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EVALUATING THE POTENTIALITY OF SUDANESE JOJOBA OIL AS CASH CROP IN SUDAN

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ABSTRACT

Objectives, to study the biotechnological aspects of Sudanese Jojoba seed oil as a potential cash crop in Sudan. Material and Methods, Jojoba *Simmondsia chinensis* (Link) C.K. Schneid. (Family Simmondsiaceae), random sampling collection of seeds from Sudan, calculation production of seeds was done. Oil percentage yield was given using cold pressing and chemical extraction. Blending bio-lubricant, was prepared by miscibility of base mineral oil SN150 with jojoba oil (1:1), then polymer and additives were adding. Seven parameters of physical properties of jojoba oil and blending bio lubricant were done by American Society for Testing and Materials methods, parameters including, Kinematic viscosity @ 40C°, the Kinematic viscosity @ 100C°, Viscosity index, Density @ 35 C°, Total acid number, Flash Point, pour point and boiling point. Chemical analysis of oil was done by GC/MS. The Bio lubricant is compared to mineral oil SN150 by FT-IR Spectra. Conditioning agent for cosmetic was done using emollient and jojoba oil micro-emulsion. Results, one tree production of seeds per season equal 5,6 kg, one feddan energy of jojoba equal 630 trees, that mean one feddan production of seeds equal 3528 kg. From 500g of seeds, the oil percentage yield was 200g (40%). Kinematic viscosity @ 40C° (25.30 cSt), Kinematic viscosity @ 100C° (6.525 cSt), Viscosity index (232), Density @ 35 C° (0.8566 g/ml), Total acid number (0.69 mg.KOH/g), Flash Point (281 C°), Pour point (9 C°) and boiling-point (397-398C°). GC/MS chemical analysis gave 13 compounds this study focusing on: - 2H-1-Benzopyran-6-ol, 2, 2-diphenyl (α Tocopherol), Butyrate Hydroxytoluene, both are chemically a derivative of phenol that is useful for its antioxidant properties. They are widely used in the industrial additive and cosmetic with suitable dose. Also 9. Octadecenoic acid (Z), methyl ester (Oleic acid, methyl ester), Erucic acid, the two compounds have a suitable property for biodiesel. Conclusion, The biotechnological aspects of jojoba cultivation led to a scientific activity, uses scientific research to activate creativity and the knowledge economy, to encourage market operation.

KEYWORDS: Jojoba, Viscosity index, seed production, biotechnological aspects.

1. INTRODUCTION

Jojoba *Simmondsia chinensis* (Link) C.K. Schneid. (Family Simmondsiaceae), is native to North and Central American deserts. it is cultivated as hybrid plants in Sudan, brought from Sonora desert (California)¹. In Sudan the red sea region has an ecological diversity with a Mediterranean climate, sandy hills, with suitable temperatures and rainfall in winter of success jojoba trees cultivation².

Jojoba plant is cultivated as commercial plant in different parts of the world³. There is much research continues on breeding, growing and harvesting to convert jojoba from a wild desert bush to a fully cultivated crop capable of producing a sufficient quantity of seeds every year to serve the market⁴. Jojoba molecules contain two double bonds at C-9 position in both alcohol and acid sides, this may be supported in giving different products with chemical structure provide formation of polymers which can be used in industrial application⁵. previous study

was done on *Simmondsia chinensis* oil and its derivatives⁶. Refining of jojoba oil reduce its stability due to the removal of natural antioxidants (tocopherols and phospholipids) from the oil⁽⁷⁻⁸⁾

Vitamin E (α) tocopherol was isolated and quantitatively estimated in the jojoba oil where α tocopherol makes up approximately 79% of these compounds. Other fat-soluble vitamins such as vitamin A are also found⁹. Modification of jojoba oil for lubricant formulation can done by additive treatment⁹. Physical properties of Materials were done by American Society for Testing and Materials methods¹⁰ ASTM. Jojoba oil has many industrial applications that include lubricant in the form of sulfurized oil, which in high temperature and high pressure will not change its viscosity¹¹. Jojoba lubricant has good specification in term of commercial standards, it was comparable to the commercial standards for Hydraulic oil SAE 10 W, lubricant¹³.

