



**UNIVERSITI PUTRA MALAYSIA**

**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)**

**AISHA LARABA YUSUF**

**FP 2014 9**



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**By**

**AISHA LARABA YUSUF**

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

**August 2014**

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## **DEDICATION**

**This thesis is dedicated to my Mother Hajiya Baraka Yusuf**



**“Allah is indeed The Most Generous for it is He Who teaches by the pen and teaches man that which he knew not”**

**(QUR'AN 96:3-5)**

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Doctor of Philosophy

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By

**AISHA LARABA YUSUF**

**August 2014**

**Chairman: Awis Qurni bin Sazili, PhD**  
**Faculty: Agriculture**

Synthetic feed additives such as antibiotics and antioxidants play a significant role in improving the health, overall performance of animals, and quality of animal products. Despite the numerous benefits derived from the use of these synthetic feed additives, there are also health concerns on their usage. Thus, there is a need to find alternatives to these additives in order to bridge the gap between improved animal performance and safety of animal products. Hence, the search for natural growth promoters that can stabilize digestibility, improve growth performance, quality and increase yield of product that will lead to higher profitability in any livestock venture. Therefore, the objective of this research was to evaluate the influence of feeding diets supplemented with different parts of *Andrographis paniculata* (AP) on growth performance, rumen fermentation and meat quality of goats. The first experiment was conducted to evaluate the amount of polyphenols in the leaf, root and stem of AP and the effects of those parts on apparent nutrient digestibility and ruminal biohydrogenation in vitro. Significantly higher concentrations of total polyphenols, non-tannin and tannin polyphenols were recorded in the leaf of AP (APL). Subsequently, three diets which contained separately, the leaves (APL), roots (APR) and stems (APS) of *Andrographis paniculata* at 1% (w/w) levels of inclusion were formulated, in addition to the control diet (AP0). The samples of these diets were incubated for 24 h in buffered ruminal liquor obtained from goats. The results showed that in comparison with AP0, the APL, APR and APS diets showed lower ( $P < 0.05$ ) concentrations of ammonium nitrogen. Thereafter, six diets containing the leaves, roots and stems of *Andrographis paniculata* at 1 and 2% (w/w) levels of inclusion and their effects on in vitro ruminal biohydrogenation evaluated. The control diet (AP0) was not supplemented. The assessment on rumen biohydrogenation revealed significantly a higher proportion of cis-9, trans-11 conjugated linoleic acid (CLA) and C18:3n-3 in the APR2 diet. Higher ratios of unsaturated fatty acid to saturated fatty acids ( $P < 0.05$ ) were also recorded in the APL2 diet. The rates of biohydrogenation of oleic, linoleic and linolenic acids were significantly higher in the

APR2 diet compared to the other dietary treatments. Experiments that followed consisted of a 100-days feeding trial involving 24, four month old Boer bucks was conducted to determine the growth performance and digestibility of the diets. The animals were randomly allotted to three different dietary groups: (1) AP0 -basal diet only or control; (2) APL -basal diet + 1.5% (w/w) leaf powder of *Andrographis paniculata* and (3) APWP - basal diet + 1.5% (w/w) whole plant of *Andrographis paniculata*. In a concurrent separate experiment using fistulated goats, the effects of these diets on rumen metabolism were assessed. The dietary supplementation of different parts of *Andrographis paniculata* improved feed intake, feed efficiency, weight gain and body weight. Except for crude fibre and ether extract, digestibility of the other nutrients were significantly higher ( $P < 0.05$ ) in the APL and APWP than the AP0 diet. Both APL and APWP diets reduced ( $P < 0.05$ ) the concentration of ammonium nitrogen and increased ( $P < 0.05$ ) total VFA and rumen pH values. The analysis of rumen free fatty acid profiles demonstrated a higher composition of CLA in the APL diet. Higher compositions of total unsaturated fatty acids, monoenoic fatty acids, total n-3 and n-6 PUFA and ratios of unsaturated fatty acids (USFA) to saturated fatty acids (SFA) and polyunsaturated to saturated fatty acids (PUFA) were noted in the APWP diet. The ratio of n-6 to n-3 was significantly ( $P < 0.05$ ) lower in both APL and APWP diets when compared with the AP0 diet. The real-time PCR analysis revealed a higher population density of the cellulolytic bacteria in the APWP diet.

