoh, S., Samsudin, A. A., Alimon, A.R., Yaakub, H., & Sazili, A Q. Influence of *Nigella sativa* Seeds, *Rosmarinus officinalis* Leaves and their combination on Growth Performance, Immune Response and Rumen Metabolism in Dorper Lambs. *Tropical Animal Health and Production*. Accepted for Publication.

Odhaib, K.J., Adeyemi, K.D & Sazili, A.Q. Carcass traits, fatty acid composition, gene expression, oxidative stability and quality attributes of different muscles in Dorper lambs fed *Nigella sativa* seeds, *Rosmarinus officinalis* leaves and their combination. *Asian- Australasian Journal of Animal Science*. Accepted for Publication.

UNIVERSITI PUTRA MALAYSIA

STATUS CONFIRMATION FOR THESIS / PROJECT REPORT AND COPYRIGHT

ACADEMIC SESSION : _____

TITLE OF THESIS / PROJECT REPORT :

RUMEN METABOLISM, MEAT QUALITY AND GENE EXPRESSION CHANGES ASSOCIATED WITH *Nigella sativa* L. SEEDS AND *Rosmarinus officinalis* L. LEAF SUPPLEMENTATION IN DORPER SHEEP

NAME OF STUDENT: KIFAH ODHAIB JUMAAH

I acknowledge that the copyright and other intellectual property in the thesis/project report belonged to Universiti Putra Malaysia and I agree to allow this thesis/project report to be placed at the library under the following terms:

1. This thesis/project report is the property of Universiti Putra Malaysia.
2. The library of Universiti Putra Malaysia has the right to make copies for educational purposes only.
3. The library of Universiti Putra Malaysia is allowed to make copies of this thesis for academic exchange.

I declare that this thesis is classified as :

*Please tick (√)

☐	**CONFIDENTIAL**	(Contain confidential information under Official Secret Act 1972).
☐	**RESTRICTED**	(Contains restricted information as specified by the organization/institution where research was done).
☐	**OPEN ACCESS**	I agree that my thesis/project report to be published as hard copy or online open access.

This thesis is submitted for :

☐	**PATENT**	Embargo from_____ until _____ (date) (date)

Approved by:

_____	_____
(Signature of Student)	(Signature of Chairman of Supervisory Committee)
New IC No/ Passport No.:	Name:
Date :	Date :

[Note : If the thesis is CONFIDENTIAL or RESTRICTED, please attach with the letter from the organization/institution with period and reasons for confidentially or restricted.]