EXTRACTION, CHARACTERIZATION AND POTENTIAL OF OIL HARVESTED FROM THE JOJOBA SEEDS IN MESARYA PLAIN

A THESIS SUBMITTED TO THE GRADUATE SCHOOL OF APPLIED SCIENCES OF NEAR EAST UNIVERSITY

By
METİN BİLİN

In Partial Fulfilment of the Requirements for the Degree of Doctor of Philosophy in Mechanical Engineering

NICOSIA, 2020

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Approval of Director of Graduate School of Applied Sciences

Prof. Dr. Nadire ÇAVUŞ

We certify this thesis is satisfactory for the award of the degree of Doctor of Philosophy in Mechanical Engineering

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

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Don’t try to be different

Just be good

To be good is different enough

ABSTRACT

Jojoba plant is an extraordinary desert shrub that has a life span of 100 to 200 years. Since it does not lose its physical properties at elevated temperatures and under high pressures, there are not many alternatives of jojoba oil as lubricant in industrial application. In particular, the similarity of its molecular structure with the molecular structure of human skin oil (sebum) has led its widespread need in the cosmetics industry.

A part of the current work considers jojoba cultivation in the 200000 decares area in Mesarya Plain that was left dormant in the region and a 12 years cost-benefit estimation has been made. It was noted that the jojoba seed crop, ultimately, the jojoba oil production would result in a much higher income than barley agriculture.

An expeller type press system was designed and manufactured to extract oil from jojoba seeds collected from the test plantation in Mesarya Plain. The test results of the extracted jojoba oil were consistent with the other jojoba oils produced across the world and comply with the International Jojoba Export Council (IJEC) standards.

Four basic factors were chosen and experiments designed by applying the Taguchi approach. Seed size and temperature have been found to be the most effective parameters for high oil yield followed by humidity level of the seeds. The least effective factor was determined to be the pressure applied during pressing.

Biodiesel fuel was produced from the extracted jojoba oil and its viscosity and cold flow properties were determined. In addition, the ANFIS method was used to examine the cold flow properties of the biodiesel samples produced from jojoba and other crop oils.

Keywords: ANFIS; expeller; jojoba oil; Mesarya; Taguchi

ÖZET

Bir çöl çalısı olan jojoba her dem yeşil, iki evcikli, 100 - 200 yıllık bir ömre sahip, tohumlarından çok özel bir yağ çıkartılan sıra dışı bir bitkidir. Yüksek sıcaklıkta ve basınç altında fiziksel özelliklerini kaybetmediği için jojoba yağının endüstriyel uygulamalarda yağlayıcı olarak çok fazla alternatifi bulunmamaktadır. Özellikle, moleküler yapısının insan derisi yağının (sebum) moleküler yapısı ile uyuşması kozmetik endüstrisinde çok yaygın biçimde kullanılmasına yol açmaktadır.

Bu çalışmada öncelikle Mesarya bölgesinde atıl durumda bekleyen 200000 dekar alanda jojoba yetiştirilmesi incelenmiş ve 12 yıllık sürede oluşabilecek maliyet-kazanç hesaplamaları yapılmıştır. Jojoba yağı getirilerinin arpaya göre çok daha yüksek olacağı anlaşılmıştır.

Yağ çıkartmak üzere ekspeller tipi bir pres sistemi tasarlanmış ve imal edilmiştir. Mesarya ovasında yetiştirilen jojoba bitkisinin çekirdeğinden elde edilen yağın fiziksel ve kimyasal özelliklerinin dünyada üretilen diğer jojoba yağlarının özellikleri ile örtüştüğü ve IJEC (Uluslararası Jojoba İhracat Konseyi) standartlarına uygun olduğu görülmüştür.

Yağ üretimini ve verimini etkileyen dört temel unsur seçilmiş ve deneyler Taguchi yaklaşımı uygulamak suretiyle gerçekleştirilmiştir. Tane boyutunun yağ çıkartma işleminde verime en çok etki eden unsur olduğu tespit edilmiştir. Tohumun sıcaklığı ve nem oranı, yağ çıkarımı sırasında uygulanan basınç sırası ile üretim verimini etkileyen unsurlar olarak belirlenmiştir.

Üretilen jojoba yağından biyodizel yakıtı üretilmiş ve bu yakıtın vizkositesi ve soğuk akış özellikleri değerlendirilmiştir. Buna ek olarak, ANFIS yöntemi, jojoba ve diğer bitkisel yağlardan üretilen biyodizel örneklerinin soğuk akış özelliklerini incelemek için kullanılmıştır. ANFIS modelinin girdileri biyodizel üretiminde kullanılan hammaddelerin yağ asidi bileşimleri olarak belirlenmiştir

Anahtar Kelimeler: ANFIS; ekspeller; jojoba yağı; Mesarya; Taguchi

TABLE OF CONTENTS

CHAPTER 2: A COMPARATIVE SURVEY OF JOJOBA VERSUS BARLEY AGRICULTURE IN MESARYA PLAIN

CHAPTER 3: EXTRACTION AND TESTING OF OIL FROM JOJOBA SEEDS HARVESTED FROM THE EXPERIMENTAL PLANTATION IN MESARYA PLAIN

CHAPTER 4: OPTIMIZATION OF JOJOBA OIL PRODUCTION USING TAGUCHI METHOD

CHAPTER 5: PRODUCTION OF BIODIESEL FROM JOJOBA OIL AND TESTING

CHAPTER 6: CONCLUSIONS & RECOMMENDATIONS

APPENDICES

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AISI: American Iron and Steel Institute

AJORP: Association of Rajasthan Jojoba Plantation and Research Project

ANOVA: Analysis of Variance

ANF: Anti-nutritional factor

ANFIS: Adaptive Neuro Fuzzy Interference System

AOCS: The American Oil Chemists Society

ASTM: American Society for Testing and Materials

BD: Biodiesel

BUTAL: Tubitak Bursa Test and Analysis Laboratory

CFPP: Cold Filter Plugging Point

CFP: Cold Flow Properties

CP: Cloud Point

DA: Decare (1000 m^2)

DOE: Design of Experiment

DOF: Degrees of Freedom

EN: European Norms

FA: Fatty Acid

FAME: Fatty Acid Methyl Ester

G: Gram

GC: Gas Chromatography

HA: Hectare (10000 m^2)

HFFR: High Frequency Reciprocating Ring

HV: Vickers Pyramid Number

HZ: Hertz

IJEC: International Jojoba Export Council

ISO: International Standards Organization

ISTA: International Seed Testing Association

JUST: Jordanian University of Science and Technology

KKTC: Kuzey Kıbrıs Türk Cumhuriyeti

KG: Kilogram

KW: Kilowatt

M: Major Axis

ME: Maximum error

MUFA: Mono Unsaturated Fatty Acid

MSV: Multi strip vise

N: Minor Axis

NEU: Near East University

P: Phosphor

pH: Potential of Hydrogen

PP: Pour Point

PUFA: Poly Unsaturated Fatty Acid

RA: Roughness average of a surface

RMSE: Root mean square error

SE: Standard error

SD: Standard deviation

SFA: Saturated Fatty Acid

SLBOCLE: Scuffing Load Ball on Cylinder Lubricity Evaluator

S/N: Signal to Noise ratio

SI: International System Units

SSE: Sum of squared error

TL: Turkish Lira

TRNC: Turkish Republic of Northern Cyprus

TS: Turkish Standards

TSK: Takagi-Sugeno-Kang

US: United States

USA: United States of America

USD: United States Dollar

WSD: Wear Scar Diameter

CHAPTER 1
INTRODUCTION

1.1 Identification of Jojoba

Jojoba is a plant originally cultivated in United States (US) California and Sonaran Desert in Mexico with Latin name *Simmondsia Chinensis* from *Simmondsiaceae* family and it is pronounced as “hohoba”. This unique plant is also known as Deer nut, Goat nut, Wild hazel, and Coffeberry.

1.1.1 History

Jojoba is always green perennial woody shrub not more than 2 m height and long-life plant. The origin of jojoba is to the Southern California, Southern Arizona and Northwestern Mexico (Wisniak, 1994). Jojoba was discovered and named as *Bruxus chinensis* by American botanist H. F. Link in Santa California 1882 (National Research Council, 1985), later Thomas Nutall changed the name to *Simmondsia California*. Austrian botanist, Camillo Karl Schneider renamed it as the *Simmondsia chinensis* in 1907 (Miwa and Rothfus, 1979). Jojoba oil has been used by the local Americans for treating their injury and sores centuries ago. The sperm whale and desert grown nuts from jojoba are the only major sources of natural liquid waxes. After the ban on whale fishing jojoba cultivation was spread all over the world. Plant can survive in the arid and semi-arid lands because it does not need a lot of water to survive (Wisniak, 1994). Best climate for jojoba plantation is warmish weather like in Mediterranean countries, United States, Israel, Mexico, India and most of the countries that lie on the same longitude (Sanches et al., 2016; Wisniak, 1994). United States, Mexico and Argentina were used to be considered as the major jojoba producer in the world and the major exporter countries with considerable quantities of oil being exported to Europe and Japan (Sanches et al., 2016; Wisniak, 1994). Nowadays, according to the last estimations and evaluations, Israel is the leading producer and exporter of jojoba oil with nearly 40% of the overall global production. United States of America (USA) is the largest market with 40% of the overall global volume (Jojoba Valley, 2019). Jojoba oil can contribute to increase the income of the poor countries hence is named as "Green Golden Tree" (United Nations, 2007).

1.2 Agriculture of Jojoba Plant

Jojoba plant is a woody shrub which reaches up to 2 m of height. It has 2-3 cm long and 2.5 cm wide dark color oval shaped leaves. Jojoba plants of test plantation in Mesarya (Mesaoria) Plain near Meriç village located in Turkish Republic of Northern Cyprus (TRNC) can be seen in Figure 1.1. This plant does not need a large amount of water to grow. Only 300 mm of rainfall or its equivalent is enough to survive but with a convenient irrigation, the annual yield efficiency can rise up apparently (Wisniak, 1994). Jojoba plant and jojoba seeds are durable against insects and plant diseases (Wisniak, 1987).

Jojoba shrubs do not need special care for economical production. Minimum amount of water and fertilizers are enough for optimal production. Jojoba plant is dioeciously as seen in Figure 1.2. Small flowers of female plant are pollinated from wind by the male flowers (Benzioni et al., 2007). Ultimately male plants are cultivated only for pollination, female plants are grown seeds. Normally, 10% male & 90% female plants in a land are good enough for essential fertilization.

At the age of three years jojoba plants normally bring into flower. February and March are the months for pollination in North hemisphere however August and September in South hemisphere (Argentina, Peru and Australia). The flowering starts in March to June when the soil temperature and ambient temperature rise up to above 15°C. When the flowering period begins the sex of the jojoba can be figured out and the extra male jojoba plants (Figure 1.2(a)) are removed away and new female jojoba plants are replanted (Figure 1.2(b)) (Arya and Khan, 2016). The female flowers contain one or more booming seeds in the hardened capsule. The capsule wall becomes gradually thinner when the seeds are grown and filled the capsule as shown in Figure 1.2 (c). Ultimately the ripped and sun-dried seeds split off and drop to the ground in August. Initial yield can be obtained after the fourth year of growth. The optimum yield of well-maintained jojoba plant is after ten years of cultivation. The seed of jojoba is in brown color and oblong shape, about 12 mm long, 5 mm diameter and approximately 0.6 grams of mass as shown in Figure 1.3.

Figure 1.1: Jojoba shrub in the Mesarya Plain of TRNC

(a) (b) (c)

Figure 1.2: Jojoba plant; (a) Male, (b) Female, (c) Its nut (Asir Institute, 2019)

Figure 1.3: Jojoba seeds from Mesarya Plain

1.2.1 Convenient meteorological conditions of jojoba plant

Jojoba plant is grown particularly in hot weather conditions because it is a good resistive plant to high temperature even above 40℃ (Advanced Biofuel Center, 2019). Cultivation of jojoba plants are limited at low temperatures 5℃ and the plants can be damaged when the temperature drops below zero. The most convenient temperature for vegetative improvement of jojoba plant is 28-33℃ (Dunstone, 1986). Average daily temperature in summer 35-48℃ and 65℃ of soil surface temperature are the common temperature to keep up the plant in natural environment (National Research Council, 1985). The optimum temperature of jojoba for photosynthesis is ranging from 19-25℃, however jojoba can make a photosynthesis even at temperatures ranging from 10-40℃ (Wardlaw et al., 1983). Jojoba plant grows better where the annual rainfall exceeds 300 mm (Advanced Biofuel Center, 2019). Jojoba plant can be grown even above the sea level where it is naturally grown in California by the sea as far as 1200 m altitude above sea level. Mediterranean climate and California climate are similar which makes the Mediterranean region very suitable for jojoba plantation (U.S. Department of Energy, 1975). Eventually the first parameter of suited jojoba plantation is to use frost free fields.

1.2.2 Suitable soil of jojoba plantation

Jojoba known as a desert plant can be grown in arid, semi-arid and even in desert lands. Jojoba shrubs can be grown with annual rainfall of 300 mm even in salty limy and clayey soil (Dunstone, 1986). It needs less than one quarter of the amount of water needed for an olive tree (Advanced Biofuel Center, 2019). Most wild jojoba populations occur on coarse, light or medium textured soils with good drainage and good water infiltration. Alkalinity and acidity are assumed to be as a limiting factor of jojoba cultivation (Ayanoğlu, 2000). The pH value below six refers to acidic soil and is not suitable for jojoba plantation, but alkaline soil is more tolerant even to the pH value of 8.5 (Dunstone, 1986). The pH values of the soil changes between five and eight in the countries which jojoba plantations spread over United States and Mexico (Ayanoğlu, 2000). The pH value of the soil sample collected from Meriç village located on Mesarya Plain in TRNC is eight (alkali) (Appendix 1) which is suitable for jojoba plantations.

1.2.3 Harvesting

Jojoba seeds are normally harvested by handpicked once a year however very seldom more than one harvesting could be necessary. Nowadays, new technological agricultural machines are in use especially large-scale jojoba farming industry. Different fruit harvesting equipments can be adapted to jojoba harvesting. Usually September and October are the annual months for jojoba harvesting (Advanced Biofuel Center, 2019).

