UNIVERSITI PUTRA MALAYSIA

MALAYSIAN GROWN EGUSI (*Citrullus lanatus*) CROP AS POTENTIAL FEED STOCK FOR BIO-ENERGY

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By

YAHAYA MUHAMMAD-BANDE

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

November 2013

DEDICATION

To the family of
Late Alhaji Muhammad-Bande
(BARADEN BESSE)

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

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Chair: **Nor Mariah Adam, PhD PE**

Faculty: **Engineering**

The quest for newer renewable energy sources is an issue of major concern to many researchers world-over as a result of consistent world energy crisis on fossil-derived fuels, thus informs the need to diversify search for newer oil/energy crops. Egusi (*citrullus lanatus*) is a crop grown in African tropical countries. Works on the crop in Africa revealed that 50% is oil, utilizing only its seed kernel, being the main purpose of its cultivation in Africa. The crop was introduced in Malaysia, being a tropical country to observe its propagation adaptation and characterize it for biomass and biodiesel. A fundamental research initiated on the crop here in Malaysia involves planting on two different soil types and seasons to select suitability in terms of growth, crop maintenance and harvest, and finally processing the fruit to obtain seeds. On a 200m^2 experimental plot, a harvest of 1,125 fruits was made, producing 45.56kg of seeds during dry season, with a harvest of 137 fruits during wet season producing 1.373kg of seeds.

Physical and mechanical properties of fruits were determined to guide development of machines for production, harvest and post-harvest operations and mechanized seed extraction devices from the harvested fruits. Mechanical properties of fruits were similar irrespective of the season grown, but there were smaller and fewer fruits during wet season.

Physical and mechanical properties of seeds were determined as a guide to the design and development of devices on the mechanization of oil extraction from seeds since using solvent is uneconomical and impracticable for large oil production from egusi. There was no difference in the properties of seeds by season. Values of physical and

mechanical properties were determined at four different moisture contents (7.11%, 14.65%, 28.07% and 38.70% w.b) the mean values of properties determined for seeds at 38.70% were length (15.21±1.04mm), thickness (2.56±0.27mm), width (8.59±0.53mm), angle of repose (33.63^{o}±1.58), hardness (vertical 51kg±1.08; horizontal 121.3±2.65kg) and coefficient of friction on different surfaces.

The heating values of its biomass components (roots, stalk and leaves), lowest of which was the roots, with 11.9MJ/kg and the highest value recorded was 31.16MJ/kg for seed kernel, at 7.45% w.b moisture content, with egusi whole seed oil methyl ester (EWSOME B100) generating 45.72MJ/kg with the pure diesel oil (PDO), generating 47.95MJ/kg. Ultimate analysis was conducted to determine the elemental composition of its biomass, roots (C 40.92%; H 4.15%; N 1.54%; S 0.17%; O 52.22%), stalk (C 39.73%; H 5.11%; N 1.21%; S -0.07%; O 54.02%) and leaves (C 39.18%; H 4.88%; N 1.92%; S -0.12%; O 54.15%) for determination of elemental composition of burning the biomass. Biomass, oil and biodiesel prospect of the crop in Malaysia was also estimated as additional source of oil/energy to the well-established oil palm.

Oil extracted from 800g dehulled and whole seeds produced 480ml and 380ml respectively. The extracted oil from both whole seed (EWSO) and dehulled seeds (EDSO) were synthesized and characterized for their respective fuel properties. A basic engine performance test was conducted on both biodiesels using B5, and reference was made to engine performance on pure diesel oil (PDO). The results showed that EWSOME B5 performed better than EDSOME B5, with power and torques 2% less than PDO but specific fuel consumption was 4% more than PDO.

Economic implication of semi-mechanizing the production of biomass and biodiesel from egusi plantation was estimated based on the available data on basic farm implements and costs, using the most productive season in Malaysia. Cultivating egusi over the experimental plot during current work was evaluated to cost RM 1,451 only.

Abstrack tesis yang dikemukakan kepada Senat Univaersiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah .

PENCIRIAN HASIL EGUSI (*CITRULLUS LANATUS*) TANAMAN DI MALAYSIA SEBAGAI SUMBER BIO-TENAGA

Oleh

YAHAYA MUHAMMAD-BANDE

November 2013

Pengerusi: **Nor Mariah Adam, PhD PE**

Fakulti: **Kejuruteraan**

Usaha untuk mempelbagai sumber tenaga boleh diperbaharui yang baru adalah satu isu yang besar kepada ramai penyelidik dunia, hal yang demikian terjadi apabila wujudnya krisis bahan api fosil yang berulang. Ini sekali gus memberi laluan mempelbagaikan sumber tumbahan tenaga boleh diperbahrui yang baru. Egusi (*citrullus lanatus*) merupakan tanaman yang ditanam di negara tropikal Afrika. Kajian telah membuktikan bahawa hasil tanaman Egusi di Afrika adalab 50% untuk minyak daripada kernel bahagian dan tanaman ini menjadi punca utama minyak sayum di Afrika. Seperti negara tropikal yang lain, Egusi telah diperkenalkan di Malaysia kerana persamaan iklim tropikal bertujuan untuk meneliti percambahan dan adaptasi terhadap ciri-ciri biojisim dan biodiesel. Penyelidikan asas dimulakan dengan penanaman pada dua jenis tanah yang berbeza serta musim yang berlainan bagi tujuan perbandingan hasil tanaman musim yang terbaik baik dari faktor pertumbuhan, penyelenggaraan tanaman dan menuai, serta pemprosesan buah untuk mendapatkan benih. Bagi plot eksperimen yang bersaiz 200m^2, penanaman pada musim hujan mencatat hasil sebanyak 1100 buah yang dapat menghasilkan 45.56 kg benih, dan pada musim kering hasil tuaian direkodkan sebanyak 137 buah yang menghasilkan 1.373 kg benih.

