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(54) **Title**: PROCESSES FOR PRODUCING VIRGIN COCONUT OIL. COCONUT COOKING OIL AND RAW MATERIAL FOR COCONUT BIODIESEL

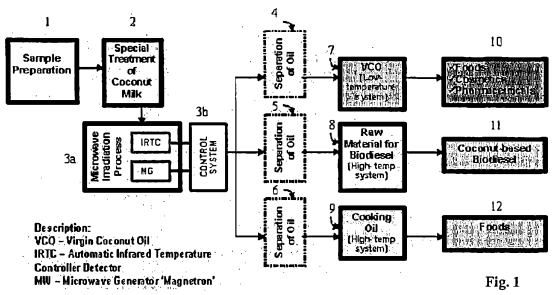

Fig. 1

(57) **Abstract**: Virgin coconut oil, cooking oil and coconut oil for biodiesel are obtained by irradiating fresh coconut milk with microwave. Depending on the desired end-product, the optimum set up of microwave power, time and temperature are electronically controlled accordingly. Virgin oil requires a microwave power setting of 50 to 1500 Watt at a frequency of 300 MHz to 20 GHz and a temperature range of 40 to 60 °C for a period of 10 to 60 minutes, while cooking oil requires a temperature range of 60 to 80° C and coconut oil for biodiesel, between 80 and 100 °C, The oil is separated from the irradiated milk by gravitational or centrifugal means.

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PROCESSES FOR PRODUCING VIRGIN COCONUT OIL, COCONUT COOKING OIL AND RAW MATERIAL FOR COCONUT BIODIESEL

FIELD OF INVENTION

This invention relates to process for preparation of virgin coconut oil (VCO), raw material for high quality coconut biodiesel and coconut cooking oil from coconut milk by applying microwave separation technology.

BACKGROUND OF INVENTION

Coconut oil is a fat consisting of about 90% saturated fat. The oil contains predominantly medium chain triglycerides; with roughly 92% saturated fatty acids, 6% monounsaturated fatty acids and 2% polyunsaturated fatty acids. Of the saturated fatty acids, coconut oil is primarily 44.6% lauric acid, 16.8% myristic acid, 8.2% palmitic acid and 8% caprylic acid, although it contains seven different saturated fatty acids in total. Its only monosaturated fatty acid is oleic acid while its only polyunsaturated fatty acid is linoleic acid. Unrefined coconut oil melts at 24-25°C(76°F) and smokes at 170°C (350°F) while refined coconut oil has a higher smoke point of 232°C.

Coconut oil can be classified as virgin coconut oil, refined oil, hydrogenated oil and fractionated oil. Virgin coconut oil is derived from fresh coconuts (rather than dried, as in copra). Most oils marketed as "virgin" are produced one of three ways:

a) Quick drying of fresh coconut meat which is then used to press out the oil.

b) Wet-milling (coconut milk). With this method the oil is extracted from fresh coconut meat without drying first."Coconut milk" is expressed first by pressing. The oil is then further separated from the water. Methods which can be used to separate the oil from

the water which includes boiling, fermentation, refrigeration, enzymes and mechanical centrifuge.

c) Wet-milling(direct micro expelling). In this process, the oil is extracted from fresh coconut meat after the adjustment of the water content, then the pressing of the coconut flesh results in the direct extraction of free-flowing oil.

Coconut oil is commonly used in cooking, especially when frying. In communities where coconut oil is widely used in cooking, the refined oil is the one most commonly used. Coconut oil is commonly used to flavor many South Asian foods. Coconut oil is used in volume quantities for making margarine, soap and cosmetics. Hydrogenated or partially hydrogenated coconut oil is often used in non-dairy creamers and snack foods. Fractionated coconut oil is also used in the manufacture of essences, massage oils and cosmetics. Coconut oil is an important component of many industrial lubricants, for example in the cold rolling of steel strip. Coconut oil has been tested for use as a feedstock for biodiesel to be used as a diesel engine fuel. In this manner, it can be applied to power generators and transport using diesel engines.