1.2.4 Potential yield of jojoba plant

Only the female plant yields jojoba seeds. The correct male to female ratio is 10% which can yield the maximum seeds in a land. The productive lifespan of Jojoba tree can be over 150 years and it starts to produce fruit at the fourth year after plantation. The plants reach maturity at the age of 10 to 15 years. The seed yield during the initial years is about 100 g/plant, which increases up to 2500 g/plant during the 12^{th} year, and 14 kg/plant after 25^{th} year as shown in Table 1.1 (Advanced Biofuel Center, 2019; Benzioni, 2006) and also in Figure 1.4. It has been reported that in Israel high yielding clone (spaced 4.5 x 2 m apart) are produced 4.65 tonnes of seed per hectare in 12^{th} year. Nelson and Watson (2001) attained a maximum of 2665 g of seeds per shrub from irrigated clones. McKelvie et al. (1994) recorded that seed yield of the new jojoba clones, at density of 1250 g of seeds per shrub was at least 1.6 tonnes of seed per hectare by twelfth year. Production of seed varies greatly from plant to plant in a stand and from year to year for a particular plant (Undersander et al., 1990). A properly cultivated and maintained plant will grow faster and live longer than one that is incorrectly planted. Jojoba plant normally reaches full maturity and break-even point after ten years (Advanced Biofuel Center, 2019).

1.3 Jojoba Plantation

1.3.1 Jojoba plantation across the world

Jojoba plant is native to the desert region of Arizona California and Sonaram in Mexico. Nowadays jojoba is cultivated commercially all over the world, such as in India, Australia, Egypt, Israel, Mexico, Peru, and the USA as shown in Figure 1.5. Jojoba is being examined for its potential as a crop in many countries around the world with climate and soil conditions similar to those of its native habitat.

Table 1.1: Expected yield of jojoba seeds (Advanced Biofuel Center, 2019)

Time	Seed/Plant (g)	Seed/da (kg)	Seed/ha (kg)
3th year	0	0	0
4th year	100	18	180
5th year	200	36	360
6th year	350	63	630
7th year	500	90	900
8th year	750	135	1350
9th year	1000	180	1800
10th year	1500	270	2700
11th year	2000	360	3600
12th year	2500	450	4500
15th year	5000	900	9000
20th year	10000	1800	18000
25th year	14000	2520	25200

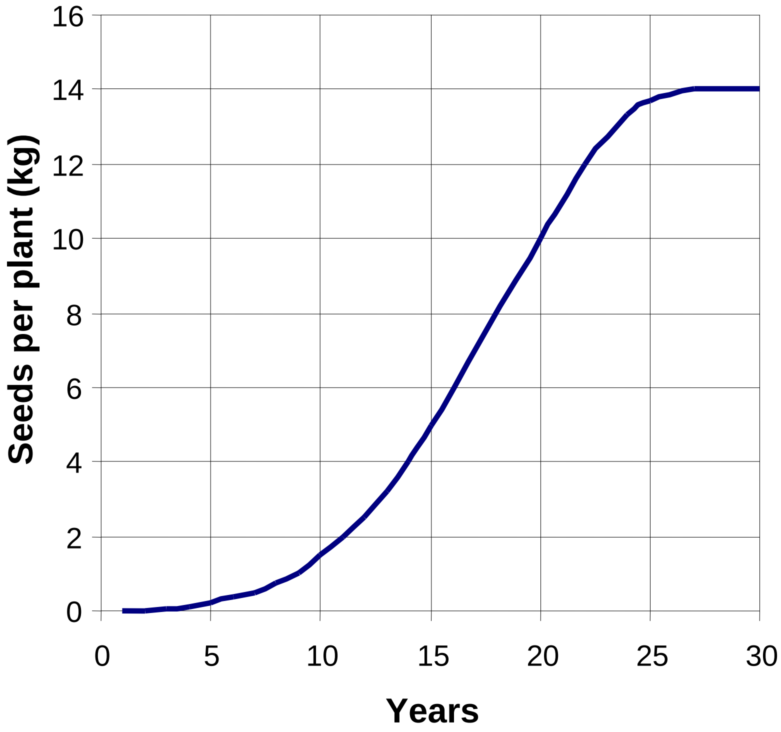


Figure 1.4: Jojoba yield

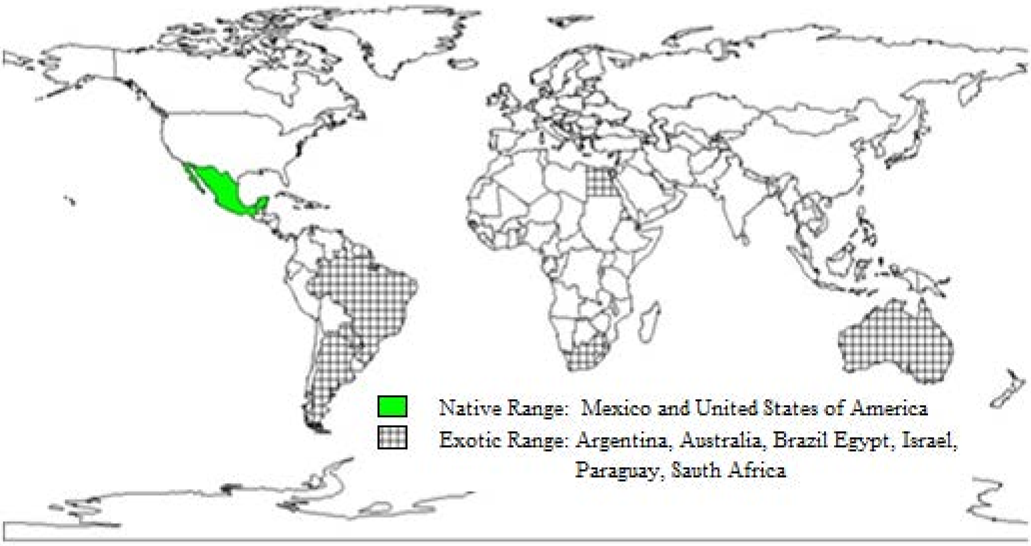


Figure 1.5: Distribution of the jojoba plantation in the world (Orwa et al., 2009)

USA used to be the largest producer of jojoba seed during the early year 2000 in the world. Argentina has the largest jojoba cultivation area in the year 2000 as seen in Table 1.2 and 1.3. However, currently Israel is the biggest producer and distributor of jojoba oil, accounted for nearly 40% of the overall global production. North America accounted for about 40% of the overall global volume which made it the largest market as seen in Figure 1.6 (Jojoba Valley, 2019). A great difference has been realized between this unique oil and the rest of vegetable oils by many researchers. Therefore, it is clear that worldwide jojoba oil production has been grown sharply in the last few years as shown in Figure.1.7 (Farghaly et al., 2013; Seifert at al., 2008; El Bassam, 2010). This fact can be confirmed taking into account the estimated jojoba oil demand in the world, that it is approximately 200000 tonnes per year (Seifet et al., 2008) which is enormously higher than the current production. In addition, the use of jojoba meal after extraction process is being thoroughly studied in order to increase the global interest of jojoba cultivation. After 1976 jojoba cultivation is concentrated mainly in the United States, Mexico, Israel, Argentina, India, South Africa, Egypt and Peru due to the importance and increasing the demand of this oil. Jojoba plant can be a major motivation crop especially for the poor countries in the regions of Africa desert because the United Nations financially supports the cultivation of oil seeds crops (Wisniak, 1987). Nowadays growers in Egypt, Tunisia, India, and even in China are giving a try to jojoba planting. Jojoba acreage planted in Israel and Argentina, primarily from rooted cuttings, began commercial production in the early nineties. Jojoba grown in Peru began coming to markets in the beginning of the millennium. Although the origin of the jojoba is from North America, nowadays no significant planting and growing is attributed to the richest country on earth (Jojoba Valley, 2019).

Table 1.2: Jojoba Seed Production by country (Metric Tonne) (Thagana et al., 2003)

Country	2000	2001	2002	2003
Argentina	950	900	1500	2000
Australia	8	20	50	80
Egypt	15	25	35	50
Israel	1000	1000	1000	1100
Mexico	90	100	100	100
Peru	75	300	600	900
USA	1455	1000	1400	1000
Wild Harvest	50	100	100	100
Total	**3643**	**3445**	**4785**	**5330**

Table 1.3: Worldwide jojoba cultivation and seed production in 2000 (Thagana et al., 2003)

Country	Under cultivation (ha)	Seed production (metric tonnes)	Productivity (kg/ha)
Argentina	4800	950	198
USA Australia	2000	1455	728
Israel	700	1000	1429
Mexico	470	90	191
Australia	400	8	20
Peru	300	75	250
Egypt	140	15	107
Total	**8810**	**3593**	**2923**

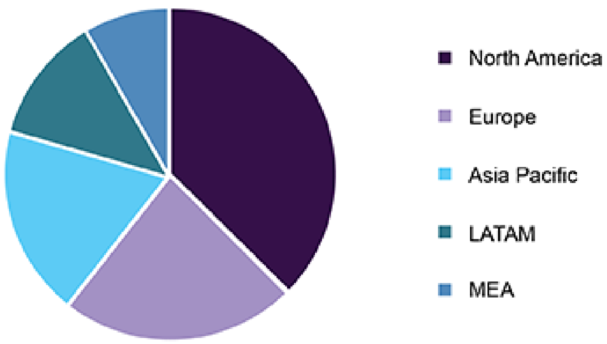


Figure 1.6: Global jojoba oil market share by region (%) in 2018 (Jojoba Valley, 2019)

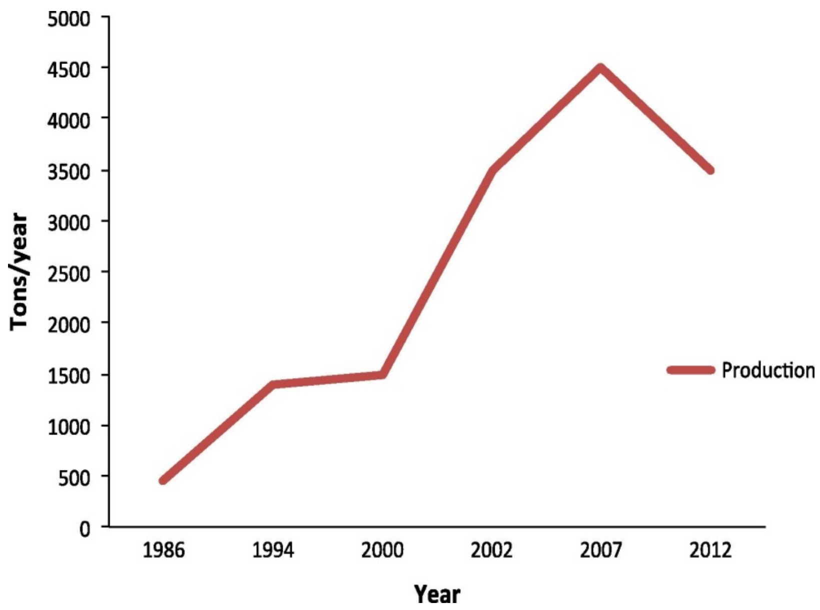


Figure 1.7: World total jojoba oil production (Jojoba Valley, 2019)

1.3.2. International jojoba export council (IJEC)

The International Jojoba Export Council (IJEC) is made up of jojoba growers, processors and marketers around the world. Members include private companies and academic institutions from Argentina, USA, Mexico, Israel, South Africa, India, Egypt, Peru and Chile. The consistency of testing and reporting of jojoba oil has been provided and established the parameters in Tables 1.4, 1.5 and 1.6 are adopted by IJEC. In Table 1.4 the most universal test methods are listed where a supplementary method is also provided.

The IJEC mentioned its mission as follows.

- New jojoba marketing contingency and products.
- To give contribution to the use of jojoba as a renewable, biodegradable and natural resource.
- To announce and arrange the uniform standards of jojoba.
- To organize forums for technical collaboration.
- To support the new harvesting techniques and efforts of agriculture developing.

The chemical and physical specifications of jojoba oil recommended by the IJEC are also shown in Table 1.4, 1.5 and 1.6.

Table 1.4: The tests and reporting for products and recommended ranges by the International Jojoba Export Council (IJEC, 2018)

UNITS	LITE	GOLDEN	TEST METHOD	SUPPLEMENTARY METHOD
Density g/ml 25°C	0.86-0.87	0.86-0.87	AOCS Cc 10 a-25	
Refractive Index 40°C	1.45-1.47	1.45-1.47	AOCS Cc 7-25	
Iodine Value, g/100g	82-87	82-87	AOCS Cd 1-25	
Saponification Value mg KOH/g	88-96	88-96	AOCS Cd 3-25	
Peroxide Value, meq/kg	2 max	2 max	AOCS Cd 8-53	
Triglyceride Content, %	< 1%	< 1%	AOCS Ci 2-91	JEC01
Acid Value, mg KOH/g	1.0 max	1.0 max	AOCS Ci 4-91	
Color, Gardner units	1 + max	9 max	AOCS Td 1a-64	
Color, Lovibond units	1 Red, 3 Yellow max	5 Red, 75 Yellow max	AOCS Cc 13e-92	
Microbial Contamination	< 100	< 100	CTFA M-1	JEC03
Gram Negative Bacteria CFU/g	Zero allowed	Zero allowed	CTFA M-2	

Table 1.5: Recommended fatty acid composition (%) of jojoba oil (IJEC, 2018)

Fatty Acids	Composition (%)
C 16.0	< = 3.0
C.16:1	< = 1.0
C 18:1	5.0-15.0
C 20:1	65.0-80.0
C 22:0	< = 1.0
C 22:1	10.0-20.0
C 24:1	< = 3.0
Others	< = 3.0

Table 1.6: Recommended wax ester composition area (%) of jojoba oil (IJEC, 2018)

Wax Esters	Composition (%)
C.36	0-2
C.38	5-8
C 40	26-34
C 42	44-56
C 44	8-12
C 46	0-3

1.3.3 Jojoba plantation in Turkish Republic of Northern Cyprus (TRNC)

Cyprus Island is located at the east of Mediterranean Sea between 34° 33' and 35° 41'North latitudes and 32° 20' and 34° 35' East longitude. Cyprus Island is the third biggest island in Mediterranean Sea. Island is only 65 km distance from the Anamur shores of Turkey (Figure 1.8). The acreages of whole Cyprus Island are 9251 km^2 and 3355 km^2 of this area is the territory of TRNC (Figure 1.9) which is located on the northern side of the island.

Figure 1.8: Location of the Cyprus Island (Google Earth 2019)

Figure 1.9: Cyprus Island and the territory of TRNC (Google Earth 2019)

As it is listed in Table 1.7, approximately 3 million 300 thousand decares (da) (net 3298908 da) of lands exist, in TRNC of which 1870688 da is used as farm lands and 621543 da are inactive dormant. According to data collected from the Ministry of Agriculture of TRNC, 163446 da are pasture field (Çiftcioğlu, 2011). The unused plots of Akdoğan (78369 da), Geçitkale (31560 da), Yeni İskele (41663 da) and G. Magusa (49558 da) located in Mesarya Plain sum up to a total of more than 200000 da. This region shown in Figure 1.10 is suitable and has a potential for jojoba plantation and it is worth to conducts further investigations for jojoba cultivation.

