

**Sudan University
of Science & Technology
College of Graduate Studies**

**Viability of Using Vegetable Oil as a Fuel in
Internal Combustion Engines**

**قابلية الزيت النباتي للإستخدام كوقود في
محركات الاحتراق الداخلي**

**A thesis submitted in fulfillment of the requirements
for the degree of Ph.D. in Mechanical Engineering**

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April-2009

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

قال الله تعالى:

(اللَّهُ لَا إِلَهَ إِلَّا هُوَ الْحَيُّ الْقَيُّومُ لَا تَأْخُذُهُ سِنَّةٌ وَلَا نَوْمٌ لَهُ مَا فِي السَّمَاوَاتِ وَمَا فِي الْأَرْضِ مَنْ ذَا الَّذِي يَشْفَعُ عِنْدَهُ إِلَّا بِإِذْنِهِ يَعْلَمُ مَا بَيْنَ أَيْدِيهِمْ وَمَا خَلْفَهُمْ وَلَا يُحِيطُونَ بِشَيْءٍ مِنْ عِلْمِهِ إِلَّا بِمَا شَاءَ وَسِعَ كُرْسِيُّهُ السَّمَاوَاتِ وَالْأَرْضَ وَلَا يَئُودُهُ حِفْظُهُمَا وَهُوَ الْعَلِيُّ الْعَظِيمُ).

صدق الله العظيم

البقرة الآية (255)

DEDICATION

**It is of honor, dedication of this thesis,
To my parents,
To my teachers,
To my family.**

ACKNOWLEDGEMENT

I would like to thank my supervisor Professor Dr. Saber Mohammed Salih for his continuous support, valuable guidance and advice provided regarding the completion of this thesis project. My appreciation is expressed to the Engineering College of Sudan University of Science and Technology (SUST) for the financial support, and to the staff of Thermal Power Laboratory of Mechanical Engineering Department for the assistance of conducting the bulk of the experimental work. Further more thanks are conducted to the College of Science at SUST, and to the Central laboratory of Bahri Electric Power Station for conducting some experimental measurements.

Sincere thanks are due to the Associate Professor Dr. Ahmed Elamin Haroun and the Assistant Professor Dr. Elkhawad Ali Elfaki the Head of Mechanical Engineering Department and colleagues for their encouragement and generous assistance.

As last, but not least, I would like to thank my friends and family for their support and encouragement during the course of my academic career.

ABSTRACT

The world has recently faced fossil fuel depletion and environmental degradation that triggers the research for using alternative modes. Bio-fuels appear to be one of the most reliable and recommended ones. Sudan potentiality of producing bio- fuels is highly promising and can be quite feasible since enough fertile land, water and suitable climate are available.

In this research production of sudanese peanut oil methanol ester was attempted and tested in a 4-stroke diesel engine for performance evaluation and compared with fossil fuel. Using transesterification process at volumetric ratio of 40oil: 12methanol: 1 NaOH, at a temperature of 60 °C and stirring for one hour time, a bio-diesel of better properties was produced. It was considered as an acceptable substitute for conventional diesel fuel. More over blends of straight vegetable oil (SVO) with benzene was attempted and tested in 4-stroke and 2-stroke petrol engines for performance evaluation and compared with fossil fuel. Using 40% SVO by volume in the blend for 4-stroke engine, and 50% by volume for 2-stroke engine as maximum limit, blends of good properties were produced and proved to be an acceptable substitute for conventional (carburetor) petrol fuel system. Without any need for engines systems modifications, engines performance was improved and exhaust emissions were highly reduced.

مستخلص

يواجه العالم اليوم مشكلتي تناقص مخزون الوقود الأحفوري واتساع استخدامه والتدهور البيئي مما أدى الى توجيه البحوث عالميا نحو الوقود الحيوي كفضل بديل لحل هذه المشكلة مستقبلا. للسودان امكانية كبيرة من اراضي زراعية، ومياه، وطاقات طبيعية وبشرية مما يمكنه من انتاج هذا الوقود والتنافس به في السوق العالمي محققا استراتيجيات اقتصادية واجتماعية مقدره.

