UNIVERSITI PUTRA MALAYSIA

DIETARY MANIPULATIONS USING OIL PALM (ELAEIS GUINEENSIS) FRONDS TO INCREASE THE UNSATURATED FATTY ACID CONTENT OF MUTTON UNDER TROPICAL CONDITIONS

GOH YONG MENG

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By

GOH YONG MENG

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

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"Let food be thy medicine,
and medicine be thy food."

-- Hippocrates

"To conceive of knowledge as a collection of information seems to rob the concept of all its life...Knowledge resides in the user and not in the collection. It is how the user reacts to a collection of information that matters."

-- Churchman, 1971

DEDICATION

To the many beings that had made sacrifices for the advancement of Science and the finalisation of their Karmas.

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

DIETARY MANIPULATIONS USING OIL PALM (*ELAEIS GUINEENSIS*) FRONDS TO INCREASE THE UNSATURATED FATTY ACID CONTENT OF MUTTON UNDER TROPICAL CONDITIONS

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Faculty : Veterinary Medicine

Forty-three seven-month old Barbados Black Belly x Malin crossbred rams were used for the first trial which lasted 14 weeks, inclusive of two weeks of adjustment period. They were allotted into three treatment groups fed varying levels of oil palm (*Elaeis guineensis*) frond pellets and commercial sheep pellets. Treatment diets were 80 % commercial pellet + 20 % (% w/w) oil palm frond pellet (CON group, n=15), 50 % commercial pellet + 50 % oil palm frond pellet (% w/w) (HAF group, n=14) and 80 % oil palm frond pellet + 20 % (% w/w) commercial pellet (OPF group, n=14). The total lipids were extracted using the Folch method and methylated using 14 % methanolic Boron triflouride with a known added amount of heneicosanoic acid (21:0) as an internal standard. The fatty acid methyl esters were separated by capillary column gas liquid chromatography and the fatty acids quantitated as absolute amounts or as percentage of total fatty acids.

The plasma and tissues of the CON animals had significantly ($P<0.05$) increased levels of unsaturated fatty acids (UFA) at the end of the trial compared to their initial values and both HAF and OPF groups. The increase in the UFA content was mainly due to the increased monounsaturated fatty acid (MUFA) content. The plasma and tissues of the HAF animals had the highest amount of saturated fatty acids (SFA) proportionately and in absolute amounts among the three treatment groups. The fatty acid unsaturation status of the plasma and tissues from the OPF animals was midway between those of the CON and HAF groups. All groups had low concentrations of EFA with unfavourable n-6:n-3 ratios. However, the CON animals had more ($P<0.05$) n-6 PUFA in their tissues, whereas the n-3 PUFA were more abundant ($P<0.05$) in the OPF animals. It was also noticed that the forequarter muscles were lower in n-3 PUFA compared to the hindquarter muscles.

Generally, the plasma lipids of the sheep were not markedly affected by their respective treatment diets. The weight gain was the highest in the CON group at 113 g/d and the lowest in the OPF group at 35 g/d. The carcass (Table 20) and meat characteristics (Table 21) obtained from 34 slaughtered animals were significantly different ($P<0.05$) between treatment groups with the best traits observed in the CON animals.

Nine surviving animals (three for each treatment group) from the first trial were used for the second trial. Oesophageal intubations were carried out at zero, two, four, six and eight hours post feeding on each animal to determine the changes

in the rumen conditions due to the treatment diets. The rumen pH was significantly different ($P<0.05$) between treatment groups. It was always in the decreasing order of OPF>HAF>CON at all time points. The rumen volatile fatty acids, ammonia nitrogen content, bacterial and protozoal counts were significantly different ($P<0.05$) between groups as well. The marked differences in the rumen conditions had resulted in the highest ($P<0.05$) amount of UFA present in the rumen of CON animals even after eight hours post-feeding. The UFA in the rumen contents of the CON animals (63.7 ± 6.1 mg/100mL) was two fold higher than those of HAF animals (31.9 ± 4.9 mg/100mL), and quadruple that of the OPF animals (12.1 ± 1.5 mg/100mL) at this point. Subsequently, this had led to the higher levels of UFA in the CON tissues and plasma as shown in the first trial.