Figure 1.10: Potential jojoba plantation areas in TRNC (Google Earth 2019)

Cyprus Island represents Mediterranean climate, i.e., the summers are dry and hot, winters are rainy and chilly. According to Meteorological Service of TRNC the lowest and highest monthly average climatic temperatures of island are given in Figure 1.11. Although some local variances shift out in all Cyprus Island, the annual average temperature is around 20°C. The average temperature in January is 14°C, which characterize the winter and in July it is 25°C that characterize the summer. In Cyprus general average temperatures during the period from November to April is between 10-20°C and in the period from May to October is 20°C and over. Average temperature of 0-20°C is referred to the period of spring season, and over 20°C is refer to the period of summer season. There are six months summer season and six months spring season. Eventually it can be expressed that there is no-winter season in Cyprus. Annual rainfall is 400 mm dense rain during the winter months (November to February) is 70% of the total rainfalls receive in a year over Cyprus (Figure 1.12). The rainless period is from July to the end of August, even 1mm of precipitation not fall during these months. There is no perennial stream that discharges into the Mediterranean Sea. A rich Mediterranean flora is seen under the influence of Mediterranean climate in TRNC.

Table 1.7: Land utilization in TRNC (Çiftcioğlu, 2011)

Region	Agriculture (acres)	Region	Forest (acres)	Region	Public land (acres)	Region	Inactive (acres)
Akdogan	132.663	Y. Erenköy	96.884	Güzelyurt	20.673	Akdoğan	58.572
Güzelyurt	126.800	Çamlıbel	20.478	Geçitkale	15.096	Güzelyurt	41.734
Ercan	123.203	Girne east	63.549	Gönendere	12.342	Y. Erenköy	39.430
Y. Erenköy	111.131	Geçitkale	54.091	Yeni İskele	11.923	Lefke	38.056
Çamlıbel	108.674	Yeni İskele	45.035	Y. Erenköy	8.385	G. Magusa	37.039
Lefkoşa	105.506	Mehmetçik	41.786	Akdoğan	8.312	Lefkoşa	33.084
Geçitkale	100.922	West Girne	30.191	Mehmetçik	7.192	Yeni İskele	31.139
Mehmetçik	93.040	Bogaz	20.389	G. Magusa B	7.062	G. Magusa B	29.306
G.Magusa B	91.588	Lefke	20.038	G. Magusa A	5.965	Geçitkale	23.588
Yeni İskele	74.629	Gönendere	17.817	Bogaz	5.384	Girne East	23.067
Gönendere	73.964	Değirmenlik	13.689	Değirmenlik	5.178	Çamlıbel	22.295
G.Magusa A	63.362	Güzelyurt	3.211	Çamlıbel	4.494	Ercan	20.272
Değirmenlik	54.325	G.Magusa A	2.733	Lefkoşa	3.821	Mehmetçik	17.978
Boğaz	50.491	Lefkoşa	262	Ercan	3.604	Boğaz	13.624
Girne east	34.725	Akdoğan	251	Girne east	1.885	Değirmenlik	12.165
Lefke	33.694	Ercan	214	Lefke	783	Gönendere	11.688
Girne west	20.346	G.Magusa B	122	Girne west	58	Girne west	11.515
Total (acres)	**1398123**		**480740**		**122157**		**464532**
Total (da)	**1870688**		**643730**		**163446**		**621543**

1 (English) acres = 1338 m^2 = 1.338 da = 14400 ft^2
1 are = 100 m^2 (1 ha = 10 decare),
1 decare = 10 ares = 1000 m^2 (1da = 10 ar)
1 hectare = 10 decares = 10.000 m^2 (1ha = 10da)

The Mesarya Plain of Cyprus Island is a semi-arid area with a Mediterranean climate with its average elevation around 100 m above sea levels. It is located between Lefkoşa and G. Magusa cities as can be seen in Figure 1.10. According to the soil characterization in Table 1.8 the structure of the soil in test plantation of Mesarya Plain is clayey, limy and salt free as shown in Table 1.9 which is suitable for cultivation of grains such as barley and thus grown in this area (Çiftcioğlu, 2011). Consequently, irrigated farming is almost absent in this region (Çağa, 2017). Hence, it appears that the soil in this area is a medium quality soil which is very limy and poor nutrition level but nevertheless unsalted. It seems that Mesarya Plain is suitable for jojoba plantation according to its soil quality and climate.

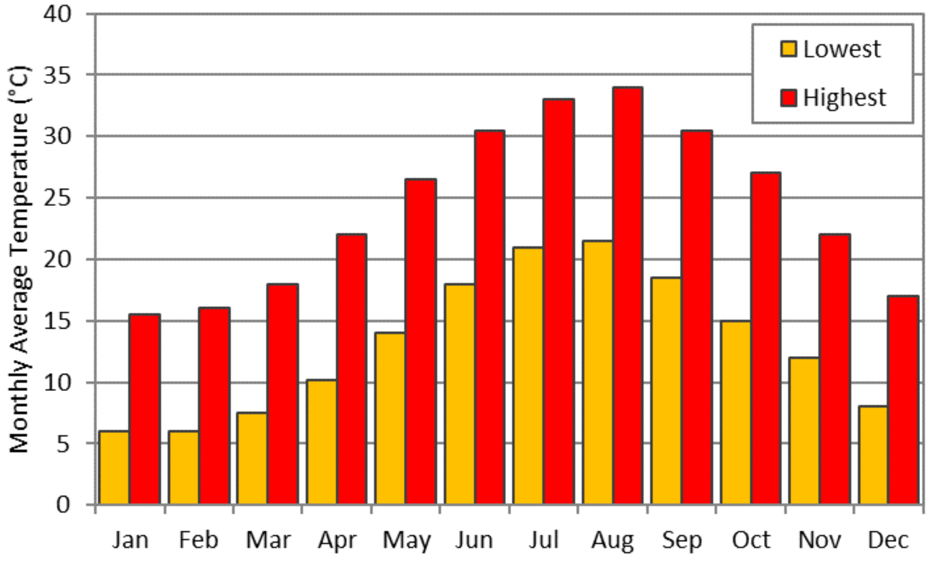


Figure 1.11: Monthly average temperature distribution of Cyprus Island

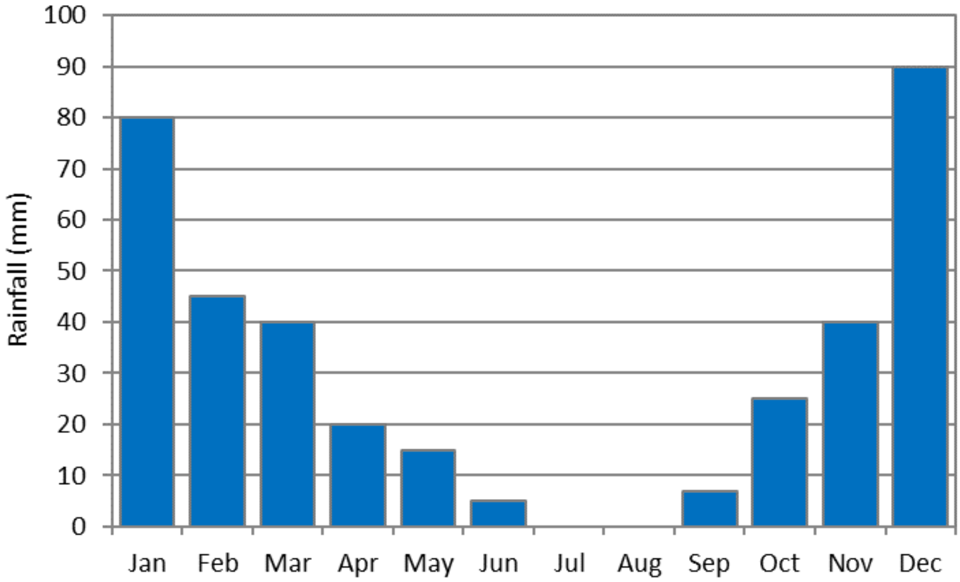


Figure 1.12: Monthly rainfall average distribution of Cyprus Island

Table 1.8: Classification of physical and chemical characteristics of soil

Saturation degree %	Structure
< 30	Sandy
31-50	Loamy
51-70	Clayey loamy
71-100	Clayey
> 100	Serious clayey

(Richards, 1954)

Organic Article %	Characterization
< 10	Very little
1.0-2.0	Little
2.0-3.0	Mid grade
3.0-4.0	Good
> 4	high

(Richards, 1954)

Total Salt %	Salinity degree
0.0-0.15	Salt-free
0.15-0.35	Light salty
0.35-0.65	Mid-grade salty
> 0,65	excessively salty

Anonymous, (1982)

Useful P (P_2O_5, kg/da)	Characterization
0-3	Very little
3.0-6.0	Little
6.0-9.0	Mid-grade
> 9	high

Olsen and colleagues (1954)

Lime content %	Lime matter
< 1.0	Very little limy
1.0-5.0	Little limy
5.0-15.0	Mid-grade lime
15.0-25.0	Too limy
> 25.0	Excessively limy

(Çağlar, 1949)

Useful K (K_2O, kg/da)	Characterization
0-10	Very little
10-20	Little
20-25	Mid-grade
25-30	Sufficient
> 30	high

(Richards, 1954)

pH	Soil reaction
< 4.0	Excessively acid
4.0-4.9	High-grade acid
5.0-5.9	Mid-grade acid
6.0-6.9	Light acid
7.0	Neutral
7.0-7.9	Light alkali
8.0-8.9	High-grade alkali
9.0-9.9	Excessively alkali

(Jakson, 1960)

Table 1.9: Characteristics of the soil of Mesarya Plain

Saturation Soil	Properties	Test result	Characterization
Saturation	%	53	Clayey loamy
pH		8.0	Strong alkali
Lime	%	39	Excessively limy
Total salt	%	0.04	Salt-free (saltless)
Organic article	%	0.8	Very low
Useful phosphor	kgP_2O_5/da	1.0	Very low
Useful potash	kgK_2O/da	94	good

Source: Appendix 1

A jojoba test plantation about 15 ha has been grown by the TRNC Government since 2004 (Bilin, 2013) close to Ercan Airport near Meriç village (Figure 1.10) located in the semi-arid Mesarya Plain. Table 1.10 shows climatic conditions of Meriç in comparison with other jojoba plantation area over the world. Harvesting of jojoba seeds from the test plantation area was observed in 2009. The first academic study of jojoba oil has been performed by Bilin et al. (2018).

Table 1.10: Comparison of the climate conditions of Meriç with other jojoba plantation regions

Ecosystem	Temp. max (^oC)	Temp. average (^oC)	Temp. min (^oC)	Relative humidity (%)	Precipitation (mm)	Wind speed (km/h)	Global radiation (Wh/m^2)
Meriç-Mesarya Plain TRNC[a]	41.4	20.4	2.35	58	687.5	14.76	167.64
Sonoyta Mexico[b]	30.6	21.8	13.0	41.4	215	3.18	518.54
Todos Santos Mexico[b]	32.8	23.9	15.0	53.7	483	4.36	420.37
Ndigena la Huerta[b]	24.7	15.0	5.2	43.30	266.3	5.49	498.06

[a] Meteorological office of TRNC. [b](Lizarde et al. 2017)

1.4 Variety of Soil in TRNC

Terra Rossa: The red color soil named as *Terra Rossa* is a result of decomposition of limestone in the Mediterranean climate. *Terra Rosa* is a very productive soil when it is irrigated in flat areas. This type of soil is especially widespread around Koruçam and G. Magusa, where potato and citrus are cultivated with high yield and good quality. This type of soil is also available in Akaca and Peristerona areas located in southern part of Cyprus.

*Chestnut-Colored Step Soil***:** The Chesnut colored (gray) step soil is most widely available in the poor rainfall region like central Mesarya Plain where the annual rainfall is under 400 mm (Kıbrıs Coğrafyası, 2012). Since the area is not suitable for vegetative farm the grain agriculture is generally performed in this area.

Brown Forest Soil: This type of soil is in brown color, humid, chilly and available under coniferous forests. Brown color is composed of organic matter. The layers are not thick while the forests in Cyprus are generally located on inclined slopes. This type of land lies along the Troodos slopes under coniferous forests, and around pine forests in the northern slopes of the Kyrenia Mountains.

Alluvial Soil: Alluvial soil is a very rich soil and commonly available between the mountains and plains. The severed materials are slided into the stream beds and accumulated in the plains to create the alluvial soil lands. Güzelyurt Plain in TRNC is the biggest alluvial soil area where the most vegetative and citrus agriculture carried out. Yeşilova region in the southern part of Cyprus is located in Paphos district where the alluvial soil field is available.

The soil characteristic and vegetation of Cyprus resemble great similarities with the soil and slopes of Toros Mountain, of Turkey. Generally, the soil feature of Cyprus is acknowledged fertile since the ancient times (Koday, 1998). Terra Rosa and alluvial soils are the most fertile land in Cyprus where the major citrus and vegetative farm is performed. The soil in Mesarya Plain is rich in organic matter but dry and less suitable for irrigated compliance as shown in Table 1.11. Various lands of Mesarya Plain near Meric village the soil is poor in organic matter, salt-free, limy and clayey as Table 1.9. Eucalyptus tree still can be seen in this region, however they are not the original plant of Cyprus Island but also planted by the British administration to dry the bogs from Australia. Although the precipitation is very low in this area a number of irrigation canals have been opened with the drainage systems to accumulate the water in the region. The most important area for grain agriculture is Mesarya Plain where barley and wheat are mainly farming in this region (Koday, 1998).

1.5 Jojoba Oil

Jojoba oil is natural plant oil with superior physical and chemical properties. The oil is contained in the seeds of the plant. It can be obtained by pressing the seeds in an expeller or extracting with leaching method. Main use of this oil and its derivatives are as cosmetics, pharmaceuticals and lubricants (Arya and Khan, 2016) as seen in Figure 1.13. It is used in aircraft and rocket engines. Jojoba oil is a clear, golden-colored, unsaturated liquid wax with no scent or greasy feel. Jojoba oil is chemically a liquid wax, not an oil i.e. not a liquid fat and not a triglyceride as all other plant oils. Jojoba oil has superior physical properties as shown in the Table 1.12 and composed mainly of straight chain monoesters similar of chemical structure with sperm whale oil Figure 1.14.