Sifat fizikal dan mekanikal buah egusi telah ditentukan bagi tujuan memudahkan kerja pembangunan mesin untuk pengeluaran, penuaian dan pemprosesan lepas tuai; serta kerja mekanisasi menyedut bijibenih dari buah tuaian. Sifat fizikal buah adalah serupa untuk kedua-dua musim, namun hasil daripada musim hujan menghasilkan bilangan buah yang kurang dengan saiz buah yang lebij kecil. `

Sifat fizikal dan mekanikal bijibenih telah ditentukan untuk membantu kerja-kerja merekabentuk dan membangun peranti mekanisasi penyarinagn minyak daripada

bijibenih; disebabkan penggunaan pelarut adalah tidak ekonomik untuk penyarinagan secara komersil. Tiada perbesaan niali sifat berasaskan musim. Nilai sifat fizikal dan mekanikal untuk bijibenih telah ditentukan pada empat nilai kanudgan lembapan (7.11%, 14.65%, 28.07% dan 38.70% asas basah). Pada kandunagn lembapan 38.70% nilai mean panjang bijibenih adalah (15.21±1.04mm), ketebalan (2.56±0.27mm), lebar (8.59±0.53mm), sudut rehat (33.63^{o}±1.58), kekerasan (menegak 51kg±1.08; ,mendatar 1.3±2.65kg) gengan pekali geseran pada permukaan yang berbeza.

Nilai haba komponen biojisim (akar, batang, dan dedaun) yang terendah adalah untuk akar 11.9MJ/kg dan yang tertinggi untuk kernel 31.16MJ/kg. Pada kandunagan lembapan kernel bijibenih keseluruhan 7.45% asas basah menghasikan nilai minyak methyl ester (EWSOME B100) sebanyak 45.72MJ/kg dicampur bersama minyak disel tulen (PDO), dapat menghasilkan 47.95MJ/kg. Analisis muktamad untuk menentukan komposisi elemen biojisim akar the (C 40.92%; H 4.15%; N 1.54%; S 0.17%; O 52.22%), batang (C 39.73%; H 5.11%; N 1.21%; S -0.07%; O 54.02%) dan dedaun (C 39.18%; H 4.88%; N 1.92%; S -0.12%; O 54.15%). Untuk mencari komposisi elemen pembakaran bagi biojisim, minyak dan biodiesel telah mengukuhkan prospek tanaman baru bagi Malaysia sebagai sumber baru tenaga minyak sayur bersama minyak saeit.

Minyak yang disaring daripada 800g bijibenih dengan dan tanpa kulit menghasilkan masing-masing senamyak 480ml dan 380ml. Kedua=dua minayk yang disaring ini (EWSO dan EDSO) telah disintesis cirinya sebagai bahanapi enjin. Satu ujian prestasi enjin menggunakan sebuah enjin disel telah dijalankan untuk B5 bagi kedua=dua jenis minyak dan didasarkan kepada minyak disel tulen (PDO). Keputusan ujian menunjukkan EWSOME B5 mempunyai prestasi yang lebih baik daripada EDSOME B5, yakni dengan nilai kuasa dan tork 2% rendah daripada PDO tetapi nilai penggunaan bahanapi tentu melebihi 4% daripada PDO.

Implikasi kos untuk kaedah pengeluaran biojisim dan biodiesel secara separa mekanisasi bagi lading egusi telah dianggar berdasarkan data yang diperolehi menggunakan implemen asas ladang. Dengan kiraan kos untuk musim panas di Malaysia untuk pengeluaran egusi di atas plot eksperimen melibatkan kos sebanayak RM 1,451.

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I certify that a Thesis Examination Committee has met on 19 November 2013 to conduct the final examination of Yahaya Muhammad Bande on his thesis entitled "Malaysian Grown Egusi *(Citrullus lanatus)* Crop as Potential Feed Stock for Bio-Energy" 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:

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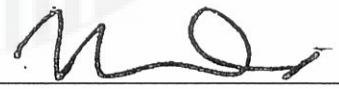

NORITAH OMAR, PhD
Associate Professor and Deputy Dean
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Date: 21 January 2014

This thesis was submitted to the Senate Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Doctor of Philosophy. The members of the supervisory committee were as follows;

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Date:

DECLARATION BY GRADUATE STUDENT

I hereby confirm that:

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Name and Matric No.: YAHAYA MUHAMMAD BANDE (GS30833)

Declaration By The Members Of The 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 (Revised 2012 -2013) are adhered to.

Signature:	----------	Signature:	----------
Name of Chairman of Supervisory Committee:	----------	Name of Member of Supervisory Committee:	----------
Signature:	----------	Signature:	----------
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