Preparation and evaluation of jojoba oil methyl esters as biodiesel and as a blend component in ultra – low sulfur diesel fuel¹⁴.

Jojoba oil is the unsaturated liquid wax readily extractable in large quantities from plant sources¹⁵ ($\approx 52\%$ of the total seed weight)

Crude jojoba oil obtained directly by either cold pressing or chemical solvent extraction of seeds, yields an oil with golden light color, the oil shows high resistance toward rancidity due to presence of natural antioxidant (α , γ , δ , tocopherol), Jojoba oil is widely used in the pharmaceutical industry, especially in the cosmetics industry as a valuable ingredient in moisturizers, cleansers and conditioners, to restore the ordinary health of hair and skin¹⁶. the successful preparation of microemulsion using jojoba wax as the oily phase using different surfactants and cosurfactants, in which the content of jojoba oil determined the transition from the water-in-oil to bicontinuous and to oil-in-water structures¹⁷. the successful preparation of microemulsion using jojoba wax as the oily phase using different surfactants and cosurfactants, in which the content of jojoba oil determined the transition from the water-in-oil to bicontinuous and to oil-in-water structures¹⁸.

Cake for animal's meal may be containing Simmonds compounds which can neutralizes its toxicity, by hydrolysis it to glucose using beta glucosidase enzyme. This is an enzyme that commonly found in bacteria, fungi, plant and animals. Glucosidase enzyme is responsible for breakdown carbohydrates (starch, glycogen and their) into monomers and transfer glycon-cino group to amino group¹⁸.

Most extensive applications of jojoba oil includes an extreme temperature/extreme pressure lubricant in the form of sulfurized oil, which can bear high temperature and pressure without changing its viscosity. Its stability at elevated temperatures permits the constant provision of a thin-film lubricating border, which is of remarkable necessity in decreasing frictional wear and temperature increase, which helps directly to extend the life span of the lubricating oil and indirectly to protect the automobile parts¹⁹.

The most popular source of polyols used in the production of polymer is petrol; however, the researchers were forced to substitute petrol with clean natural resources such as vegetable oils, especially seed oils, due to the need for saving the environment. Seed oils are biodegradable, abundant, inexpensive substituents that entice many researchers to use them to produce PUs. This process converts different seed oils into reactive polyols by introducing hydroxyl groups into their structure with the consequent production of PUs with varying mechanical and thermal properties²⁰.

This research focuses on the aspects of jojoba as local hybrid plant in Sudan, of economic value, to exploit jojoba trees to produce oil, which is characterized by compounds suitable for many environmentally friendly industrial products.

2. OBJECTIVE:

Specific objective:

to study and evaluate biotechnological aspects of Jojoba seed oil as a potential cash crop in Sudan.

General objective:

Using scientific research in activating creativity and the knowledge economy for the purposes of social development.

To encourage the process of market, of agricultural biotechnological products, that will support service and raises the standard of living for residents of rural , thus reviving the local economy and contributing to increasing national income.

3. MATERIAL AND METHODS

Seeds collection

Jojoba *Simmondsia chinensis* (Link) C.K. Schneid. (Family Simmondsiaceae). Collecting Jojoba seeds from hundred trees randomly and then calculating the average number of seeds to give what can be produced by on tree.

Seeds were collected by traditional way from Arquweet farm at red sea state in Sudan, each feddan capacity is 620 trees.

Oil production

Production of pure jojoba seed oil were done by two process, cold pressing oil process using ten kg seeds in one press by press machine, and chemical extraction process, using 500 g seeds in Soxhlet extractor with N-hexane as solvent which would be removed by rotary evaporator. First reducing seeds size by grinding them carefully, then extraction of the oil was done yields an oil with golden light color. The resultant percentage of jojoba oil from its seeds was calculated and recorded. And its physical and chemical characters were reported.