Coconut oil is blended to make biodiesel but can also be used straight, without blending. B100 biodiesel blends are only possible in temperate climates as the gel point is approximately 10°C (50 degrees Fahrenheit). The oil needs to meet the Weihenstephen standard for pure vegetable oil used as a fuel since otherwise moderate to severe damage from coking and clogging will occur in an unmodified engine.

Unlike olive oil, there is no world or governing body that sets a standard definition or set of guidelines to classify coconut oil as "virgin". The conventional method of extracting coconut oil involves long process, expensive and sometimes using external chemical such as enzymes. There is a need for quick method which is fast, cheap, easy and chemical free.

Most commercial grade coconut oils are made from copra. Copra is basically the dried kernel (meat) of the coconut. It can be made by smoke drying, sun drying or kiln drying or derivatives or a combination of these three. Since World War 2, coconut oil has been used as

a raw material for biodiesel. Some of the benefits of coconut based biodiesel are less emissions and toxic fumes than petroleum diesel fuel, lower viscosity, and specific energy closer to petroleum diesel and higher cetane number. However, copra based coconut cooking oil involves a long process, the quality is not as good as palm oil and the solidification point of about 25°C, making it not suitable for winter diesel.

Due to the above factors, we proposed an improved process for the production of high quality virgin coconut oil, coconut cooking oil and raw material for coconut-based biodiesel which is prepared directly from coconut milk by exposing it to microwave irradiation. It is chemical free, a faster method, easier to operate and high yield of about 300ml/kg (coconut milk) and 10-15 coconuts for one litre of biodiesel oil.

Any discussion of the prior art throughout the specification should in no way be considered as an admission that such prior art is widely known or forms part of common general knowledge in the field.

It is an object of the present invention to overcome or ameliorate at least one of the disadvantages of the prior art, or to provide a useful alternative.

SUMMARY OF THE INVENTION

According to a first aspect, the present invention provides a process for preparing virgin oil from a liquid obtained from fruits of coconut, palm fruitlet or palm kernel or similar edible fruits or seeds, or edible oily based plant, in which the process includes the step of irradiating the liquid using microwave separation technology at a frequency of between 300 MHz to 20 GHz, power level of between 50 to 1500 Watt, at a temperature of between 40 to 60°C for a period of between 10 to 60 minutes, wherein the liquid is frozen by keeping it in a freezer overnight before irradiating the same.

According to a second aspect, the present invention provides a process for preparing virgin oil from a source obtained from fruits of coconut, palm fruitlet or palm kernel or similar edible fruits or seeds, or edible oily based plant, in which the process includes the steps of extracting liquid from the fruits, irradiating the liquid using a microwave separation technology at a frequency of between 300 MHz to 20 GHz, power level of between 50 to 1500 Watt, at a temperature of between 40 to 60°C for a period of

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between 10 to 60 minutes, wherein the liquid is frozen by keeping it in a freezer overnight before irradiating the same.

According to a third aspect, the present invention provides a process for preparing cooking oil from a liquid obtained from fruits of coconut, palm fruitlet or palm kernel or similar edible fruits or seeds, or edible oily based plant, in which the process includes the step of irradiating the liquid using microwave separation technology at a frequency of between 300 MHz to 20 GHz, power level of between 50 to 1500 Watt, at a temperature of between 60 to 80°C for a period of between 10 to 60 minutes, wherein the liquid is frozen by keeping it in a freezer overnight before irradiating the same.

According to a fourth aspect, the present invention provides a process for preparing cooking oil from a source obtained from fruits of coconut, palm fruitlet or palm kernel or similar edible fruits or seeds, or edible oily based plant, in which the process includes the steps of extracting liquid from the fruits, irradiating the liquid using a microwave separation technology at a frequency of between 300 MHz to 20 GHz, power level of between 50 to 1500 Watt, at a temperature of between 60 to 80°C for a period of between 10 to 60 minutes, wherein the liquid is frozen by keeping it in a freezer overnight before irradiating the same.