Table 1.11: Classification of the irrigated compliance of TRNC territory (Çağa, 2017)

Irrigated Compliance Class	Area (acres)	Area (%)
1. Class (Very suitable)	164843	4.92
2. Class (Medium)	435115	12.99
3. Class (Less suitable)	881168	26.31
4. Class (Suitable for special plants)	254131	7.58
5. Class (Temporarily not suitable for irrigated compliance)	Nil	Nil
6. Class (Not suitable)	1068197	31.89
7. Others	546018	16.30
Total (acres)	3349471	
Total (da)	4481592	

Table 1.12: Typical properties of Jojoba oil by IJEC

Property	Grade
Freezing point °C,	10.6 – 7.0
Melting point °C	6.8 – 7,0
Boiling point at 757 mm under N_2,°C	389
Kinematic Viscosity, mm^2/s at 40°C,	26
Density at 20 °C ASTM-1298-85 g/cc	0.85 – 0.87
Heat of fusion by DSC cal/g	21
Specific gravity g/cc 25 °C	0.86-087
Specific conductivity (27°C) mho/cm	8.86×10^{-13}
Flash point (AOCS Cc 9a-48) ^{0}C	8.86×10^{-13}
Fire point ^{0}C	338
Pour point ASTM-D97-87°C	+11
Cloud point AOCS-Cc6-2°C	+15
Moisture ppm	< 300
Acid value AOCS-Ci 4-91 mgKOH/g	1.0
Iodine value AOCS Cd 1-25 g/100g	82 – 92
Phosphorus ppm	50-100
Dielectric constant 27°C	2.68
Refractive Index 40°C	1.45-1.47

The composition of jojoba oil has high resistant against temperature, i.e. its fire point and boiling temperature are 338°C and 389°C, respectively. Jojoba oil is used mainly without any refining material because it is pure non-toxic and biodegradable. Jojoba oil is very susceptible to many different types of chemicals manipulations (Table 1.4) as it contains straight-chain C20 and C22 fatty acids and alcohols and two unsaturated bonds, (Table 1.5). After the ban of whale sperm oil at the beginning of 1980's the real commercial use of jojoba oil raised up in the USA as a substitute for sperm whale oil and the whales have been saved (Wisniak, 1994). The whale sperm oil (*spermaceti*) has exactly the same chemical structure with jojoba oil (Figure 1.14). The main applications of the whale sperm oil are used in cosmetic industry and industrial uses such as additive oil and as lubricant. Jojoba oil possesses several advantages over sperm oil. It has no fishy odor. The crude jojoba oil contains no stearins (triglyceride of stearic acid) and requires little or no treatment for many industrial purposes. It can take larger amounts of sulfur and does not darken on sulfurization. The highly sulfurized jojoba oil is liquid, whereas sperm oil when highly sulfurized requires addition of mineral oil in order to remain liquid (Wisniak, 1994).

Figure 1.13: Potential uses of jojoba oil (Bilin et al, 2018)

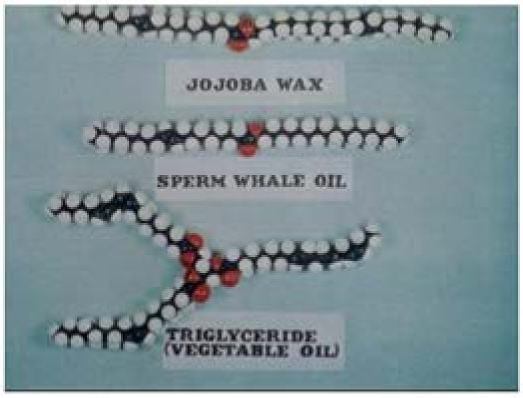


Figure 1.14: Chemical structure of jojoba oil compared to the sperm whale oil-and triglycerides (vegetable oil) (Asir Institute 2019)

Jojoba oil is a natural skin moisturizer since it is similar to the sebum, i.e. the moisturizer produced by human skin. The identical double bonds are available in the molecular structures of human skin sebum and jojoba oil (Benefits, 2017) as shown in Figure 1.15. It penetrates in to the skin rapidly without leaving any oil traces within only a few seconds and gives a true benefit. Thus, this oil keeps the skin and hair from drying.

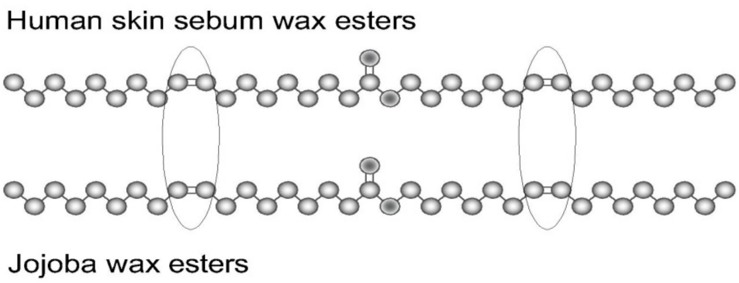


Figure 1.15: Molecular structure of jojoba & human skin sebum wax esters (Bilin et al, 2018)

1.6 Jojoba Industry

Jojoba oil is very valuable oil since it is the only available liquid wax. The economic value of jojoba plant comes from its seeds which contain jojoba oil by about 50% of seeds weight. Jojoba is a new industrial crop that has attracted much attention in last decades. Farmers are now growing jojoba in all over the world. Jojoba industry is spreading everywhere, because jojoba oil consumption is rising up. The jojoba oil market reached an amount of 12000 tonnes in 2016 and expected to reach 22000 tonnes by 2022 (Imarc, 2017).

1.6.1 The major uses of jojoba oil

Jojoba oil uses can be summed up in three categories:

- Cosmetics
- Lubrication
- Biodiesel

1.6.2 Cosmetics

The molecular structure of jojoba oil wax esters is in very similar characteristics with human skin wax esters as shown in Figure 1.15. Therefore, jojoba oil and creams produced from jojoba oil can easily penetrate into human skin and does not leave any residue. This is an advantage for jojoba oil in cosmetics industry. Jojoba oil is used in various aspects in cosmetics such as natural (as-is), liquid cream, hair oil and massage oil. In industrial cosmetic it is used as improver and constituent of shampoos, conditioners, body lotions, creams, soaps, lipstick, etc. (Arya and Khan, 2016).

External medicinal uses are as follows:

- For massage for relieving joint and muscle pains, and the massage of tense muscles of the back and neck as it contains the anti-inflammatory substance myristic acid.
- For treating baby and body rash.
- For treating minor burns and sunburn.
- For the prevention of urinary tract infections in females, and fungus formation
- For treating hemorrhoids by adding to affected areas.
- For distributing and/or breaking external fat deposits on the stomach or legs, thus removing the fats from unwanted areas by continuous rubbing and massaging (Abu Zeid, 2002)

1.6.3 Lubrication

Lubricity is the ability to reduce friction and wear by a lubricant between solid surfaces in relative motion. A lubricant performs many diverse functions which help to protect and prolong the life of the machine or equipment. These functions are follows;

Lubrication; Lubricant reduces friction and wear by introducing a lubricating film between mechanical moving parts such as gears and bearings to minimize the metal-to-metal contact surfaces.

Cooling; Lubricant decreases and dissipates the heat away from the moving parts and equipment to prevent the possibility of the component deformation.

Protection; Lubricant prevents the metal damage due to oxidation products, corrosion, and wear. This achieves by forming a physical film on metal surface to prevent the contact of the metal with atmosphere.

Power transfer; Lubricant is used as a power transfer resource in some applications, like hydraulic systems. The lubricant performs this function to operate the lifts, transmissions, forklifts, drills, loaders, etc.

Jojoba oil and other vegetable oils are evaluated to be used as lubricants for the diverse functions mentioned above. The jojoba oil is found to be the most suitable lubricant of precision machinery among all other seed oils since the unique properties and physicochemical characteristics of jojoba oil is superior against the others. Lubricity is also termed a substance's anti-wear property. In metal industry the lubrication process and the lubricity value are very important facts as to prevent or decrease the frictional force and the heat of the two or more rough metal surfaces. The prevention can be done by creating an oil layer between two surfaces. As a lubricant jojoba oil most widely used such as engine oil or as an additive in automotive industry, aviation industry, metallurgical industry space vehicles, military vehicles, rockets, missiles and various machines (Wisniak, 1994; Wisniak, 1987). Jojoba oil is used also in clock industry because it is very thin oil. Jojoba oil is colorless, odorless, very pure oil and can be stored in the warehouse for many years. It is stated that lubrication can be improved by adding jojoba oil in to engine oil or to transmission oil in automotive industries (Miwa and Rothfus, 1979). The vehicles can travel 200000 km when jojoba oil is used as motor oil (Söylemez, H. 2002). It can also be used for precision machinery lubrication.

Additionally, jojoba oil can be used; (Wisniak, 1994; Arya and Khan, 2016).

- As a surfactant improver of paints, varnishes, and waxes to improve their spread-ability shine and stability
- In waxing, it can be used "as-is" or mixed with other waxes
- For protection wooden furniture, shoes, and leather items by polishing.
- Polishing the automotive dashboard leather.

- As a lubricant in sharpening of knives and in metal cutting.

1.6.4 Biodiesel

Biodiesel (BD) is a mixture of mono-alkyl esters of saturated and unsaturated long chain-fatty acids made from any tri-glyceride oil molecule (Knothe and Steidley, 2007). BD is produced from the renewable resources hence named as a renewable energy. The main parameters of this environmental friendly fuel are that biodiesel is manufactured from plant oils or animal oils. A number of plant oil which can be used for biodiesel production can be listed as sunflower, canola, mustard, jojoba, soybean, corn and palm. Used cooking oils named as fried oil can also be a source of biodiesel. Better lubricating capabilities, ease to manufacture and environmental properties are the major advantages against petroleum diesel. It has been reported that jojoba-fueled engines kick out fewer pollutants run more quietly and perform just as well as diesel engines (Selim et al., 2003). The study for substitute fuels, decreasing oil reserves and concerns over exhaust emissions, has led researchers to investigate more sustainable sources such as plant oils. Sunflower oil and soybean oil have all been tested as potential fuels. Engineers think the oil has potential as a motor fuel because it releases a lot of energy when it burns and is chemically stable at the high temperatures and pressures in a working engine. It is reported that jojoba oil has been used as an engine fuel in pure form (100% jojoba oil) in some experiments (Al-Widyan and Al-Muhtaseb, 2010). Biodiesel can be produced with chemical methods such as transesterification that will be described in following sections. Eventually this renewable energy source is considered as a superior fuel to petro-diesel because;

- Greater lubricity than low sulphur petro-diesel.
- It is more biodegradable than petro-diesel.
- It is possible to manufacture on farm from oilseeds like canola, jojoba, etc.
- It is considered a renewable fuel.

1.6.5 Others uses of jojoba oil

Jojoba oil is also used in medical sector such as in penicillin production and as a medicine against stomach cancer and kidney disorders. It is a lubricant to the digestive tract system and helps to relieve constipation and stomach ulcers. The most important problem in the production of penicillin is to become foamy, jojoba oil is sought so hard to avoid this problem in the production of penicillin (Wisniak, 1994) The hydrogenated jojoba oil (as in the case in making margarine), becomes a fairly stiff and convenient wax, for polishing cars, shoes, cardboard, paper process. Hydrogenated jojoba oil, can be used in candle connatural, shows candle property known as the finest quality candle carnauba. Carnauba candle achieved digging by hand with palms in Brazil and is marketing with jojoba oil.

Jojoba oil can be used in food industry as well. The freshness and taste of the canned foods can be preserved in a long time during storage by using jojoba oil in food industry. Jojoba oil is really diet oil with minimal calories because it is a wax and is absorbed very little. Although.it can be used as a cooking oil in frying eggs and potatoes, in salads, rice, and various meals with or without meat, jojoba oil production remains limited out of its high cost and it seems it will remain relatively expensive for some times because the plantation of jojoba shrubs around the world are very limited. The meal remaining after the wax has been removed, is high in crude protein 25-30% (Wisniak, 1994) and plenty of carbohydrates which is suggested for utilization as an animal feed or feed supplement. Such utilization is not straight forward because the meal also contains toxic components (Wisniak, 1994; Imarc, 2017). Researcher stated some objection of the cattle feeding with jojoba pulp but the research about of this matter is continuing. Many publications have reported on the use of jojoba meal (as such or detoxified) for animal feed, some of these studies dealt with the toxicity of purified *simmondsia* (Booth, 1972). Feeding studies with diets supplemented with jojoba meal have been conducted with broiler chick and lambs (Manos et al., 1986). They have addressed ration palatability, feed efficiency, growth, and toxicology. Practically, it has been found that the meal cannot be fed directly to animals since the meal is contained anti-nutritional factors (ANF). In monogastric animals the ANF apparently cause death by cyanide poisoning. Ruminants are more tolerant of the ANF but do not use the protein efficiently or gain weight well (Wisniak, 1994; Manos et al., 1986).

1.7 The Aim and Objectives of the Study

The basic aim of the current study has two folds i.e. both academic and also economic aspects of jojoba agriculture and its oil. Hence, the objectives will cover the following work.

- Investigation and comparison of jojoba cultivation with current traditional agriculture in Mesarya Plain of TRNC.
- Extraction and characterization of Mesarya jojoba oil.
- Optimization of jojoba oil extraction.
- Investigation of alternative usages of extracted jojoba oil including cosmetics, lubrication and biodiesel

CHAPTER 2
A COMPARATIVE SURVEY OF JOJOBA VERSUS BARLEY AGRICULTURE IN MESARYA PLAIN

2.1 A Brief Analysis of Investment and Yield of Jojoba Agriculture

Commercial farming of jojoba shrub, harvesting of jojoba oil from its seeds and profitable trade in Israel (Wisniak, 1994; Wisniak, 1987) was followed by many jojoba plantations across the Middle East and also in various African countries. TRNC government decided to prove this new crop in Cyprus. Therefore, a jojoba test plantation of 15 ha has been grown in Mesarya Plain since 2004 near Nicosia (Lefkoşa) by the Department of Agriculture (Bilin et al, 2018). There are 621543 da inactive lands which can be used for various plantations in TRNC (Table 1.7). Among these, Mesarya Plain which is located between Lefkoşa and Famagusta (G. Magusa) is the largest of all. Jojoba plantation can be a remarkable alternative in this semi-arid land. 200000 da of the inactive land located in Mesarya Plain (Akdoğan, G. Magusa, Geçitkale, Yeni Iskele) as shown in Figure 1.10 was investigated for jojoba plantation and barley agriculture in this survey. For a cost-benefit analyses of 200000 da of jojoba plantation and barley agriculture considered. Eventually, a comparison was carried out with barley and jojoba plant.

2.2 Barley Cultivation in TRNC

Barley is the most commonly grown crop in dry cultivation in TRNC (Figure 2.1). Agriculture of barley is carried out in the months of October, November and December according the annual climatic conditions. The most widely cultivated barley types in TRNC are Atenais, Gidriya, Dimitria and Lysi according to the soil type and climate. In average 25-30 kg barley seeds are used in sowing per decare. The selection of the fertilizer depends of the soil analysis. An average of 20-30 kg/da fertilizer is used during sowing. In Mesarya Plain the average yield of barley is approximately 250-500 kg/da (Agricultural Products Board, 2019). The selling price of barley is 1.35 TL/kg in the year 2019. Stock farming tend to increase in TRNC in which barley is the main feeding raw material. The demand of barley in TRNC is approximately 100000-110000 tonnes/year (Agricultural Products Board, 2019).

This demand was afforded from the domestic agriculture but when the amount of yield is less than required import of barley can be necessary. Barley agriculture is carried out mainly in Mesarya Plain which is located between Lefkoşa and G. Magusa (Figure 1.9).