In the third trial, seventy-five individually housed male Sprague-Dawley rats aged between six to seven months were used. Fifteen rats were selected randomly and sacrificed to establish the initial baseline values for the serum lipids at the onset of the trial. The remaining 60 rats were allotted randomly into five groups of 12 animals each. Three groups were fed with meat pellets derived from the mutton in the first trial. One group was fed with meat pellets prepared from commercially available mutton whole carcass for comparison purposes, and another group fed with standard rat chow as control. Blood and arterial tissue samples were obtained from the euthanised rats. Sampling was done on four animals from each group sacrificed serially at two, four and six weeks after the onset of the trial. Results showed that the CON mutton increased the rat serum HDL-Cholesterol significantly

($P<0.05$) over those fed with the commercially available mutton. The serum HDL-Cholesterol levels in the CON mutton fed rats was 1.09 ± 0.31 mmol/L, while those fed commercially available mutton was 0.79 ± 0.10 mmol/L. The results on other serum lipids and arterial lesions were inconclusive.

In summary, the dietary manipulations demonstrated the feasibility of increasing the mutton UFA content to a level that would promote healthy changes in the consumers' blood lipid profiles, using sheep reared under tropical conditions fed diets formulated from oil palm frond pellets and commercial concentrates.

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

MANIPULASI PEMAKANAN MENGGUNAKAN DEDAUN KELAPA SAWIT (*ELAEIS GUINEENSIS*) UNTUK MENINGKATKAN KANDUNGAN ASID LEMAK TAK TEPU DAGING BEBIRI DALAM PERSEKITARAN TROPIKA

Oleh

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Empat puluh tiga ekor bebiri jantan kacukan Barbados Blackbelly x Malin berumur tujuh bulan digunakan untuk eksperimen yang pertama selama 14 minggu. Bebiri tersebut dibahagikan secara rawak ke dalam tiga kumpulan. Bebiri ini diberi-makan campuran bahan makanan yang terdiri daripada pellet dedaun kelapa sawit (*Elaeis guineensis*) dan konsentrat komersial. Kumpulan CON (n=15) diberi makan campuran 80 % (w/w) pelet dedaun kelapa sawit + 20 % (w/w) konsentrat komersial, kumpulan HAF (n=14) 50 % (w/w) pelet dedaun kelapa sawit + 50 % (w/w) konsentrat komersial, sementara kumpulan OPF mendapat 80 % (w/w) dedaun kelapa sawit + 20 % (w/w) konsentrat komersial. Kandungan asid lemak sampel diekstrak menggunakan kaedah Folch dan dirawat dengan larutan 14 % Boron trifluorida selepas penambahan sejumlah asid heneikosanoik (21:0) yang diketahui amaunnya sebagai piawaian dalaman. Metil ester asid lemak dipisahkan dengan mesin kromatografi gas yang dilengkapi kolum kapilari. Jumlah asid lemak

dalam sampel dilaporkan sebagai nilai mutlak, ataupun sebagai peratusan kepada jumlah asid lemak keseluruhan.

Plasma dan tisu bebiri CON menunjukkan peningkatan bererti ($P<0.05$) kandungan asid lemak tak tepu (UFA) berbanding kedua-dua kumpulan HAF dan OPF di penghujung eksperimen. Peningkatan asid lemak tak tepu adalah kerana bertambahnya kandungan asid lemak monounsaturat (MUFA). Kandungan asid lemak tepu (SFA) dalam tisu dan plasma bebiri HAF adalah yang tertinggi di kalangan semua kumpulan bebiri. Sementara itu, tahap kandungan asid lemak tak tepu dalam bebiri OPF terletak di perantaraan kumpulan HAF dan CON. Kandungan asid lemak perlu (EFA) adalah rendah dalam semua kumpulan dengan nisbah n-6:n-3 yang kurang memberangsangkan. Bebiri CON mencatatkan kandungan asid lemak poliunsaturat n-6 yang terbanyak ($P<0.05$), sementara kandungan asid lemak poliunsaturat n-3 adalah tertinggi dalam bebiri OPF. Keputusan juga menunjukkan kandungan asid lemak poliunsaturat n-3 otot bahagian suku depan adalah lebih rendah berbanding dengan otot bahagian suku belakang pada bebiri yang sama.