Blending bio-lubricant

Production of jojoba blending bio-lubricant, was prepared by miscibility of base mineral oil- with jojoba oil – (1:1) - in the preparation vessel, they completely mixed to give new product. in order to improve the viscosity of this new product, at 95% of the product add 1.6 polymer and 3.4 additives, (Petro bash multi activities co.lTD – Fuchs Sudan).

Conditioning agent for cosmetic

Conditioning agents for cosmetic was done using emollient and jojoba oil micro-emulsion properties, products were prepared from jojoba oil as base oil ointment base 20%, glycerin plus H₂O 50%, other additive 30%.

Physical properties of jojoba oil and blending bio-lubricant

Measuring the physical properties of jojoba oil and blending bio-lubricant, were done by American Society for Testing and Materials (ASTM) then reported : -

Kinematic viscosity @ 40°C by test method ASTM D-445 with unit cSt, using LAUDA E200 Viscometer – UK.

Kinematic viscosity @ 100°C by test method ASTM D-445 with unit cSt. using LAUDA E200 Viscometer – UK.

Viscosity index by test method ASTM D- 2270. (Viscosity Index of the fluid is a calculated number according to ASTM D2270, Calculation done by Viscosity index (VI) Calculator from kinematic viscosity (KV) at 40c and 100c according to ASTM. Therefore, higher viscosity index (VI) means oil is more stable and less changes in viscosity over a wide temperature range. Viscosity index indicates the change in fluid (oil) viscosity in dependence of temperature.

Density @ 35 °C by test method ASTM D-4052 with unit g/ml, using Density meter-Germany DMA4500M Anton at 15 °C with (Adjustment the apparatus by inject toluene to avoid contamination, then inject acetone and air then finally inject three ml of oil sample and read).

Flash Point by test method ASTM D-92 with unit C, (Using Mult-flash automatic, SeTA- persky Martin – England).

Pour point by test method ASTM D-97 with unit C, by using (10ml of oil sample was poured into test tube with thermometer, then heated to 45 °C on bathwater, then the apparatus was undergone in cooling process with examine

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the degree of heat every three degrees till the lowest temperature that oil still flow that is pour point. At same test the first degree at which the oil starts to be cloud that is cloud point.). Total acid number (TAN) by test method ASTM D-974 with unit mg.KOH/g.

Chemical analysis of Jojoba oil

Chemical analysis of Jojoba oil was done by GC/MS – (Agilent Technologies 5973N/ mass selective detector – model: G2577A / type: capillary – length: 60m, ID: 0.2mm, OD: 0.33mm/ temperature: 60-280/ software: chemstation), The Chromatogram was matched with NIST library; the compound is probably present if the match is more than 800. Compounds results were tabulated and curves were given (tables 1 – 4 and Fig. 1 – 4) . Correlation criteria of blending bio-lubricant was compared with mineral base oil SN150 using FT-IR Spectra (Fig.5-6)

4. RESULTS:

Production Capacity of seeds and jojoba oil in Arquweet farm for one feddan in one season

Random collection seeds of ten trees from arquweet farm equal 56kg and the average of one tree production - seeds per season equal 5. 6 kg Capacity of jojoba trees in one feddan equal 630 trees.

The average feddan production of seeds per season = $630 \times 5.6 = 3528$ kg.

In this research the extraction of one kg seeds gave half a liter of jojoba oil.

Therefor production of jojoba oil from one feddan per season = $630 \times 5.6 \times 0.5 = 1764$ liters.

Production of Conditioner agent for cosmetic

The prepared product from jojoba oil as base oil ointment the result in deep moisturizing cream named as Alag cream.

Production of blending bio-lubricant

The prepared product from jojoba oil and mineral base oil SN150, its viscosity has been improved by adding the polymer and some additives from Petro bash company.