Figure 2.1: Barley cultivation in TRNC

The average barley agriculture in TRNC is around 800000 da and cultivated mostly in Mesarya Plain (Akdoğan, G. Magusa, Yeni İskele, Geçitkale, Mehmetcik) as can be seen in Table 1.7 on the agriculture region (Agricultural Products Board, 2019). Harvesting season of barley is in the months of May and June.

2.3 A Brief Survey of Investment and Yield Analysis of Jojoba Plantation in Mesarya Plain

In the survey 200000 da of the inactive land in TRNC was considered as plantation area for jojoba plant. According to rough estimates from Cyprus point of view, it is assumed that 200 plants in one decare can be planted. 20 plants out of the 200 are male and the remaining will be female. However, jojoba growers have to wait for several years to earn profit. As can be seen in Table 1.1, after 5 years 36 kg/da @ 200 g/plant jojoba seeds can be obtained. After 8 years the seed production would be 135 kg/da @ 750 g/plant. After 12 years it would be 450 kg/da @ 2500 g/plant (Advanced Biofuel Center, 2019). Since the jojoba seed contains 50% oil of the dry seed weight, then 225 kg of jojoba oil can be obtained from 450 kg jojoba seeds per decare and 2250 kg oil per hectare in 12th year after plantation. If 200000 da inactive lands cultivated with jojoba plant as mentioned above then 90000 tonnes jojoba seeds can be obtained, which yield 45000 tonnes of oil @ 50% per year. It should be noted that the area considered in the survey is only 32% of the total inactive lands. The 45000 tonnes of jojoba oil will boost the cosmetics production and industrial applications.

2.3.1 Cost-benefit analysis of jojoba seed and oil over 12 years.

Cost analysis was examined for one decare of jojoba plantation. Assumptions made in the current survey can be listed as follows:

- 200 pits scooped out (50 cm diameter, 4 cm depth)
- 4 jojoba seeds in every pit
- 180 female and 20 male jojoba plants in one decare.
- The most suitable month for planting is April
- The first harvest at the end of 4 years: 18 kg/da
- Yield after 12 years: 450 kg/da
- Assumed feasible life time for the Jojoba plant: 100 years
- Labor average wage: $23/day.
- Jojoba seed selling price: $5/kg
- First 12 years after plantation considered.
- The current exchange rate: $1=5.8TL

Cost of jojoba plantation until the first harvesting.

(1) For sowing 0.48 kg of jojoba seeds: $10 x 0.48kg/da = $4.8/da
(200 pits x 4 seeds = 800 seeds per decare, 800 seeds x 0.6 gr = 480 g seeds).

(2) Plowing the field = $52/da (once a year)

(3) Labor cost of 200 pits: $92/da (2 persons for 2 days from $23/day).

(4) Labor for irrigation: $23 (once until germination)

(5) Water expense: $3 (2 tonnes)

(6) Labor cost for irrigation until harvesting: 3 years x 2 times/year x $23 = $138

(7) Water expenses 2 tonnes x 2 times x 3 years x $1.5/ton = $18

(8) Labor cost for pruning: $23/year x 3 years = $69

(9) Labor for harvesting: $1/kg (a person can harvest 23 kg/day)

(10) Average $5/da is the initial investment

(11) Field hire: $4.3/da·year + Interest $2.4/da·year = $6.7/da·year

Initial investment cost until first harvesting (4th year) = $523.3/da

Initial investment of one decare $524 ÷100 years = $5.24/year·da (average 5 $)

Cost-revenue estimation of the jojoba crop in 12 years

The expenses in jojoba agriculture in12 years can be seen in Table 2.1 whereas cost-revenue projection in a decare of jojoba plant in 12 years can be seen in Table 2.2.

Table 2.1: Expenses of jojoba agriculture in12 years

	Years											
Works	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
(1)	4.8	0	0	0	0	0	0	0	0	0	0	0
(2)	52	52	52	52	52	52	52	52	52	52	52	52
(3)	92	0	0	0	0	0	0	0	0	0	0	0
(4)	23	0	0	0	0	0	0	0	0	0	0	0
(5)	3	0	0	0	0	0	0	0	0	0	0	0
(6)	46	46	46	46	46	46	46	46	46	46	46	46
(7)	6	6	6	6	6	6	6	6	6	6	6	6
(8)	23	23	23	23	23	23	23	23	23	23	23	23
(9)	0	0	0	18	36	63	90	135	180	270	360	450
(10)	0	0	0	5	5	5	5	5	5	5	5	5
(11)	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7
Tot. $	256.5	133.7	133.7	156.7	174.7	201.7	228.7	273.7	318.7	408.7	498.7	588.7

Table 2.2: Cost-revenue projection in a decare of jojoba plant in 12 years

Years	**Yield kg/plant**	**Yield kg/da**	**Selling price $/kg**	**Revenue $/da**	**Expenses $/da**	**Profit (benefit) $/da**	**Balance**
1	0	0	-	-	256.5	-256.5	-256.5
2	0	0	-	-	133.7	-133.7	-390.2
3	0	0	-	-	133.7	-133.7	-523.9
4	0.1	18	5	90	156.7	-66.7	-590.6
5	0.2	36	5	180	174,7	5.3	-585.3
6	0.35	63	5	315	201.7	113.3	-472
7	0.5	90	5	450	228.7	221.3	-250.7
8	0.75	135	5	675	273.7	401.3	150.6
9	1	180	5	900	318.7	581.3	731.9
10	1.5	270	5	1350	408.7	941.3	1673.2
11	2	360	5	1800	498.7	1301.3	2974.5
12	2.5	450	5	2250	588.7	1661.3	4635.8
Total		1602	5	8010	3374.2	4635.8	4635.8

Average cost of seeds in 12 years $3374.2÷1602 kg = $2.10/kg

1.602 kg x $5 = $8.010/da total income in 12 years

Total expenses = $3374.2/da in 12 years

Net profit (benefit) = $4635.8/da

Total profit in 200000 da = 200000 x $4635.8 = $927160000

Cost-revenue estimation of jojoba oil production.

- Transport the jojoba seeds to the factory: $100 ÷ 10000 kg = $0.01/kg
- Cost of jojoba seed: $2.10/kg
- Cost of jojoba seeds at the factory $2.10 + $0.01 = $2.11/kg
- Cost of jojoba seeds: 2.11$/kg
- Selling price of jojoba seeds: 5 $/kg
- The factory investment is neglected

Table 2.3: The cost estimation of oil production from 1000 kg of jojoba seeds

Item	Value
Cost of jojoba seeds ($)	2110
Labor ($)	150
Electric ($)	100
Direct Operating expenses ($) *	70
Indirect expenses ($) **	30
Cost of oil ($)	2460
Jojoba oil (kg)	500

* Operating expenses: Fuel, tools and spare parts expenses
** Indirect expenses: Telephone, stationery, cleaning, water, internet expenses of the factory

Cost of jojoba seeds at the factory: $2.11/kg

Cost of jojoba oil at the factory: $2460÷500 = $4.92/kg

Total cost-benefit of jojoba oil in 200000 decares

Jojoba seeds yield 1602 kg/da ⟶ 801 kg/da jojoba oil

Cost of oil: 801 kg/da x $4.92/kg = $3940.92/da

Revenue of oil: 801 kg/da x $20/kg = $16020/da (Bilin et al., 2018).

Benefit of jojoba oil: $16020 – $3940.92 = $12079.08/da

Benefit (200000 da): $2415816000

2.4 Cost-Benefit Analysis of Barley Agriculture Over 12 Years.

The cost expenses of barley for one decare collected from Department of Agriculture of TRNC are given in Table 2.4.

Table 2.4: Cost expenses of barley *

	Cost component	TL/da	$/da
1	Field hire	25	4.30
2	Soil processing	23.53	4.00
3	Seed price	38.06	6.55
4	Fertilizer price	93.43	16.10
5	Seed cultivation and fertilization	9.40	1.62
6	Chemical drug cost	25.86	4.45
7	Cost of spraying	6.37	1.10
8	Harvest- reaping	47.50	8.18
9	Transport	8.63	1.48
10	Interest	13.86	2.39
11	Total	291.44	50.25
12	Unseen expenses	2.91	0.50
13	Grand total	294.35	50.75

* (TRNC Department of Agriculture, 2019)

Grand total Cost of barley agriculture: $50.75/da·year

Total cost expenses in 12 years: $50.75 x 12 = $609/da

Total revenue of barley in 12 years

- The expected yield of barley: 400 kg/decare·year (depending on annual rainfall) (Agricultural Products Board, 2019)
- Selling price of barley: 1.35 TL/kg ($0.24/kg) (Tarımdan Haber, 2019)
- Revenue of barley: 400 kg x $0.24 = $96/da·year
- Revenue in 12 years: $96 x 12 years = $1152/da
- Net income in 12 years: 1152 – 609 = $543/da
- *Benefit (200000 da): $108600000*

2.5 Comparison of Jojoba and Barley in TRNC

Comparison of barley and jojoba can be seen in Table 2.5.

Table 2.5: Comparison of barley and jojoba agriculture in Mesarya Plain

Product	Expenses ($/da) 12 years	Revenue ($/da) 12 years	Net income ($/da) 12 years	Benefit ($) 200000 da
Barley	609	1152	543	108600000
Jojoba seed	3374.2	8010	4635.8	927160000
Jojoba oil	3940.92	16020	12079.08	2415816000

Hence, it can be estimated that in 12 years the total benefit of jojoba seed is more than eight times than benefit of barley. This scenario suggests that jojoba cultivation in Mesarya Plain with high-yielding clones could be a potentially profitable alternative crop against barley. Moreover, the total benefits of jojoba oil would be more than twenty-two times of the barley and 2.6 times of the jojoba seed. It is worth to note further that the yield of jojoba seeds will reach to a maximum level of the 25th year after plantation which is 14 kg/plant. This value is 7 times more than it is at the 12th year (2 kg/plant).

CHAPTER 3
EXTRACTION AND TESTING OF OIL FROM JOJOBA SEEDS HARVESTED FROM THE EXPERIMENTAL PLANTATION IN MESARYA PLAIN

3.1 Oil Extraction Processes

Oil production industry is an important stage of modern agriculture. Jojoba oil, one of the most valuable types of oil in cosmetics and industry, is contained by oleaginous seeds. Various methods similar to those applied to other oilseeds can be used for oil extraction from jojoba seeds (Wisniak, 1987; Wilcox, 1987). Generally, two terms, ‘‘expression’’ and ‘‘extraction’’ are used when discussing plant oil production. Expression is the process of mechanically pressing of liquid-containing solids (seeds). Extraction is expressed as the process of separating the liquid from liquid-solid mixtures with the aid of a chemical solvent which is also called leaching (Beerens, 2007; Siregar et al., 2013). In literature, the term extraction is also used for mechanical oil expression (Biris et al., 2009). Oil extraction from the seeds can be classified under three basic methods including expression (mechanical pressing), extraction (leaching) and expressing plus extraction (mechanical pressing followed by leaching). Mechanical pressing (especially screw pressing) and leaching methods are the most commonly used methods for oil extraction. Recovery of mechanical pressing method is up to 90-95%, while leaching method has a capability of 99%. Single or dual pressing can be applied to jojoba seeds composed of about 50% oil by mass to extract the maximum amount of oil. A mechanical pressing (screw pressing) method has been applied by the Mechanical Engineering Department in Near East University within the frame work of the first academic study for jojoba oil in TRNC (Bilin et al., 2018). This study will be described with comprehensive details in the following sections.

3.1.1 Mechanical pressing method

Mechanical pressing (expression) method is based on mechanical compression of the raw material. In this method the oil is separated from the seeds under the squeezing external forces. Squeezing operation can be conducted either by using an expeller or a hydraulic press which are driven by fluid pressure or with a screw (warm shaft). In spite of low yield rate, screw pressing is a popular oil extraction method as the process is simple, safe, large quantities of seeds can be processed with minimal labor and allows continuous oil extraction (Dunford, 2016). For the optimization the mechanical pressing process it is useful to examine the main variables affecting the oil recovery and oil quality. The seeds can be fed in to the press as a whole size seed, half size seed, and quarter size seed or can be grounded before processing. The grounded seeds in meal form can become sticky and plug the grinder which can be considered as a disadvantage of this method. However, the problem can be solved in different ways but this will increase the cost of oil (Rawles, 1978). In expeller pressing the seeds are squeezed under high pressure in a cylindrical container by a worm shaft and the oil comes out through an oil outlet. The second approach is hydraulic press method in which a hydraulic press is used to press the seeds in a cylindrical container. The disadvantage of the mechanical pressing method is that the mechanical presses do not have high extraction efficiencies, i.e. 8-14% of the available oil remain in the press cake (Bamgboye and Adejumo, 2007). Dual passing (pressing) operation can be beneficial in increasing the yield recovery. After the first pressing operation, the press cake discharged from the end of the screw can be broken then, can be inserted in to the container for a second time to carry out a dual pressing operation. This method increases the yield recovery i.e. first pressing 80% of the original oil content of the seeds and 94% following the second pressing (Abu-Arabi et al., 2000; Karaj and Muller, 2011).

3.1.2 Leaching (chemical) method

Leaching is chemical oil extraction method which can be applied to various types of oil containing seeds. The method is a chemical approach in which a solvent like hexane is used to extract the oil content from the seeds. Although there are some other organic solvents like heptanes, benzene, alcohol, chloroform, but hexane is the most commonly used solvent in leaching process because of its relatively low cost and low toxicity (Wilcox, 1987; Johnson, and Lucas, 1983). Abu-Arabi (2000) reported a modified procedure in their article. In this process the jojoba seeds crashed out with a crasher and then charged in to the Soxhlet extractor while adding the solvent. The mixture is heated up to the boiling point of solvent until a clear liquid was obtained from the jojoba seeds which indicate the complete leaching of the leachable oil. The extracted oil and solvent are distilled in two steps to separate the oil and solvent. First step is a simple distillation followed by applying vacuum to ensure complete evaporation of the solvent (Wilcox, 1987). Abu-Arabi (2000) indicated that hexane solvent leached the highest amount of jojoba oil followed by petroleum ether, benzene, isopropanol, toluene and the chloroform.

3.1.3 Mechanical pressing followed by leaching

This is a method in which mechanical and chemical processes are applied in a sequence. The jojoba seeds were pressed single or dual passing in an extraction machine as mentioned in the mechanical pressing method then the residue taken out from the container crushed to an average size of less than 1 mm. Following crushing the leaching operation applied by using chemical solvents. The total amount of oil extracted in this method is the sum of that obtained by first and second pressing (if applied) and leaching step.