Secara amnya, manipulasi pemakanan tidak mendatangkan kesan yang mendadak terhadap tahap kolesterol dan parameter lain dalam serum bebiri. Penambahan berat badan adalah baik bagi bebiri di dalam kumpulan CON pada 113 g sehari. Bebiri OPF mencatatkan penambahan berat harian yang terendah sekali pada 35 g sehari. Ciri-ciri karkas (Jadual 20) dan daging (Jadual 21) berdasarkan 34

bebiri yang disembelih menunjukkan perbezaan bererti ($P<0.05$) di antara kumpulan eksperimen. Bebiri CON menunjukkan profil karkas dan daging yang terbaik di antara tiga kumpulan tersebut.

Sembilan bebiri yang dikekalkan daripada eksperimen pertama telah digunakan untuk eksperimen kedua. Prosedur intubasi telah dilakukan pada setiap bebiri pada selang masa sifar, dua, empat, enam dan lapan jam selepas waktu makan terakhir untuk mengukur perubahan persekitaran rumen akibat manipulasi pemakanan. Bacaan pH rumen nyata berbeza ($P<0.05$) di antara kumpulan dan sentiasa dalam urutan menurun OPF>HAF>CON pada setiap selang masa. Takat asid lemak meruap, ammonia nitrogen, bilangan bacteria dan protozoa juga berbeza ($P<0.05$). Perbezaan persekitaran rumen yang mendadak menyebabkan rumen bebiri CON mencatatkan kandungan asid lemak tak tepu yang tertinggi ($P<0.05$) walaupun lapan jam selepas bebiri tersebut diberi makan. Kandungan asid lemak tak tepu dalam haiwan CON (63.7 ± 6.1 mg/100mL) adalah dua kali ganda lebih banyak berbanding kumpulan HAF (31.9 ± 4.9 mg/100mL), dan empat kali ganda lebih banyak daripada haiwan OPF (12.1 ± 1.5 mg/100 mL). Kesannya, haiwan dari kumpulan CON mempunyai tahap asid lemak tak tepu yang tertinggi seperti yang telah ditunjukkan oleh keputusan dari eksperimen pertama.

Eksperimen ketiga menggunakan tikus Sprague-Dawley berumur di antara enam sehingga tujuh bulan. Lima belas ekor tikus dipilih secara rawak pada permulaan eksperimen dan dikorbankan untuk mendapat bacaan dasar parameter

darah yang diukur. Enam puluh tikus yang selebihnya dibahagikan secara rawak kepada lima kumpulan yang terdiri daripada 12 haiwan setiap satu. Tiga kumpulan diberi makan pelet daging bebiri daripada eksperimen satu, satu kumpulan diberi makan pelet daging daripada daging bebiri komersial, dan kumpulan tikus terakhir diberi makan pelet tikus dan bertindak sebagai kontrol. Sampel darah dan tisu arteri diperolehi daripada tikus-tikus ini apabila empat ekor tikus setiap kumpulan dikorbankan secara bersiri pada dua, empat dan enam minggu selepas eksperimen dimulakan. Keputusan menunjukkan bahawa tikus yang memakan daging CON (1.09 ± 0.31 mmol/L) mencatatkan peningkatan HDL-Cholesterol tertinggi yang bererti ($P<0.05$) berbanding daging bebiri komersial (0.79 ± 0.10 mmol/L). Walaubagaimanapun, keputusan lipid serum yang lain dan lesi arteri tidak nyata.

Kesimpulannya, kaedah manipulasi pemakanan yang dipraktikkan ini boleh diterima-pakai untuk meningkatkan kandungan asid lemak tak tepu daging bebiri ke tahap yang akan memanfaatkan kesihatan pengguna. Kaedah-kaedah yang dibangunkan ini adalah berdasarkan campuran bahan makanan berteraskan pelet dedaun kelapa sawit dan konsentrat komersial dan sesuai untuk keadaan dan baka bebiri tropika.

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This thesis submitted to the Senate of Universiti Putra Malaysia has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy.

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