According to a fifth aspect, the present invention provides a process for preparing raw material for biodiesel from a liquid obtained from fruits of coconut, jatropha or kenaf, palm fruitlet or palm kernel or similar fruits or seeds, or oily based plant such as algae, in which the process includes the step of irradiating the liquid using microwave separation technology at a frequency of between 300 MHz to 20 GHz, power level of between 50 to 1500 Watt, at a temperature of between 80 to 100°C for a period of between 10 to 60 minutes, wherein the liquid is frozen by keeping it in a freezer overnight before irradiating the same.

According to a sixth aspect, the present invention provides a process for preparing raw material for biodiesel from a source obtained from fruits of coconut, jatropha or kenaf , palm fruitlet or palm kernel or similar fruits or seeds or oily based plant, in which the process includes the steps of extracting liquid from the fruits, irradiating the liquid using a microwave separation technology at a frequency of between 300 MHz to 20 GHz, power level of between 50 to 1500 Watt, at a temperature of between 80 to 100°C for a

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period of between 10 to 60 minutes, wherein the liquid is frozen by keeping it in a freezer overnight before irradiating the same.

According to a seventh aspect, the present invention provides virgin oil when prepared by the process according to the first or second aspects.

According to an eighth aspect, the present invention provides cooking oil when prepared by the process according to the third or fourth aspects.

According to a ninth aspect, the present invention provides raw material when prepared by the process according to the fifth or sixth aspects.

The improved process for preparation of virgin coconut oil (VCO), raw material for high quality coconut biodiesel and coconut cooking oil from the coconut milk is based on optimum set-up of time, temperature and power in the microwave irradiation separation system and initial preparation of coconut milk before microwave radiation. This process can produce high quality VCO, coconut cooking oil and raw material for coconut-based biodiesel. It is chemical free, faster method, easier to operate and high yield of about 300ml/kg (VCO) and 10-15 coconuts per litre of biodiesel oil.

The preparation of VCO involves the low temperature microwave irradiation treatment of coconut milk, generally less than 60°C. While the coconut cooking oil and raw material for coconut biodiesel wherein the temperature is controlled up to 80°C and 100°C respectively. The whole process will take about 30 minutes at the power level of about 500 Watt. In these processes, there is a need for the temperature control system in order to control the temperature of sample. The starting temperature is normally between 5-10°C. (Refer to Fig.1)

Once the process was established, the oil can be separated using conventional methods such as gravitational separation or centrifuge method. A special treatment is applied for the

preparation of VCO. For example, special care during the separation process using the highest quality coconut fruits, fresh coconut milk and avoiding any exposure to bacteria. The properties of a freshly prepared VCO has been compared with the commercial VCO in terms of their chemical compounds (refer to Fig.2). It is shown that the microwaved-VCO has higher lauric and capric acid compounds. In terms of molecule structure of this material, it is clear that the Raman spectrum of microwaved-VCO is almost similar to the commercial ones (See Fig. 3). Furthermore the biodiesel prepared from microwaved-coconut oil has the unique properties in terms of lower solidification point, -11°C and the specific energy almost comparable to the palm oil biodiesel (see Table 1). Therefore, it is suitable to be used as winter diesel.

Fuel	**Specific Energy (MJ/kg)**	**Solidification Point (°C)**
Coconut Oil	37.7 Gross (42.0 Gross Copra Base)	-11
Palm Oil	38.2 Gross	13

Table 1

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows the process flow for production of virgin coconut oil (VCO), coconut cooking oil and raw material for biodiesel.

Fig. 2 shows percentage comparison of fatty acid composition in microwaved-VCO and commercial VCO.

Fig. 3 shows intensity comparison of fatty acid composition in microwaved-VCO and commercial VCO based on Raman spectrum.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Process 1: Sample preparation

The fresh coconut fruit was chosen from high quality grade. The quality of coconut fruit is determined by their type or clone and normally selected from matured fruit. The fresh coconut milk can be obtained by normal squeezing process of coconut meat at ambient temperature and pressure.