Results of Chemical properties of jojoba oil:

Simple laboratory tests gave freezing point (7.5-8.0) C°, Boiling points (397-398) C°, table 1. Boiling point of Liquids increase with molecular weight such as chains of hydrocarbon, the chemical chain of jojoba oil contains 40 – 44 carbon atoms, Iodine value 81; higher Iodine number means more unsaturation based on alkyl double bond present in the oil.

The Chemical analysis of Jojoba oil which was done by GC/MS gave 13 compounds, research focusing on: - 2H-1-Benzopyran-6-ol, 2, 2-diphenyl (α Tocopherol) . fig1.

Butyrate Hydroxytoluene fig2. both are chemically a derivative of phenol that is useful for its antioxidant properties. They are widely used in the industrial additive and cosmetic with suitable dose.

9. Octadecenoic acid (Z), methyl ester (Oleic acid, methyl ester) Fig3, Erucic acid Fig.4, this two compounds have a suitable properties for bio-lubricant and biodiesel.

Result of physical properties of jojoba oil and bio-lubricant were tabulated on-table2 and 3. Jojoba blending bio lubricant compare with standard mineral base oil table4, it showed Viscosity index (171) higher than Viscosity index of mineral SN150 base oil (103) , and Pour point less than that of jojoba oil, reduce from 9 to 3 , Total acid number is high in jojoba oil 0.69 was decreased in Jojoba blending bio lubricant to 0.36.

Jojoba oil and jojoba oil plus SN150 their details and spectra tell that suitable diesel oil additives, it may improve the properties of Jojoba blending bio lubricant.

Results of physical properties of jojoba oil and jojoba blending bio-lubricant:

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Result of physical properties of jojoba oil and bio-lubricant were tabulated on-table2 and - table 3. Jojoba blending bio lubricant compare with standard mineral base oil table4, it showed Viscosity index (171) higher than Viscosity index of mineral SN150 base oil (103), and Pour point less than that of jojoba oil, reduce from 9 to 3, Total acid number is high in jojoba oil 0.69 was decreased in Jojoba blending bio lubricant to 0.36.

5. DISCUSSION:

At Seven International Conferences on Jojoba Oil - American Oil chemists; Society; Champaign, 1988. There is much research continues on breeding, growing and harvesting to convert jojoba from a wild desert bush to a fully cultivated crop capable of producing a sufficient quantity of seeds every year, to serve the market.

At this research random collection of seeds from Sudanese farm, for calculation the average production of seeds and its oil in one feddan at one season, showed 3528kg of seeds and 1764 litter for oil in one feddan at one season, that means Sudanese jojoba produces enough quantity of seeds and its oil every season to serve the market. And that means resources for jojoba production in Sudan will be sustainable for market.

Jojoba oil has boiling points (397-398) C°, which is high, the boiling point of Liquids increase with molecular weight such as chains of hydrocarbon, which is strong by c-c bonds which can form a stable, backbone for large molecule, the chemical chain of jojoba oil contains 40 – 44 carbon atoms that means it has good stability for cosmetic and other industrial uses.

At J. Am. Oil Chem. Soc. 1977;54:187–189. Research reported, Jojoba oil is the unsaturated liquid wax readily extractable in enormous quantities from plant sources.

In this research Jojoba oil has higher Iodine number which means more unsaturation based on alkyl double bond present in the oil.

At J. Am. Oil Chem. Soc. 1994;71:999.(Jojoba wax: Its esters and some of its minor components) the research reported that vitamin E (α) tocopherol was isolated and quantitatively estimated in the jojoba oil where α tocopherol makes up 79% of these compounds. Also there is fat-soluble vitamins such as vitamin A.

In this research the result of chemical analysis of jojoba oil gave -2H-1-Benzopyran-6-ol, 2, 2-diphenyl (α Tocopherol) and Butyrate Hydroxytoluene both compounds are chemically a derivative of phenol that is useful for its antioxidant properties, they were used in the industrial additive and cosmetic with suitable dose.