في هذا البحث استخدم زيت الفول السوداني لانتاج الوقود الحيوي الميثانولي بمساعدة هيدروكسيد الصوديوم، وباستخدام نسبة حجمية 40 زيت : 12 ميثانول : 1 هيدروكسيد صوديوم واجراء خلط مستمر لمدة ساعة في درجة حرارة 60 درجة سيلزيوس، تحقق مستوى افضل لخواص وقود الديزل الحيوي مقارنة بخواص وقود الديزل التقليدي. وباختبار هذا الوقود في محركات ديزل بدون اي تعديل كان مستوى الاداء مشابهها لأداء الوقود التقليدي وانبعث غازات العادم منخفضة مما يؤكد تقليل تلوث البيئة.

أيضا بخلط هذا الزيت مع البنزين مباشرة لاستخدامه كوقود في محركات البنزين رباعية وثنائية الدورة وباستخدام نسب حجمية 40% زيت في الخليط للمحرك رباعي الأشواط و 50% للمحرك ثنائي الدورة كحد اقصى، انتجت خلائط ذات خواص جيدة كبديل مقبول للوقود التقليدي في محركات البنزين. تحقق هذا بدون أي تعديل في محرك البنزين التقليدي (منظومة الوقود بالكاربيوريتور) رباعي او ثنائي الأشواط ، كان مستوى الأداء مشابهها لأداء الوقود التقليدي وانبعث غازات العادم منخفضة جدا مما يؤكد تقليل تلوث البيئة.

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NOMENCLATURE

The following is a list of abbreviations and symbols used in this thesis:

A.B.E. Acetone, Butanol, Ethanol .	IEA International Energy Agency.
A/F ratio Air / fuel ratio	I_{mep}(IMEP) Indicated mean effective pressure
AP Academic Press.	I_p (IP) Indicated power
A_nP_t Aniline Point.	IPA Isopropyl Alcohol 99% .
API American Petroleum Institute.	LTFT Low Temperature Flow Test
AICS Austral.Invent.of Chemical Subst.	NASA National American Space Agency
ASTM American Soci.for Test. and Measurement.	NBB National Bio-diesel Board
atm. Atmosphere.	No of obs. Number of observations
BSFC Brake specific fuel consumption	n Equivalence ratio.
BTL Biomass-to-liquid	oct.No. Otane number.
CCR Critical Compression Ratio.	ppm part per million
cet.No. Cetane number.	PAH Polycyclic Aromatic Hydrocarbons
C.I.E. Compression Ignition Engine.	P_B (BP) Brake power
CFPP Cold Filter Plugging	RME Rapeseed methyl ester
CPO Crude Palm Oil	S.I.E Spark Ignition Engine.
cst. Centi stoke.	SRO Semi-Refined Oil
DME Dimethyl ether (DME).	Std.Dv Standard dependent variable
df Degree of freedom.	Std. err standard error
DV Dependent Variable.	SVO Straight Vegetable Oil
EPA Environmental Protection Agency	TAME Tertiary- Amyl- Methyl –Ether
ETAE Ethyl-Tertiary-Amyl-Ether	TDC Top Dead Center
ETBE Ethyl-Tertiary-Butyl-Ether.	Temp. Temperature.
EU European Union	t-value t- test statistical method
FAME Fatty Acid Methyl Ester	Veg. oil Vegetable oil.
FFA Free Fatty Acid.	WFO Waste Frying Oil.
GHG Green House Gases.	WW-II second World War.
GTL Gas-to-liquid	η_{th}- "A" Thermal efficiency (fuel A)
HDPE High-Density Polyethylene	η_{th}- "B" Thermal efficiency (fuel B)
ice internal combustion engine	

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