Process 2: Special Treatment of Coconut Milk

To avoid the milk from bacterial contamination, it has to be kept in the freezer with the temperature setting of about -5°C or below. Preferably it should be kept overnight as a pre-treatment by which the coconut milk is separated in the form of water and emulsion. This pre-treatment is important in order to obtain highest yield of oil. This sample is now ready to be irradiated for microwave treatment.

Process 3a: Microwave Irradiation Process

The multimode microwave cavity volume with a typical dimension of 35x35x35 cm^3 is used for microwave irradiation process. It is equipped with automatic infrared temperature controller detector 'IRTC' or fiber optic temperature sensor, time counter and high power

microwave generator with the capacity to emit continuous power ranging from 400 to 1000 Watt at frequency 2.45 GHz. It is also equipped with a 2 L sample flask glass for the microwave separation process. This multi-mode microwave cavity can be designed as a single cavity for the batch process or a long cavity for continuous process.

Process 3b: Control system

This oven is connected to computer control system for time, temperature and power settings. The temperature setting of the sample for the preparation of VCO is ranging between 40 to 60°C. For the temperature setting of the sample above 60°C or ranging from 70 to 100°C, the produced oil is suitable to be used for cooking oil and raw material for biodiesel.

From the study, it is shown that the temperature setting between 70 to 80°C will give highest yield of oil. The power setting in this process is generally ranging from 500 to 1000 W for small scale production or more than 1000 Watt for a large scale system. Generally, the higher the microwave power we used, the faster for the sample to achieve the setting temperature and as this temperature is achieved the microwave power will ON and OFF accordingly in order to maintain the setting temperature. Therefore, the process time for 500 W setting and 1000 W setting is different in terms of the time for achieving setting temperature.

Process 4, 5 and 6: Oil Separation Process

The final process for the collection of oil after the microwave irradiation, normally involve with the filtering process and gravity separation system. Regardless on the type of the targeted oil, all irradiated oil will past through the same separation process.

Process 7, 8 and 9: Final Product

The final target products from the separation process, consist of microwave-prepared VCO, raw material for coconut biodiesel and microwave-prepared coconut cooking oil.

Applications

Process 10, 11 and 12: The application of each oil can be listed as follows;

(i) Microwave-prepared VCO can be used for foods, cosmetics and pharmaceuticals

(ii) Raw material for coconut biodiesel should go through the trans-esterification process for the production of coconut biodiesel

(iii)Cooking coconut oil should go through the refinery process before it can be used for cooking

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THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:-

1. A process for preparing virgin oil from a liquid obtained from fruits of coconut, palm fruitlet or palm kernel or similar edible fruits or seeds, or edible oily based plant, in which the process includes the step of irradiating the liquid using microwave separation technology at a frequency of between 300 MHz to 20 GHz, power level of between 50 to 1500 Watt, at a temperature of between 40 to 60°C for a period of between 10 to 60 minutes, wherein the liquid is frozen by keeping it in a freezer overnight before irradiating the same.

2. The process as claimed in claim 1, wherein the liquid is directly frozen using liquid nitrogen before irradiating the same.

3. A process for preparing virgin oil from a source obtained from fruits of coconut, palm fruitlet or palm kernel or similar edible fruits or seeds, or edible oily based plant, in which the process includes the steps of extracting liquid from the fruits, irradiating the liquid using a microwave separation technology at a frequency of between 300 MHz to 20 GHz, power level of between 50 to 1500 Watt, at a temperature of between 40 to 60°C for a period of between 10 to 60 minutes, wherein the liquid is frozen by keeping it in a freezer overnight before irradiating the same.

4. The process as claimed in claim 3, wherein the liquid is directly frozen using liquid nitrogen before irradiating the same.

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5. A process for preparing cooking oil from a liquid obtained from fruits of coconut, palm fruitlet or palm kernel or similar edible fruits or seeds, or edible oily based plant, in which the process includes the step of irradiating the liquid using microwave separation technology at a frequency of between 300 MHz to 20 GHz, power level of between 50 to 1500 Watt, at a temperature of between 60 to 80°C for a period of between 10 to 60 minutes, wherein the liquid is frozen by keeping it in a freezer overnight before irradiating the same.