Referring to Li, T.S.C. (2000) Medicinal Plants: Culture, Utilization, and Phytopharmacology. the successful preparation of microemulsion using jojoba wax as the oily phase using different surfactants and cosurfactants, in which the content of jojoba oil determined the transition from the water-in-oil to bicontinuous and to oil-in-water structures.

In this research conditioning agents for cosmetic was done using jojoba oil micro-emulsion properties, products were prepared and result in deep moisturizing cream named as Alag cream.

From the chemical analysis results of jojoba oil in this research tow compounds named (9-Octadecenoic acid Z methyl ester or Oleic acid methyl ester and Erucic acid) both have a suitable property for formation of bio-lubricant and biodiesel.

At bioenergy. Res. (2010) 3:214-223.) the previous study reported that Preparation and evaluation of jojoba oil methyl esters as biodiesel and as a blend component in ultra – low sulfur diesel fuel.

In the previous study in (J. Am. Oil Chem. Soc. 1984;61:407–410.). applications of jojoba oil include lubricant in the form of sulfurized oil, which can bear high temperature and pressure without changing its viscosity, its stability at elevated temperatures permits the constant provision of a thin-film lubricating border, which is of remarkable necessity in decreasing frictional wear and temperature increase, which helps directly to extend the life span of the lubricating oil and indirectly to protect the automobile parts.

At this research, from jojoba oil and mineral base oil SN150, Jojoba blending bio lubricant was prepared, this product was compared with standard mineral base oil SN150 and jojoba oil, it showed viscosity index (171) higher than viscosity index of mineral SN150 base oil (103), this may indicate present of jojoba oil was improve the viscosity index of mineral SN150 base oil. Also, to improve the viscosity of Jojoba blending bio lubricant we add polymer and some additives from Petro bash company.

The Pour point of Jojoba blending bio lubricant is three which is less than that of jojoba oil (9), Total acid number is high in jojoba oil 0.69 which is more than Jojoba blending bio lubricant 0.36, this gave good result for pour point and total acid number of Jojoba blending bio lubricant.

6. CONCLUSION

The results that obtained in this study gave indications of the potentiality of jojoba oil as cash crop in Sudan. jojoba seeds quantity and its oil will be a multipurpose oil seed crop for industrial uses.

The biotechnological aspects of jojoba cultivation led to a scientific activity for postgraduate students, who uses scientific research to activate creativity and the knowledge economy, to encourage market operation, which supports service and raises the standard of living for rural residents in Sudan.

Table 1
Freezing point, Boiling point and Iodine value

Properties	Study test result	reference
Freezing point	7.5-8.0	7.0-7.5
Boiling point	397-398°C	300-400
Iodine value	81	80

Table 2
Physical properties of jojoba oil

Test	Test Method	Unit	Result
Kinematic viscosity @ 40C°	ASTM D- 445	cSt	25.30
Kinematic viscosity @ 100C°	ASTM D-445	cSt	6.525
Viscosity index	ASTM D- 2270	**	232
Density @ 35 C°	ASTM D-4052	g/ml	0.8566
Total acid number (TAN)	ASTM D-974	mgKOH/g	0.69
Flash Point	ASTM D-92	C°	281
Pour point	ASTM D-97	C°	9