At the end of the feeding trial the goats were slaughtered and carcass characteristics and meat quality assessment were conducted. The animals were humanely slaughtered, eviscerated and longitudinally split into right and left halves the left half was assigned lean, bone and fat tissue composition determination and the right half carcasses were subjected to 0, 1 and 7 d postmortem storage at 4 °C. On each day of postmortem, the longissimus thoracis muscle (LT) samples were collected and analysed. Muscle samples for fatty acid profile and proximate composition were only taken at 0 d postmortem. The results showed that in comparison with those of the AP0 group, lean to bone ratio, lean to fat ratio and percentage of lean were significantly higher ( $P < 0.05$ ) in samples of the APWP and APL groups. Goats fed AP0 (control) had significantly higher proportions of fat and bone than those subjected to the APL and APWP diets. At 1 and 7 d postmortem, lower pH values were indicated by the muscle samples of APL and APWP groups while a lower drip loss was recorded in samples of APWP group. However, higher cooking loss was observed in both APL and APWP samples compared with the AP0. The lightness ( $L^*$ ) and tenderness of LT muscle were significantly higher in APWP compared with the AP0 group. Higher concentration of CLA was indicated by the muscles of APWP group. The total USFA and the ratio of USFA to SFA in the LT muscle were significantly higher in APL and APWP, while a higher total USFA and ratio of USFA to SFA were noted in the APWP group. Lipid oxidative stability was significantly higher in APL and APWP compared to the AP0 groups. The microbiological assay of the LT muscle stored frozen for 3 and 6 months revealed higher colony forming unit (cfu) of lactic acid bacteria in APL and APWP, with higher cfu of pathogenic bacteria and total bacteria counts recorded in samples of the AP0 group. The e-nose analysis revealed higher flavour and aroma compounds in the APWP samples. Sensory evaluation, demonstrated higher preference by the taste pannelists for meat samples from animals supplemented with APWP.

In conclusion, the dietary supplementation of AP improved meat quality, without any adverse effects on rumen metabolism and growth performance in goats. However, the diet containing the whole plant (APWP) was found to be more effective than those containing only the leaf (APL), although all parts of the plant were found to contain polyphenols.



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

**PRESTASI TUMBESARAN, FERMENTASI RUMEN DAN KUALITI DAGING BOER YANG DIBERI MAKANAN MENGANDUNGI BAHAGIAN BERBEZA DARI HEMPEDU BUMI (*ANDROGRAPHIS PANICULATA* (BURM.F.) WALL. EX NEES)**

Oleh

**AISHA LARABA YUSUF**

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**Pengerusi: Awis Qurni bin Sazili, PhD**  
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Pengaruh pemberian makanan mengandungi pelbagai bahagian *tanaman Andrographis paniculata* (AP) keatas prestasi pertumbuhan, ciri-ciri dan kualiti karkas dan daging ditentukan dalam tiga eksperimen. Eksperimen pertama telah dijalankan untuk mengevaluasi kandungan polifenol dalam daun, akar dan batang AP dan kesan bahagian tersebut keatas dayacerna nutrien dan biohidrogenasi rumen *in vitro*. Konsentrasi yang lebih tinggi yang bererti kandungan total polifenol, polifenol bukan-tannin dan polifenol tannin dicatatkan dalam daun AP (APL). Namun konsentrasi tannin terhidrolisis tidak berbeza diantara bahagian yang dianalisis. Seterusnya, tiga diet telah di formulasi mengandungi daun (APL), akar (APR) dan batang (APS) AP pada aras 1% (w/w), selain dari diet kawalan (AP0). Sampel diet telah diinkubasi selama 24 jam dan cecair rumen terpenampakan yang diambil dari kambing. Dayacerna bahan kering *in vitro* (IVDMD), asid lemak meruap (VFA), nitrogen ammonia, *total* produksi gas telah diukur. Seterusnya, 7 diets mengandungi daun (APL), akar (APR) dan batang (APS) AP pada aras 1% dan 2% dengan tambahan kawalan (AP0) telah diformulasi, dan kesan biohidrogenasi *in vitro* telah ditentukan. Dibandingkan dengan AP0, diet APL1, APR1 dan APS1 menunjukkan kandungan nitrogen ammonia lebih rendah, dengan tiada perbezaan ( $P > 0.05$ ) dalam IVDMD, VFA, jumlah produksi gas. Penilaian keatas biohidrogenasi menunjukkan kandungan cis-9, trans-11 asid linoleik konjugat dan C18:3n-3 yang lebih tinggi dalam diet APR2. Nisbah yang tinggi asid lemak tak-tepu kepada asid lemak tepu ( $P < 0.05$ ) dicatatkan pada diet APL2. Kadar biohidrogenasi asid oleik, linoleik dan linolenik adalah lebih tinggi ( $P < 0.05$ ) dalam diet APR2 jika dibandingkan dengan diet yang lain.