6. The process as claimed in claim 5, wherein the liquid is directly frozen using liquid nitrogen before irradiating the same.

7. A process for preparing cooking oil from a source obtained from fruits of coconut, palm fruitlet or palm kernel or similar edible fruits or seeds, or edible oily based plant, in which the process includes the steps of extracting liquid from the fruits, irradiating the liquid using a microwave separation technology at a frequency of between 300 MHz to 20 GHz, power level of between 50 to 1500 Watt, at a temperature of between 60 to 80°C for a period of between 10 to 60 minutes, wherein the liquid is frozen by keeping it in a freezer overnight before irradiating the same.

8. The process as claimed in claim 7, wherein the liquid is directly frozen using liquid nitrogen before irradiating the same.

9. A process for preparing raw material for biodiesel from a liquid obtained from fruits of coconut, jatropha or kenaf, palm fruitlet or palm kernel or similar fruits or seeds, or oily based plant such as algae, in which the process includes the step of irradiating the

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liquid using microwave separation technology at a frequency of between 300 MHz to 20 GHz, power level of between 50 to 1500 Watt, at a temperature of between 80 to 100°C for a period of between 10 to 60 minutes, wherein the liquid is frozen by keeping it in a freezer overnight before irradiating the same.

10. The process as claimed in claim 9, wherein the liquid is directly frozen using liquid nitrogen before irradiating the same.

11. A process for preparing raw material for biodiesel from a source obtained from fruits of coconut, jatropha or kenaf, palm fruitlet or palm kernel or similar fruits or seeds or oily based plant, in which the process includes the steps of extracting liquid from the fruits, irradiating the liquid using a microwave separation technology at a frequency of between 300 MHz to 20 GHz, power level of between 50 to 1500 Watt, at a temperature of between 80 to 100°C for a period of between 10 to 60 minutes, wherein the liquid is frozen by keeping it in a freezer overnight before irradiating the same.

12. The process as claimed in claim 11, wherein the liquid is directly frozen using liquid nitrogen before irradiating the same.

13. The process according to any one of claims 9 to 12 wherein said oily based plant is algae.

14. Virgin oil when prepared by the process according to any one of claims 1 to 4.

15. Cooking oil when prepared by the process according to any one of claims 5 to 8.

16. Raw material when prepared by the process according to any one of claims 9 to 13.

17. A process for preparing virgin oil, cooking oil or raw material for biodiesel, or virgin oil, cooking oil or raw material for biodiesel when prepared by the process substantially as herein described with reference to any one or more of the examples but excluding comparative examples.

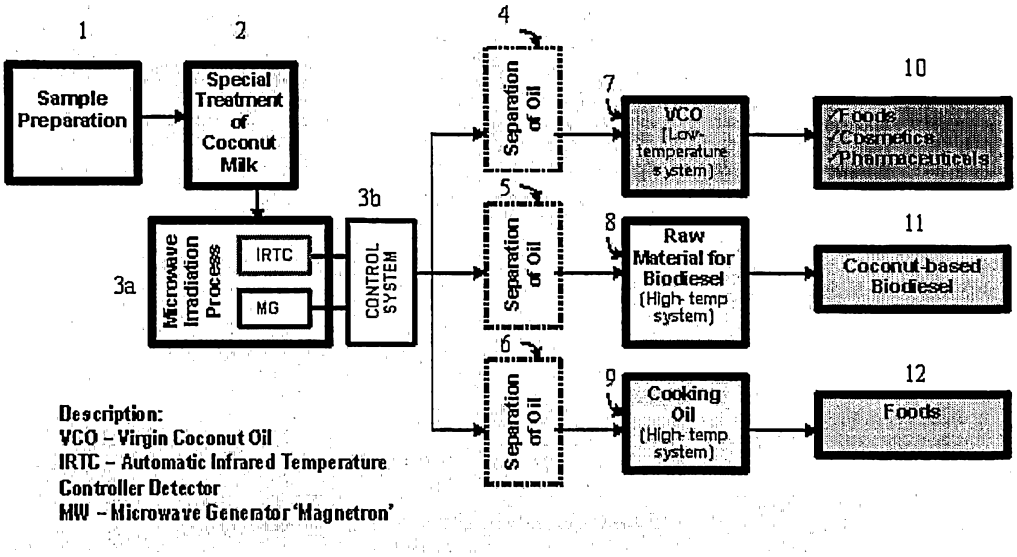
1
2
Sample Preparation
Special Treatment of Coconut Milk
3a
Microwave Irradiation Process
IRTC
MG
3b
CONTROL SYSTEM
4
Separation of Oil
5
Separation of Oil
6
Separation of Oil
7
VCO (Low-temperature system)
8
Raw Material for Biodiesel (High-temp system)
9
Cooking Oil (High-temp system)
10
✓Foods
✓Cosmetics
✓Pharmaceuticals
11
Coconut-based Biodiesel
12
Foods
Description:
VCO – Virgin Coconut Oil
IRTC – Automatic Infrared Temperature Controller Detector
MW – Microwave Generator 'Magnetron'