Table 3
Physical properties of Blending Bio-lubricant

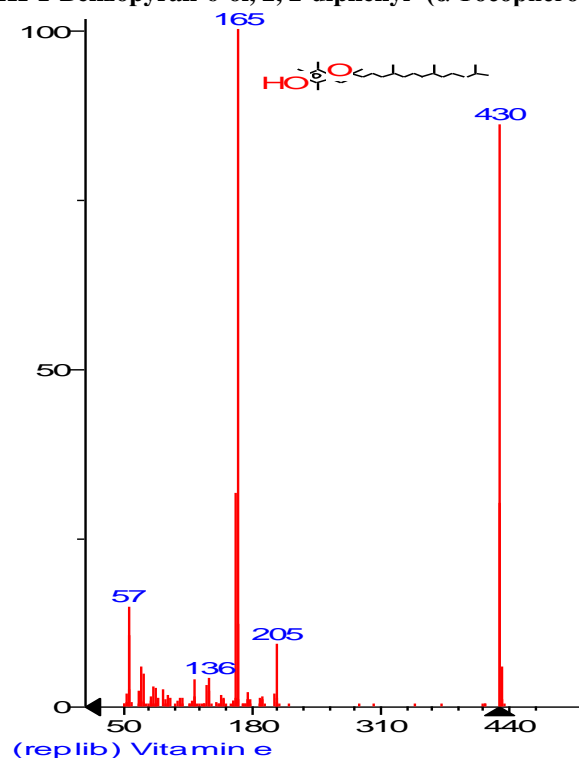
Test	Test Method	Unit	Result
Kinematic viscosity @ 40C°	ASTM D- 445	cSt	25.81
Kinematic viscosity @ 100C°	ASTM D-445	cSt	5.687
Viscosity index	ASTM D- 2270	**	171
Density @ 35 C°	ASTM D-4052	g/ml	0.8585
Total acid number (TAN)	ASTM D-974	mg.KOH/g	0.36

Flash Point	ASTM D-92	C°	245
Pour point	ASTM D-97	C°	3

Table 4
physical properties of Mineral base oil –

Test	Test Method	Unit	Result
Kinematic viscosity @ 40C°	ASTM D- 445	cSt	28.78
Kinematic viscosity @ 100C°	ASTM D-445	cSt	5.079
Viscosity index	ASTM D- 2270	**	103
Density @ 35 C°	ASTM D-4052	g/ml	0.8605
Total acid number (TAN)	ASTM D-974	mgKOH/g	0.03
Flash Point	ASTM D-92	C°	243
Pour point	ASTM D-97	C°	-12

Fig. 1.
2H-1-Benzopyran-6-ol, 2, 2-diphenyl- (α Tocopherol)



2H-1-Benzopyran-6-ol, 2, 2-diphenyl- (α Tocopherol)
Formula: C₂₉H₅₀O₂, MW: 430

Fig. 2

Butyrate Hydroxytoluene

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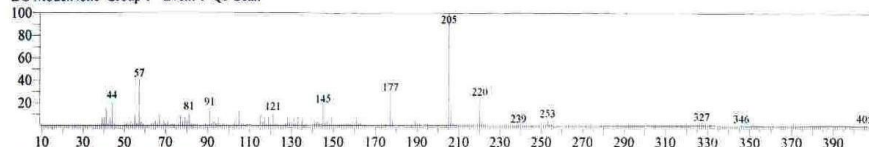
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Hit#:1 Entry:21362 Library:NIST14s.lib

SI:90 Formula:C15H24O CAS:128-37-0 MolWeight:220 RetIndex:1668

CompName:Butylated Hydroxytoluene SS Phenol, 2,6-bis(1,1-dimethylethyl)-4-methyl- SS p-Cresol, 2,6-di-tert-butyl- SS Advastab 401 SS Antioxidant DBP

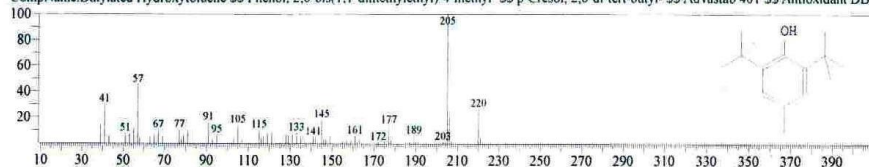


Fig.3

. 9Octadecenoic acid (Z), methyl ester (Oleic acid, methyl ester)