3.2 Oil Extraction from the Jojoba Seeds Harvested in Mesarya Plain.

The importance and specifications of jojoba oil has been widely described in the previous sections. These properties make jojoba oil particularly attractive all over the world. As mentioned in Chapter 2, a 15 ha of experimental jojoba plantation has been grown in Mesarya Plain (Bilin, 2013) near Meriç village, under local environmental conditions. Jojoba is a brand-new crop to this area. The first jojoba seeds harvested in 2009 from the plantation so it was necessary to produce, examine and evaluate the characteristics of jojoba oil. Near East University intended to be pioneers of this attempt due to the importance of jojoba oil around the world and would be an alternative crop for Mesarya Plain. Therefore, the first academic study for this purpose has been performed by the Mechanical Engineering Department of Near East University. The study was focused on the three main subjects.

- To extract jojoba oil from the seeds harvested in the region.
- To investigate the physical and chemical quality of the jojoba oil as specified by International Jojoba Exporting Council (IJEC).
- To compare these features with those reported in the current literature.

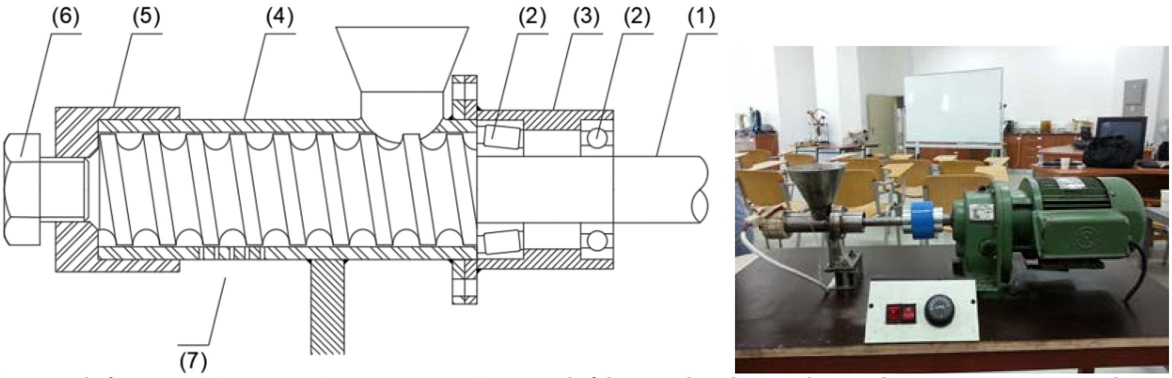
3.2.1 Preparation of jojoba seed

Jojoba plantation area is located in Mesarya Plain near Ercan Airport and Meriç village. After the permission of the Agriculture and Natural Sources Ministry, Mechanical Engineering Department students collected the jojoba seeds from the region as seen in Figure 3.1. For the first experiment of jojoba oil production, 500 g of jojoba seeds were prepared. Before the pressing process jojoba seeds were subjected to various pre-treatments, including cleaning of impurities, washing with water then, dried in three days at room temperature (22°C). No other pre-treatments like dehumidifying, sizing and heating have been necessary. The average initial natural moisture contents of the seeds were measured to be 6.02%. They were grounded in a blender to a size of less than 2 mm, weighed then transferred to a container prior to extraction.

Figure 3.1: Jojoba seeds collected in the Mesarya Plain

3.2.2 Expeller design for extraction

Mechanical pressing method was preferred for extraction of jojoba oil in the study since it was simple, safe and its components can be produced easily in a workshop environment. A simple expeller was designed and then produced in the workshop of Mechanical Engineering Department as shown in Figure 3.2. Expeller is a mechanical screw press consisting of a horizontal housing (barrel) and a vertical hopper in which the seeds are fed in to the screw. The barrel surrounding the stainless-steel screw has oil outlet holes for oil draining during the pressing. In the method the seeds were squeezed in the housing by a worm shaft. The expeller was 220 mm long and 45 mm in diameter. The oil extraction was achieved via a screw that pressed the seeds against the inner surface of the sediment expeller and the extracted jojoba oil poured out through the oil outlet holes which did not permit the passage of the sediment.



(1) Worm shaft, (screw) (2) Bearings, (3) Bearing case, (4) Worm shaft housing (barrel) (5) Sediment adjusting nut, (6) Pressure adjusting bolt, (7) Oil outlet holes,

Figure 3.2: Designed and produced jojoba oil expeller

3.2.3 Oil extraction

A batch of 500 g of jojoba seeds were weighed on an electronic balance of 0.001 kg precision as seen in Figure 3.3 (a) and prepared for a single pressing as described in the previous section. The temperature and the humidity in the laboratory were followed using a thermometer coupled with a hygrometer (Figure 3.3 (b)). The seeds ground in a blender and prepared for extraction. For each run, 70 g of ground jojoba seeds were placed in the hopper of the expeller and then subjected to the press load at room temperature. The extracted jojoba oil was strained through a filter as seen Figure 3.3 (c) and left for rest in a glass beaker for three days at room temperature and humidity before bottling. After three days of rest, the residue was deposited at the bottom of the beaker therefore; the clear jojoba oil could be sucked easily by a syringe and be bottled in 30 ml plastic bottles. The oil in the bottles shown in Figure 3.4 was ready to be analyzed for their physicochemical properties. This was the first trial for the oil extracted from the jojoba seeds harvested from Mesarya Plain.

(a) **(b)** **(c)**

Figure 3.3: (a) Electronic balance (KERN-PCB-250-3), (b) Thermometer and hygrometer, (c) Filter

Figure 3.4: Oil extracted from the jojoba seeds of Mesarya Plain (Golden Quality Jojoba)

3.3 Characterization of Jojoba Oil

This experiment was the first academic study of the jojoba seeds grown on Mesarya Plain in TRNC. Jojoba oil extracted from the seeds of Mesarya Plain referred as Golden Quality Jojoba oil grade by IJEC classification. Golden Quality means that the oil was recovered using the expeller pressing procedure and that it has not been further treated to remove any color or odor, i.e. naturally present. This type is the most popular jojoba oil use in bottling for retail sale. Jojoba oil extraction has been carried out of a single pressing method which made up to 44% of the weight of the seeds. It should be mentioned that the amount of the extracted oil was not the maximum oil yield that can be obtained from jojoba seeds. The maximum yield from the seeds was not one of the aims of this study.

The primary objective of the first experiment was to analyze and examine any differences between the Mesarya jojoba oil and those harvested across the world. The extracted jojoba oil samples recovered in this experiment were sent to a number of accredited laboratories for chemical and physical tests required by IJEC quality standards and the results are shown in Table 3.1, 3.2, 3.3. Table 3.1 illustrates the fatty acid compositions of the jojoba oil samples produced from the seeds of jojoba shrubs grown on the Mesarya Plain in TRNC, the Ismailia Desert in Egypt, Negev Desert in Israel, Arizona Desert in the USA and the jojoba plantation of the Jordanian University of Science and Technology (JUST). Table 3.2, illustrates the compositions of wax esters of the jojoba oils produced from the seeds grown on the Mesarya Plain in TRNC, the Ismailia Desert in Egypt, Negev Desert in Israel, Arizona Desert in the USA. Table 3.3 illustrates the various properties of the jojoba oils produced from the seeds grown on the Mesarya Plain in TRNC, Negev Desert in Israel (Dr. Baumann International, 2018), Sonora Desert of Mexico (Lizarde et al., 2017) and Association of Rajasthan Jojoba Plantation and Research Project (AJORP) of India (Ahmad, 2017). Lubricity analyses were carried out at accredited laboratories in Turkey and the results are shown in Table 3.4, 3.5. Various jojoba oil tests like, density, viscosity and corrosivity were carried out at the Mechanical Engineering Department Laboratory in Near East University and results are shown in Table 3.6, 3.7, 3.8

Table 3.1: Fatty acid compositions (%) of the jojoba oil of Mesarya Plain in TRNC and from around the world

Fatty Acid	Origin of jojoba oil							IJEC Standard 1998 – AOCS[h]
	Mesarya Plain			Negev Desert[d]	Ismailia Desert[e]	JUST[f]	Arizona Desert[g]	
	TRNC[a]	Butal[b]	Ege Uni.[c]					
C16:0 Palmitic acid	3.0	1.6	1.88	3.0 (max)	1.6	0.57	1	≤3.0
C16:1 Palmitoleic acid	0.9	0.05	0.07	1.0 (max)	0.1	0.09	0.4	≤1.0
C18:0 Stearic acid	0.8	0.05	0.45	5.0 (max)	0.9	0.02	0.1	-
C18.1 Oleic acid	18.5	14.2	12.2	5.0 - 15.0	14.5	4.84	11	5.0 -15.0
C20:0 Arachidic acid	-	0.05	0.12	3.0 (max)	0.2	0.05	0.1	-
C20:1 Eicosenoic acid	-	36.8	71.0	65.0 - 80.0	60.0	37.61	70	65.0 - 80.0
C22:0 Behenic acid	-	0.05	0.17	1.0 (max)	0.30	-	0.2	≤1.0
C22:1 Erucic acid	-	18.0	11.68	10.0 - 20.0	11.8	21.68	13	10.0 – 20.0
C24:1 Nervonic acid	-	17.3	1.14	3.0 (max)	1.6	0.2	1	≤3.0
Other fatty acids	-		-	3.0 (max)	1.0 (max)	21.68	1.0 (max)	≤3.0

[a] Ministry of Health, Directorate of the state laboratory office of TRNC.
[b] Ege University Center for R & D and Pharmacokinetic Applications R & D Laboratories, İzmir, Turkey.
[c] Tubitak Bursa Test and Analysis Laboratory, BUTAL, Bursa, Turkey.
[d] Wisniak, 1987; Baumann, 2018
[e] El-Mallah, and El-Shami, 2009
[f] Al-Qizwini et al., 2014
[g] Miwa, and Rothfus, 1979
[h] Uniform standards of jojoba oil quality on IJEC, 2018

The fatty acid composition of Mesarya Plain jojoba oil is given together with the others and also the IJEC standard in Table 3.1. As can be seen the C20:1 called eicosenoic acid is the major component in all jojoba oils in the table and the content of this acid of all jojoba oils were in the limits of the IJEC standard except jojoba oil produced by JUST. The eicosenoic acid followed by erucic and oleic acids in all jojoba oils. It is expected that the fatty acid compositions of jojoba oil would vary significantly depending on the soil and climate where the jojoba shrub is grown, as well as when it is harvested and how the oil is processed.

Table 3.2: Wax esters compositions (%) of the jojoba oil of Mesarya Plain in TRNC and from around the world

Wax ester	Origin of jojoba oil				IJEC Standard 1998 – AOCS[e]
	Mesarya Plain[a]	Negev Desert[b]	Ismailia Desert[c]	Arizona Desert[d]	
C40	28.2	26.0-37.0	30.1	30.5	26.0-34.0
C42	46.3	44.0-56.0	51.1	49.5	44.0-56.0
C44	8.0	8.0-13.0	10	10	8.0-12.0
C46	0.5	3.0 (max)	1.1	1.3	0-3

[a] Ege University Center for R & D and Pharmacokinetic Applications R & D Laboratories, İzmir.
[b] Wisniak, 1987; Baumann, 2018
[c] El-Mallah, and El-Shami, 2009
[d] Miwa, and Rothfus, 1979
[e] Uniform standards of jojoba oil quality on IJEC, 2018

Wax ester profiles of the Mesarya Plain and the other three jojoba oils are given in Table 3.2. The wax esters C40 and C42 were the major components in all jojoba oils, and fall within the range of the IJEC standard (IJEC, 2018). It is noticeable in both tables that the fatty acid and wax ester profiles of the jojoba oils of different regions do not seem to be influenced by geographic location since Arizona Desert is located in a different continent.

Table 3.3: Some physical and chemical properties of the jojoba oil of Mesarya Plain in TRNC and from around the world

Property [Unit]	Origin of jojoba oil								IJEC Standard, 1998 – AOCS[j]
	Mesarya Plain					Negev Desert[f]	Sonora Desert[g]	AJORP[h]	
	NEU[a]	Tüpraş[b]	Vitsan[c]	Ege[d]	Butal[e]				
Specific Gravity *[g/cm³]* *TS4959*	0.862 *(25⁰C)*	-	-	-	0.857 *(20⁰C)*	0.863-0.873	0.86	0.867	0.86-0.87 (AOCS Cc 10 a)
Refractive Index	-	-	-	1.466	1.466	1.465-1.467	1.46	-	1.45-1.47 (AOCS Cc 7 25)
Saponification Value *[mg KOH/g]*	-	-	-	92.6	96	88.0-98.0	-	86	88-96 (AOCS Cd 3-25)
Viscosity at 40ºC *[mm²/s]*	25.41	24.66	24.55	24.72	24.55	-	26.60	24.61	(ASTM D 445)
Viscosity at 100 ºC *[mm²/s]*	6.496	6.417		6.45	-	-	-	6.40	(ASTM D 445)
Acid Value *[mg KOH/g]*	-	-	-	-	0.27	1.0 (max)	0.39	0.54	1.0 (max) (AOCS Ci 4-91)
Iodine Value *[gram]*	-	-	-	-	88.9	80.0-90.0	83.11	80 (IP D-84/81)	82-87/ 100 (AOCS Cd 1-25)
Peroxide Value *[meqO2/kg]*	-	-	-	-	<1	2.0 (max)	2	7.2 (ASTM D - 1832 – 99)	2.0 (max) (AOCS Cd 8-53)
Lubricity µm (25⁰C) ISO 12156-1	-		166	183	166	-	-	-	380µm (max)
Lubricity µm (60⁰C) ISO 12156-1	-	416	-	-	-	-	-	-	450µm (max)
Corrosivity ISO 2160	1A	-	-	-	1A	-	-	-	-

[a] Mechanical Engineering Department Laboratory. Near East University, [b] Tüpraş Laboratory, Türkiye Petrol Rafinerileri A.Ş-Batman, [c] Vitsan Laboratory Gözetim mümessillik ve Ticaret A.Ş, [d] Ege University Center for R & D and Pharmacokinetic Applications R & D Laboratories, İzmir, [e] Tubitak Bursa Test and Analysis Laboratory BUTAL, Bursa/Turkey, [f] Wisniak, 1987; Baumann, 2018, [g] Lizarde et al., 2017, [h] Ahmad, 2017, [j] Uniform standards of jojoba oil quality on IJEC, 2018

Physical and chemical properties of various jojoba oils of different origins examined in Table 3.3 belong to the Mesarya Plain of TRNC, wild jojoba shrubs in the Sonora Desert of Mexico, (Lizarde et al., 2017) Negev Desert of Israel (Wisniak, 1987; Dr. Baumann

International 2018) and Association of Rajasthan Jojoba Plantation and Research Project (AJORP) of India (Ahmad, 2017). Viscosity values of Mesarya and AJORP oils appeared to be the same at 40℃ and 100℃ although they were measured using two different standards. The test results are given in a range instead of a single value for each parameter in the case of Negev Desert jojoba oil since they were not obtained from a single batch as other samples. In spite of very different geographic locations, local conditions and the different standards followed in the tests, a general uniformity and compatibility with the IJEC quality standard are apparent. Hence, the IJEC quality standard (IJEC, 2018) can be reached in all parts of the world including the Mesarya Plain. On the other hand, good planning and management are required to increase the jojoba seed yield in the field. Nowadays a company in TRNC is manufacturing and marketing the jojoba oil from the seeds harvested in Mesarya Plain under a Brand name Zeces (Figure 3.18). At present, 30 ml of this grade of oil is sold around 70 Turkish Lira in Nicosia, 60 Turkish Lira in İstanbul, i.e. 12 USD.