Fig. 1

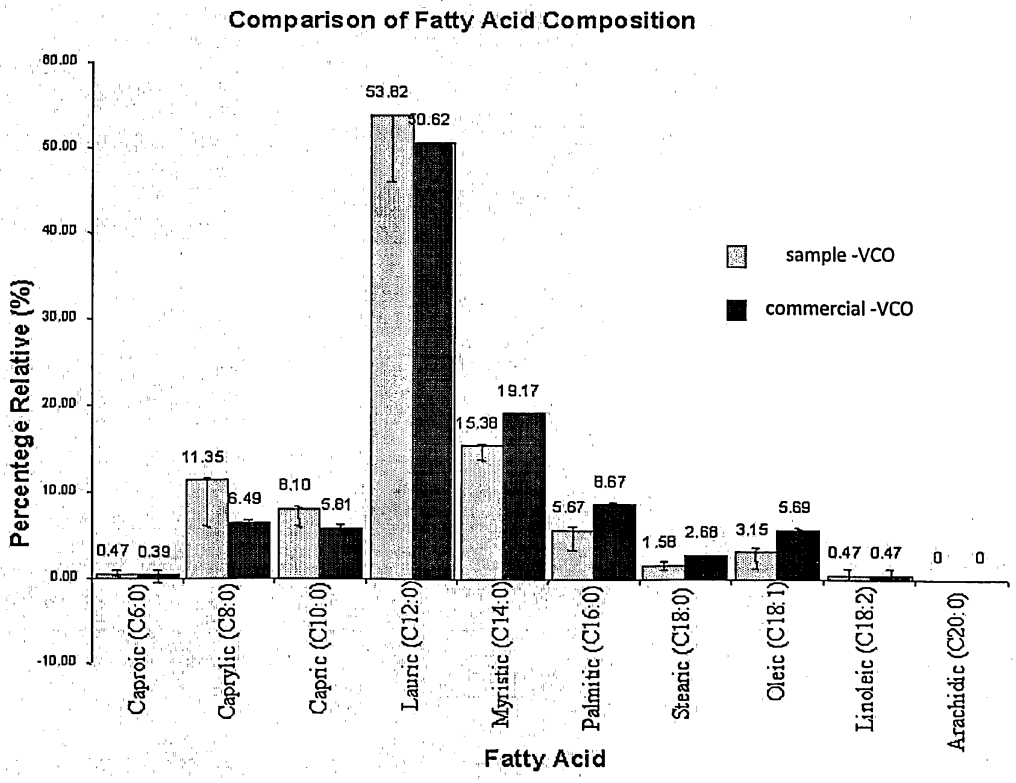
Comparison of Fatty Acid Composition
Percentege Relative (%)
60.00
50.00
40.00
30.00
20.00
10.00
0.00
-10.00
sample -VCO
commercial -VCO
0.47
0.39
11.35
6.49
8.10
5.81
53.82
50.62
15.38
19.17
5.67
8.67
1.58
2.66
3.15
5.69
0.47
0.47
0
0
Caproic (C6:0)
Caprylic (C8:0)
Capric (C10:0)
Lauric (C12:0)
Myristic (C14:0)
Palmitic (C16:0)
Stearic (C18:0)
Oleic (C18:1)
Linoleic (C18:2)
Arachidic (C20:0)
Fatty Acid