Eksperimen kedua dijalankan selama 100 hari menggunakan dua puluh empat ekor kambing Boer jantan berumur 4 bulan. Kambing dibahagikan secara rawak kepada 3 kumpulan rawatan: (1) Diet AP0-diet asas dan juga kontrol; (2) Diet APL diet asas + 1.5% (w/w) tepung daun AP dan (3) APWP – diet asas + 1.5% (w/w) tepung pokok (akar, daun dan batang) AP. Kesan diet ini keatas prestasi pertumbuhan dan



metabolisme rumen dinilai. Penambahan bahagian AP dalam diet kambing meningkatkan ( $P < 0.05$ ) pengambilan makanan, kecekapan makanan, peningkatan berat badan dan berat badan. Kecuali serabut kasar dan ekstrak eter, dayacerna nutrien laibn adalah lebih tinggi ( $P < 0.05$ ) dalam diet APL dan APWP dibandingkan diet AP0. Kedua dua diet APL dan APWP menurunkan ( $P < 0.05$ ) konsentrasi nitrogen ammonia, dan meningkatkan ( $P < 0.05$ ) jumlah VFA dan nilai pH rumen. Analisis profil asid lemak bebas dalam rumen menunjukkan kandungan CLA yang lebih tinggi dalam diet APL. Jumlah asid lemak taktepu yang lebih tinggi (USFA), asid monoenoik, jumlah n-3 dan n-6 PUFA dan nisbah asid lemak tak tepu kepada asid lemak tepu (SFA) dapat dilihat pada diet APWP. Nisbah asid lemak n-6 kepada n-3 adalah lebih rendah dalam diet APL dan Diet APWP dibandingkan dengan diet AP0. Analisis PCR real-time menunjukkan populasi methanogen yang tinggi dalam diet APL dan APWP, manakala populasi bakteria selulitik tinggi dalam diet APWP. Eksperimen yang ketiga meneliti kesan tambahan dalam diet bahagian AP keatas ciri ciri karkas dan kualiti daging kambing Boer. Kambing telah disembelih dan dikeluarkan organ dalaman, ditimbang dan dicatat sebagai peratusan karkas bersih. Karkas dipotong dua mengikut panjang dan sampel daging diambil untuk penentuan rib-eye area, lean, tulang dan lemak. Bahagian kanan di simpan untuk simpanan posmotem selama 0, 1 dan 7 hari. Sesudah disimpan bahagian otot *longissimus thoracis* di ambil untuk penentuan pH, glikogen, warna, pengoksidaan lipid, mikrobiologi, *drip* dan *cooking loss*, *aroma* dan *flavor*, sebatian *volatile* dan evaluasi sensori. Apabila dibandingkan dengan kumpulan diet AP0, berat karkas panas dan sejuk, peratus karkas, luar rib-eye, nisbah karkas kepada lemak, nisbah daging tulang dan peratus lean, masing masing adalah lebih tinggi ( $P < 0.05$ ) dibandingkan sampel dari kumpulan diet APWP dan APL. Kambing yang diberi diet AP0 (kawalan) mempunyai lebih banyak bahagian lemak dan tulang, dan juga lebih tebal lemak belakang dibandingkan kambing yang diberi diet APL dan APWP. Pada 1 dan 7 hari posmotem, pH yang lebih rendah didapati pada sample kambing yang diberi diet APL dan APWP, manakala *drip loss* yang rendah dicatat untuk sampel dalam kumpulan APWP.

Namun begitu, *cooking loss* yang tinggi dilihat pada sampel dari kumpulan APL dan APWP, dibandingkan kumpulan AP0. Warna sampel *lightness* ( $L^*$ ) dan kelembutan otot *longissimus thoracis* (LT) adalah lebih tinggi dalam kumpulan APWP dibandingkan AP0. Aras CLA yang lebih tinggi dalam otot dari kumpulan APWP. Jumlah USFA dan nisbah USFA kepada SFA dalam otot LT adalah lebih tinggi dalam APL dan APWP, manakala jumlah USFA dan nisbah USFA kepada SFA adalah tinggi dalam kumpulan APWP. Stabiliti lipid oksidasi adalah lebih tinggi dalam kumpulan APL dan APWP dibandingkan dengan AP0. Analisis mikrobiologi otot LT yang dibeku selama 3 dan 6 bulan menunjukkan bilangan koloni (CFU) bakteria asid laktik yang tinggi dalam kumpulan APL dan APWP, dengan bakteria patogenik dan jumlah bakteria lebih tinggi dalam sampel dari kumpulan AP0. Analisis *e-nose* (hidung elektronik) menunjukkan jumlah sebatian aroma dan flavour yang tinggi dalam kumpulan APWP. Evaluasi sensori menunjukkan pilihan untuk sampel daging dari kumpulan APWP oleh panel perasa. Pada keseluruhannya, penambahan AP dalam diet meningkatkan kualiti daging, dengan tiada kesan buruk keatas metabolisme rumen dan prestasi pertumbuhan kambing. Namun begitu, diet yang mengandungi semua bahagian pokok (APWP) didapati lebih efektif daripada diet yang mengandungi tambahan daun (APL).

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I certify that a Thesis Examination Committee has met on 12 August 2014 to conduct the final examination of Aisha Laraba Yusuf on her thesis entitled "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)" 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.

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**4** **IN VITRO DIGESTIBILITY AND BIOHYDROGENATION OF DIETS CONTAINING DIFFERENT PARTS OF HEMPEDU BUMI (*Andrographis paniculata*) USING RUMEN FLUID FROM GOATS**

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