3.3.1 Lubricity analysis of jojoba oil

As mentioned above, lubricity is an important parameter especially in metal industry. Lubricity is not a material property and cannot be measured directly. This value indicates how much wear is caused to a surface by a given wear object in a given time. This value can only be determined by various test methods which are performed to quantify the lubricant's performance for a system. Scuffing Load Ball on Cylinder Lubricity Evaluator (SLBOCLE) and High Frequency Reciprocating Ring (HFFR) (Figure 3.5) methods are the two most commonly used tests for lubricity (Wielling et al., 2002). The jojoba oil samples extracted from the seeds in Mesarya Plain were delivered to different laboratories in Turkey for lubricity tests according to the TS EN ISO 12156-1 (ASTM D 6079) standards. In this test method, the lubricity of the jojoba oil is evaluated by the wear scar in microns, produced on an oscillating ball from contact with a stationary disk submerged in the oil sample and rubbed at 25°C and 60°C against each other for 70 minutes at a rate of 50 Hz. The dimensions of the major and minor axes of the wear scar can be measured and recorded as shown in Figure 3.6. The wear scar generated in the HFFR test was captured using the microscope digital camera as illustrated in Figure 3.7.

Test conditions of HFFR method are given in Table 3.4 and the procedure of the method can be given briefly as follows:

- Oscillating ball is selected.
- Test disk is replaced in the frame.
- Test oil is poured until the disk submerged in the oil.
- Circular and reciprocating motions are applied on the disk by test ball.
- The wear scar diameter is measured in microns and evaluated with the standards.
- The lubricity of the oil is evaluated according to TS EN ISO 12156-1standarts.
- Wear scar diameter (WSD) is calculated as WSD = (M +N)/2 where M and N are the dimensions of major and minor axis in µm (Figure 3.6)
- Acceptable sufficient lubricity (Schumacher et al.,2003)
  Wear scar diameter (WSD) at 25°C less than 380 µm,
  Wear scar diameter (WSD) at 60°C less than 450 µm

The results of the experiments conducted according to TS EN ISO 12156-1 are given in Table 3.5. It was stated in EN ISO 12156-1 that the acceptable and sufficient lubricity of the oils (WSD) at 25°C is less than 380 µm, and at 60°C it is less than 450 µm. Hence, the lubricity value of jojoba oil extracted from the seeds in Mesarya Plain was satisfactory since lubricity values were below 380 µm and 450 µm.

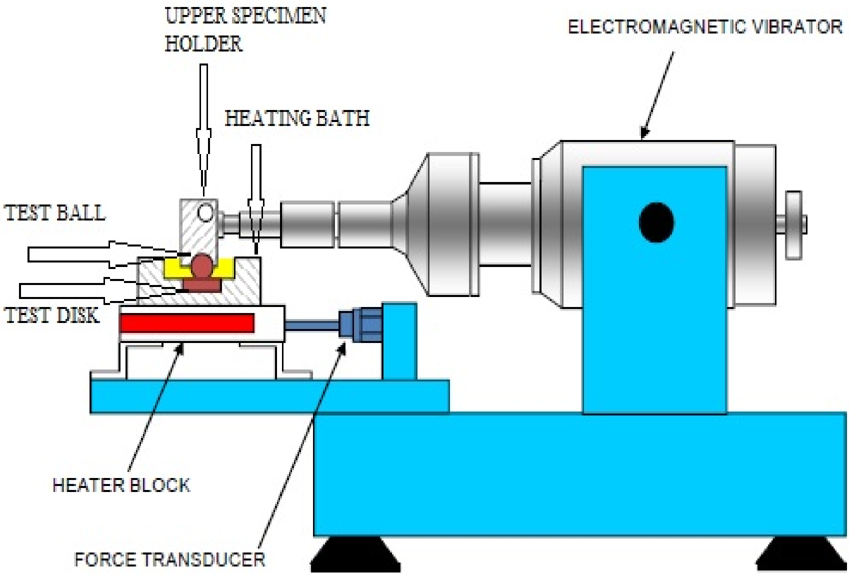
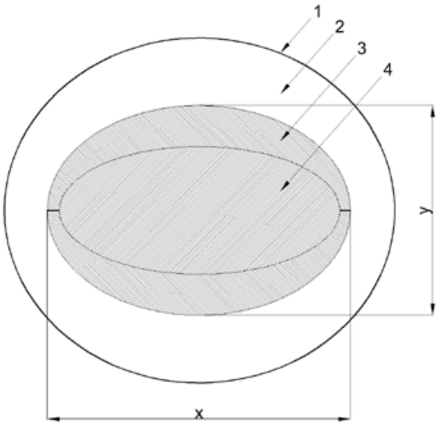


Figure 3.5: Schematic diagram of HFRR.

Table 3.4: HFRR test conditions (TS EN ISO 12156-1)

Test Conditions	Values
Fluid volume (ml)	2.0±0.20
Fluid temperature (°C)	25±2, 60±2
Bath surface area (cm^2)	6.0±1.0
Frequency (Hz)	50±1
Stroke length (mm)	1.0±0.02
Applied load (g)	200±1
Test duration (min)	70±0.1
Specimen steel	AISI E-52100
Ball diameter (mm)	6.0 dia ball upper
Surface finish (ball)	<0.05µm Ra
Hardness (ball)	58-66 Rockwell C
Surface finish (plate)	<0.02µm Ra
Hardness (plate)	190-210 HV 30
Ambient temperature (°C)	28
Ambient relative humidity	50%



1: Test ball (not to scale)

2: Unworn area

3: Less distinct worn area

4: Worn area

Figure 3.6: Example of a wear scar with an indistinct boundary

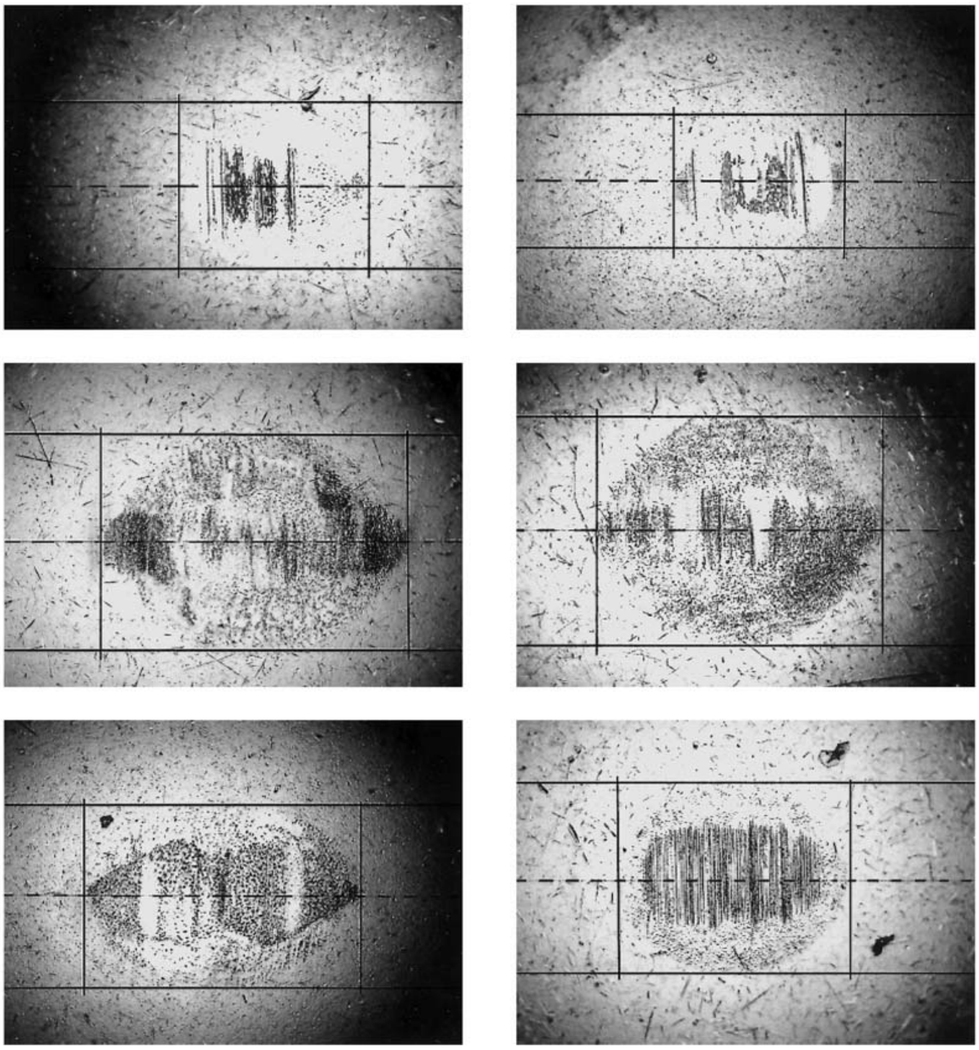


Figure 3.7: Examination of wear scars under the microscope.

Table 3.5: The results of lubricity tests and the limits given in TS EN ISO 12156-1

Laboratories	Test Temp. (°C)	Result (μm)	Limit (μm)
Tüpraş[a]	60	416	< 450
Vitsan[b]	25	166	< 380
Ege University[c]	25	183	< 380
Butal[d]	25	166	< 380

[a] Tüpraş Laboratory, Türkiye Petrol Rafinerileri A.Ş-Batman; [b] Vitsan Laboratory Gözetim mümessillik ve Ticaret A.Ş; [c] Ege University Center for R & D and Pharmacokinetic Applications R & D Laboratories, İzmir; [d] Tubitak Bursa Test and Analysis Laboratory BUTAL, Bursa/Turkey

3.3.2 Density analysis of jojoba oil

The density of a substance is an important physical characteristic and is the measure of the mass per unit of volume. Hydrometer is an instrument used to measure the specific gravity (or relative density) of liquids, that is the ratio of the density of the liquid to the density of water. The measurement of density with Hydrometer (ISO 3675) presented in Figure 3.8 schematically, is a simple and fast method. It is made from glass and consists of a cylindrical tube and a bulb weighted with mercury or lead shot to make it float upright. The jojoba oil extracted in Near East University left for rest in three days at room temperature (22°C) in laboratory and followed by measuring the densities in different temperatures. The liquid bath was filled with water enough to submerge the test tube and placed on the flat heater (Figure 3.9). Test tube is filled up enough with jojoba oil sample. Thermocouple was placed in the test bath to monitor the temperature and adjusted to the required temperature before switched on the system. The jojoba oil is poured into a long cylindrical graduated glass container and the hydrometer is gently lowered into the oil until it floats freely. The value is noted at where the oil surface matches up with the scale of the hydrometer. This value is the density of the jojoba oil in gr/ml.

The results obtained are given in Table 3.6 for various temperatures and plotted in Figure 3.10. It can be stated that the density of jojoba oil is sensitive to temperature and decreases linearly with increasing temperature. Heating the jojoba oil to a temperature higher than 50°C is sufficient to ensure that density is below 0.84 g/ml corresponding to inferior density limit for biodiesel in diesel engines by the EN14214:2012 (European Standards (2012). Consequently, the reduction in density in the temperature range, (15–84°C) is less than 5%.

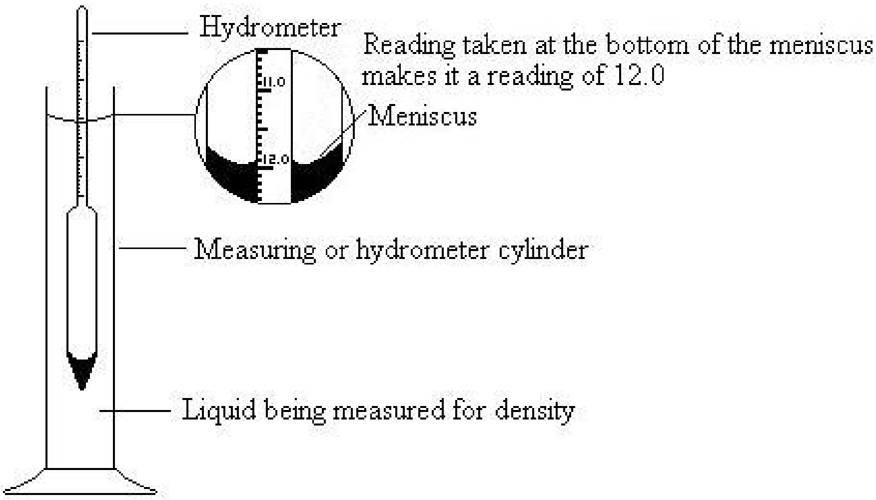


Figure 3.8: Hydrometer.