Fig.2

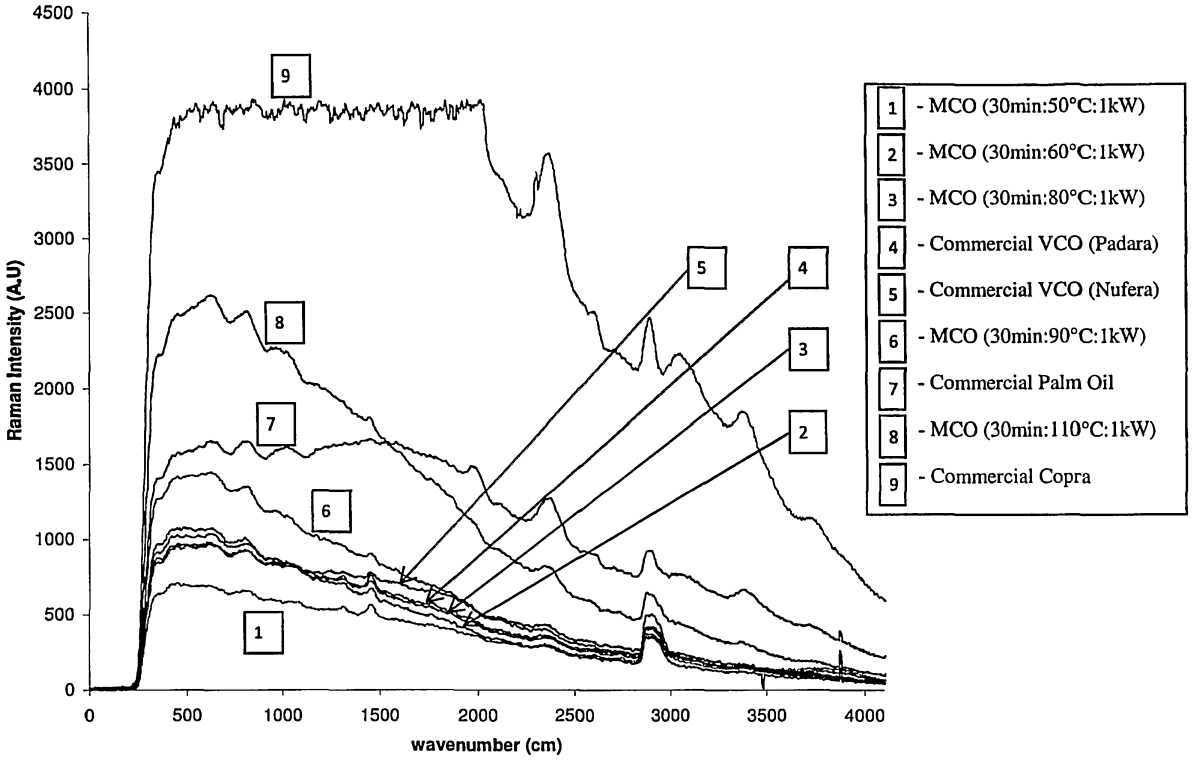
Raman Intensity (A.U)
wavenumber (cm)
0
500
1000
1500
2000
2500
3000
3500
4000
4500
1 - MCO (30min:50°C:1kW)
2 - MCO (30min:60°C:1kW)
3 - MCO (30min:80°C:1kW)
4 - Commercial VCO (Padara)
5 - Commercial VCO (Nufera)
6 - MCO (30min:90°C:1kW)
7 - Commercial Palm Oil
8 - MCO (30min:110°C:1kW)
9 - Commercial Copra

Fig. 3