Hit#:2 Entry:28135 Library:NIST14s.lib

SI:83 Formula:C19H36O2 CAS:112-62-9 MolWeight:296 RetIndex:2085

CompName:9-Octadecenoic acid (Z)-, methyl ester SS Oleic acid, methyl ester SS Emery oleic acid ester 2301 SS Methyl cis-9-octadecenoate SS Methyl ole

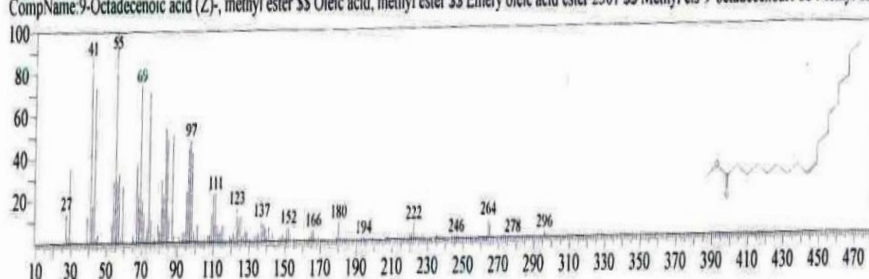
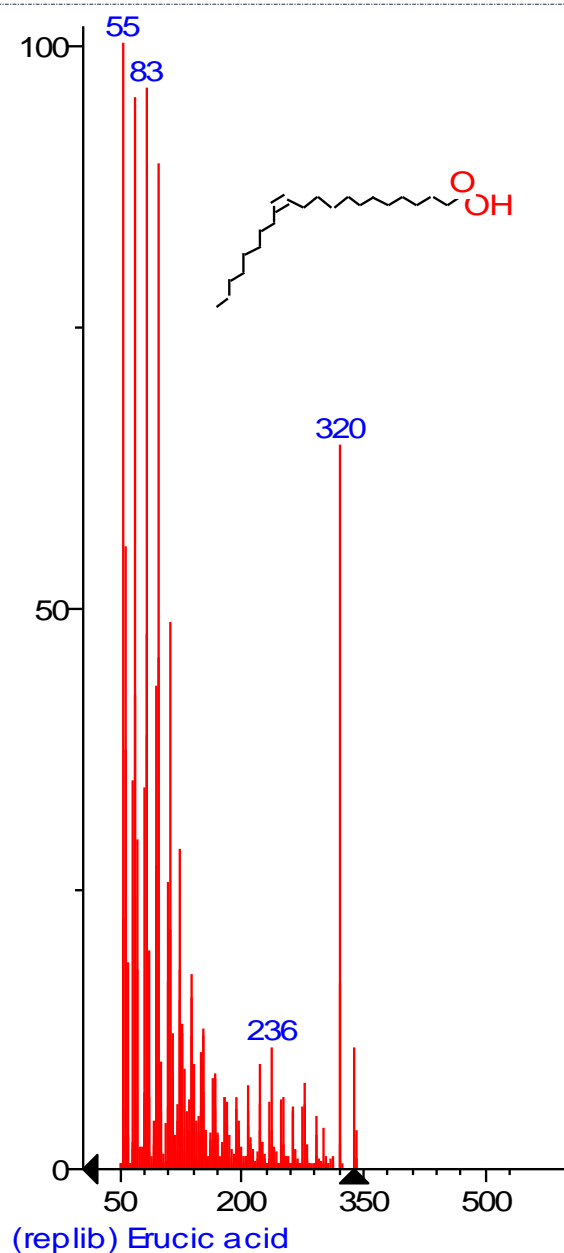


Fig.4

Erucic acid



Name: Erucic acid
Formula: C₂₂H₄₂O₂, MW: 338

Fig.5.
Jojoba Oil Details:

SampleID	Description	Correlation	Correlation Criteria	Pass / Fail
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C:\pel_data\Spectra\Jojoba Oil.sp	SN 150 (Ref)	0.170287	0.98	Fail
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JOJOBA OIL Spectra:

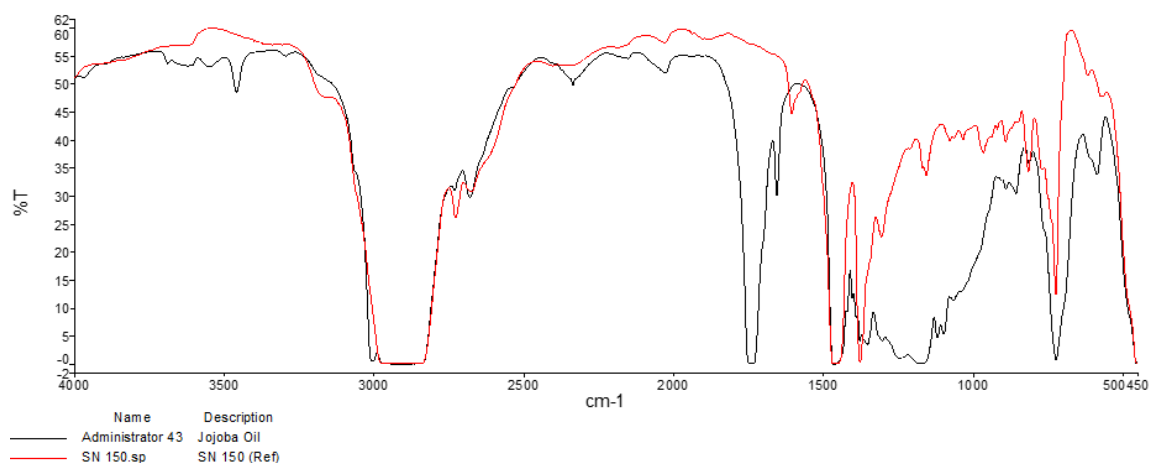
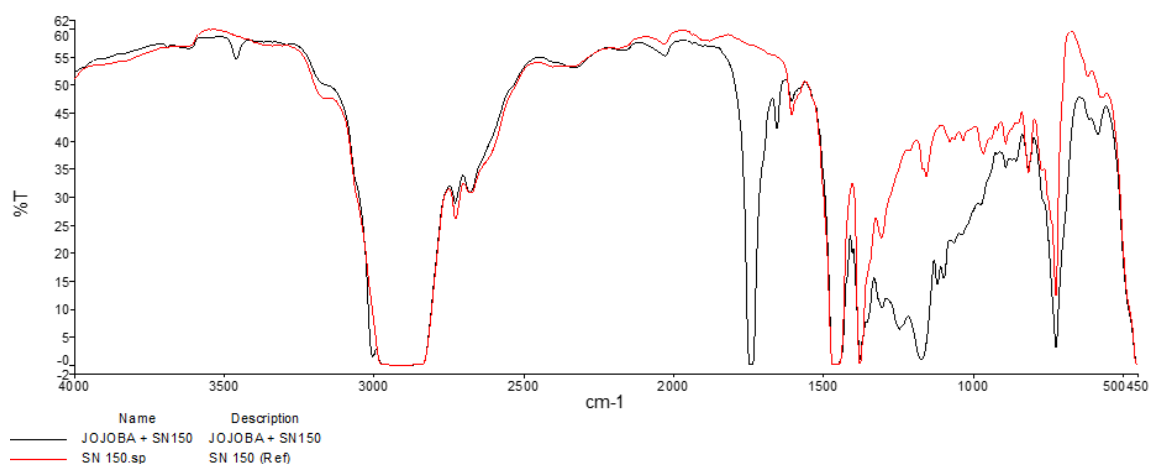


Fig.6.

JOJOBA + SN150 Details:

SampleID	Description	Correlation	Correlation Criteria	Pass / Fail
C:\pel_data\Spectra\JOJOBA + SN150.sp	SN 150 (Ref)	0.194859	0.98	Fail

JOJOBA + SN150 Spectra:



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