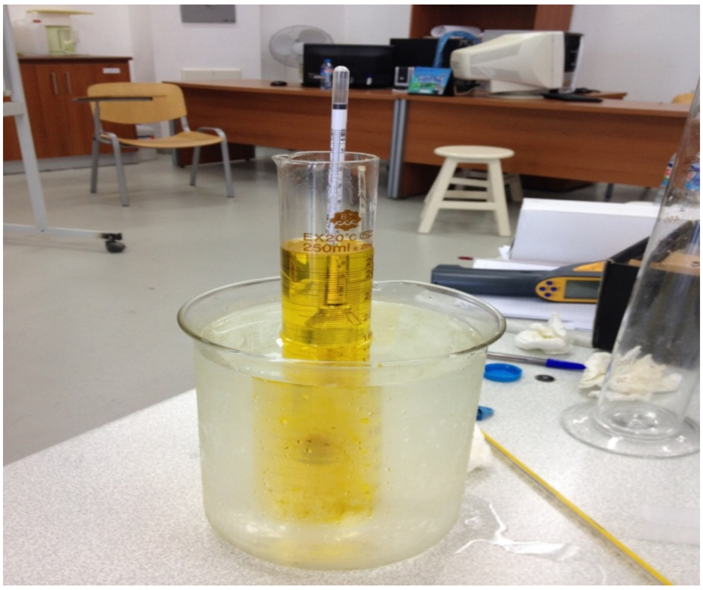


Figure 3.9: Density measurement set-up

Table 3.6: Density of jojoba oil extracted at various temperatures

Temperature (°C)	Density (g/ml)
15.00	0.864
25.00	0.862
38.00	0.857
46.60	0.851
55.66	0.845
64.60	0.839
74.90	0.833
84.40	0.826

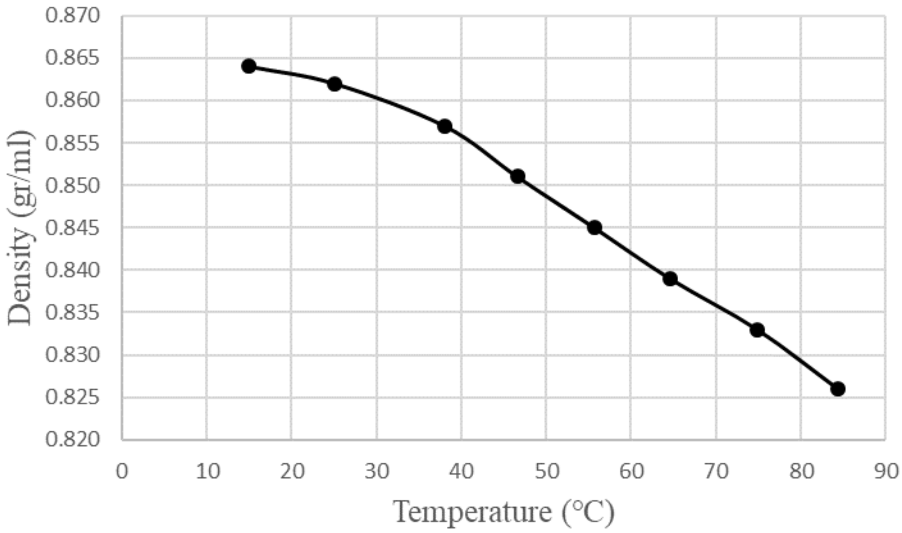


Figure 3.10: Variation of density of present jojoba oil with temperature

3.3.3 Corrosivity test of jojoba oil:

Corrosion is the disintegration of a material as it reacts with other material when they come into contact. However, the corrosion extension effects the material ions depending on its oxidation potential and various prevailing conditions; i.e., temperature, moisture content etc. (Wikipedia, 2019). The test method for measuring the corrosivity of fuels and oils is copper strip tarnish test method according to the ASTM D130 standards. Test method covers the determination of the corrosiveness to copper of aviation gasoline, automotive gasoline, cleaner's solvent, diesel fuel, lubricating oil and other oils. Since the copper strip tarnish test method is simple, it has been utilized to determine the corrosiveness of jojoba oil in the Mechanical Engineering laboratory of Near East University.

Three copper strips specimen were prepared for the experiment. The materials of the specimen strips were 99.7% purity hard-temper cold-finished copper with dimensions of 75 x 12.5 x 2 mm. Sulfur-hydrocarbon solvent (isooctane) of minimum 99.75% purity was used as wash solvent.

The copper strips were prepared in the workshop of Mechanical Engineering Department. A surface treatment was applied to obtain a bright, smooth and scratch-free surface before applying the immersion process. Various types of sandpapers were used for surface grinding and polishing. The grinding processes performed by clamping the copper strips on MSV (Multi strip vise for holding the test strips) and rubbing in the direction of the long axis of the strips shown in Figure 3.11 with sandpapers. The grinded and polished specimens were washed up by immersing the strips in wash solvents then dried with fresh pads of cotton. It is worth to note that to prevent possible surface contamination of the copper strips disposable gloves should be worn during polishing.

The strips were ready for next stage, namely immersion process. The liquid bath was filled with water enough to submerge the test tube. The test tubes were filled with 30 ml of jojoba oil samples such that the level of the oil would be at least 5 mm above the copper strip. The copper strips were immersed into the tubes containing oil samples and closed with vented stoppers. Thermocouples were placed in the test bath to monitor the temperature and fixed to stand above the bottom surface of the bath. The flat plate heater adjusted to 50℃ and switched on to heat the bath for three hours (Figure 3.12). At the end of the heating period the strips were removed from the tubes washed and the color and tarnish level assessed against the ASTM Cooper Strip Corrosion Standards as seen in Figure 3.13. The copper strips and standard strip plague were placed on a white A4 size paper in such a manner that light can reflect from the strips at an angle of approximately 45^{o} for better comparison as described in ASTM D-130 (ASTM International, 2019). The specimen strips were identified according the ASTM Cooper Strip Corrosion Standards as seen in Figure 3.14 and rated on a scale of slight tarnish from 1a-1b to corrosion 4a-4c as explained in Table 3.7.

Figure 3.11: Polishing of copper strip by using fine grain size sandpaper

Figure 3.12: Copper strip in jojoba oil heated for three hours in a hot water bath

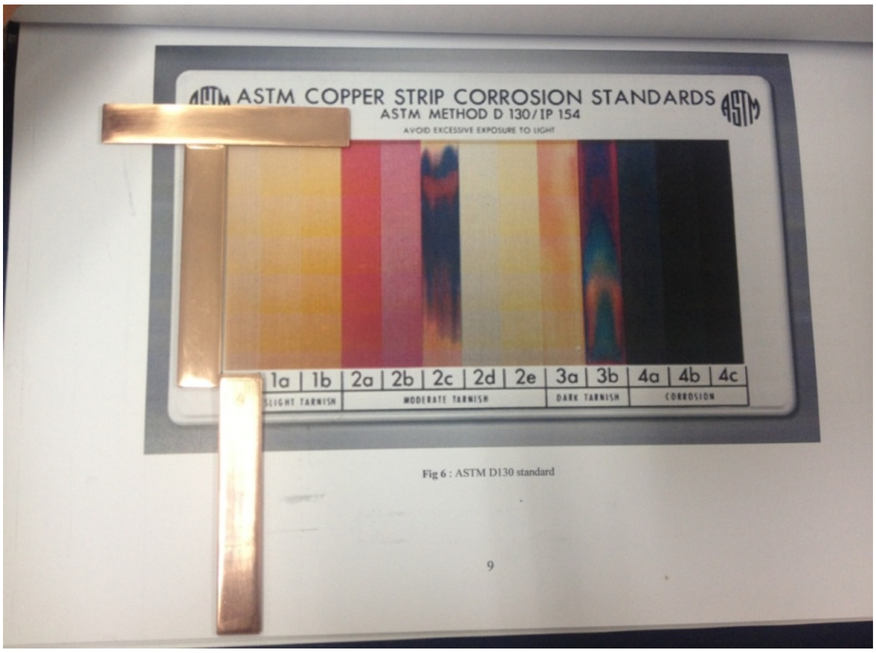


Figure 3.13: Comparison test of the copper strip with corrosion standards plaque

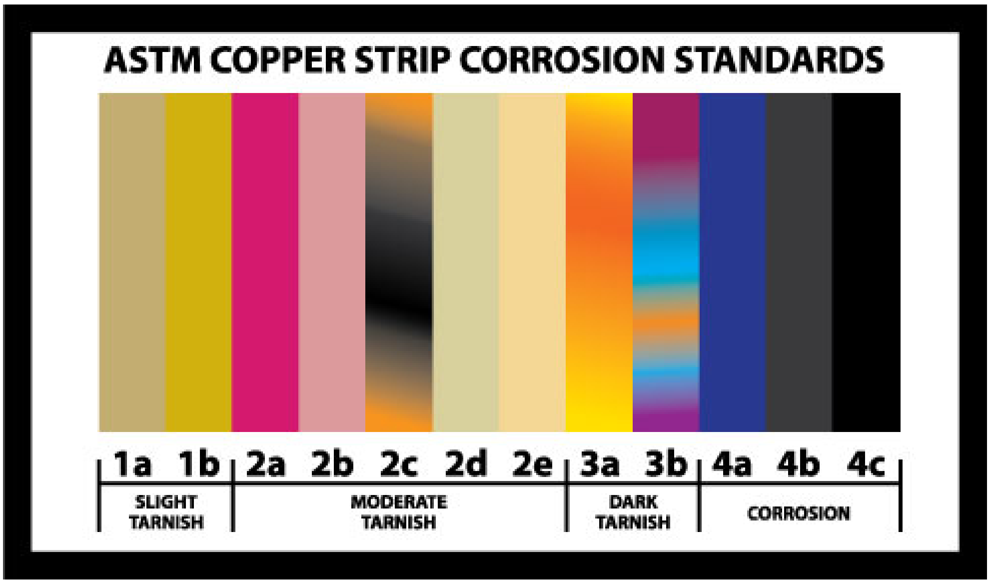


Figure 3.14: Reproduction of the ASTM copper strip corrosion standards plaque

The specimen visually inspected, compared and identified according to the ASTM D-130/IP 154 standard as shown in Figure 3.13. The samples identified as class 1a, i.e., light orange color slightly tarnished same as freshly polished strips hence the jojoba oil is almost a non-corrosive oil.

Table 3.7: Reproduction of the ASTM Copper Strip Corrosion Standards

Class	Designation	Description
1	Slight Tarnish	1a: Light orange, almost the same as the finely polished strip 1b: Dark Orange
2	Moderate Tarnish	2a: Claret red 2b: Lavender 2c: Multicolored with lavender blue and/or silver overlaid on claret red 2d: Silvery 2c: Brassy or gold
3	Dark Tarnish	3a: Magenta overcast on brassy strip 3b: Multicolor with red and green showing no gray
4	Corrosion	4a: Transparent black, dark gray or brown with peacock green showing 4b: Graphic or lusterless black 4c: Glassy or black

3.3.4 Viscosity test of jojoba oil

Fluidity, i.e. the reciprocal of viscosity, is a very important feature of liquids such as oil water and fuel. The value of the fluidity can be explained by measuring the viscosity of the liquid which is known as the resistance to flow. Viscosity is an important feature for many areas in the industry (oil, grease, printing ink, paint, polymer, liquid food stuff etc.).

Lubrication is a very critical process in industry. Main parameter which plays a fundamental role in lubrication process is the viscosity of the lubricant, i.e., oil. Viscosity value of the oil can be affected from temperature and pressure however, viscosity value decreases with high temperature and fluidity of the oil increases. Jojoba oil is viscous by nature as the product is a wax not liquid. Therefore, its viscosity is high relative to other oils and this property is attractive to its use in cosmetics application and as a lubricant in industry.

To determine the viscosity samples Ubbelohde viscometer was used. It was chosen because of its wide known application and accuracy. Figure 3.15 shows an illustrated diagram of the experimental set-up for viscosity measurement and illustrated diagram at Ubbelohde viscometer is given in Figure 3.16. With reference to Figure 3.16, Ubbelohde viscometer consists of a capillary tube (1), venting tube (2) and the filling tube (3), the capillary (7) with the measuring sphere (8), the pre-run sphere (9) and reference level vessel (5). Above and below the measuring sphere (8) timing marks M1 and M2 are printed. These marks not only define the flow-through volume of the sample, but also the mean hydrostatic head (h). The capillary ends in the upper part of the reference level vessel (5). The sample runs down from the capillary (7) as a thin film on the inner surface of the reference level vessel (5). Time of flow between M1 and M2 will be recorded in second then used to calculate the kinematic viscosity in mm^2/s using the equation,

$$\nu = K\left(t - y\right) \qquad 3.1$$

where;

K is the calibration constant of value 0.08947 mm^2/s, t is the time measured in seconds and y is the correction factor provided by the manufacturer. Table 3.8 shows the results obtained.

1: Silicone Oil (at 40˚C)

2: 3000ml Standard Beaker / Oil Bath

3: Capillary Holder

4: Thermometer

5: Capillary Viscometer (Ubbelohde)

6: Electromagnetic mixer

7: Electromagnetic plate

8: Jojoba oil

Figure 3.15: Experimental set-up for viscosity measurement

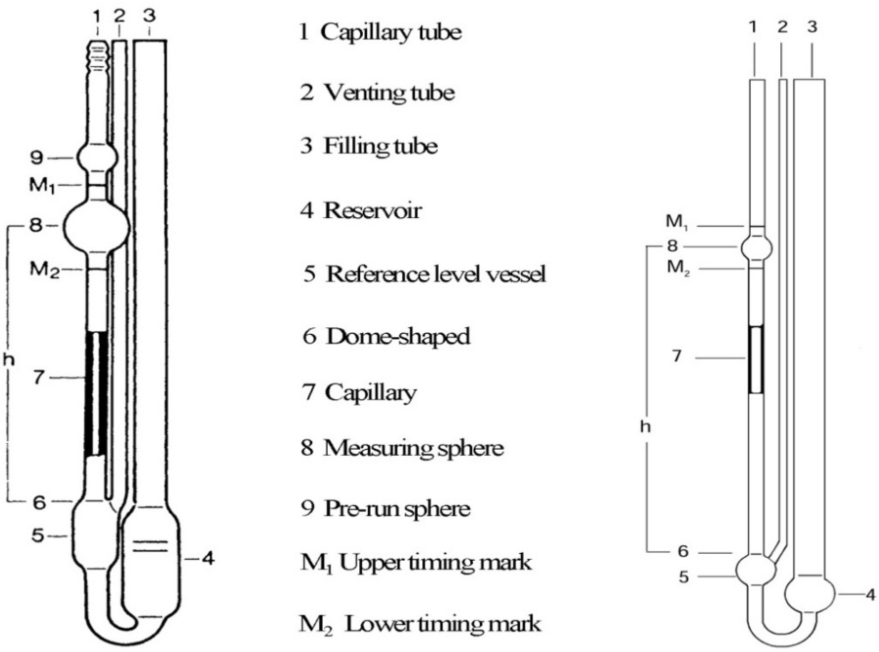


Figure 3.16: Illustrated diagram of Ubbelohde viscometer

Table 3.8: Ubbelohde Viscometer technical specifications and kinematic viscosity values of jojoba oil

Test no	Temp.℃	Time (s)	K	Type no.	Capillary no.	Viscosity (mm^2/s)
1	40℃	290.7	0.08947	525 20	II	25.26
2	40℃	292.7	0.08947	525 20	II	25.47
3	40℃	298.2	0.08947	525 20	II	25.50
Average	40℃	294.6	0.08947	525 20	II	25.41
4	100℃	-	0.08947	525 20	II	6.496

Figure 3.17: The first commercial jojoba oil from the seeds in Mesarya Plain.

CHAPTER 4

OPTIMIZATION OF JOJOBA OIL PRODUCTION USING TAGUCHI METHOD

4.1 Taguchi Method.

The Taguchi method is a statistical experiment design method developed by Japanese scientist Genichi Taguchi to improve the quality of manufactured goods. Furthermore, as a philosophy it foresees quality in design and process (Genichi and Clausing, 1990). The Taguchi approach is an experimental design that seeks to minimize variability in the product and process by selecting the optimal combination of levels of controllable factors against the factors that create variability and cannot be controlled (Canıyılmaz, 2001). Optimum working conditions to be determined at the end of the experimental study should be able to give the same or close performance values at different working environment or at different times.

Taguchi offers a method with minimum number of experiments to make the effect of selected parameters on the process more efficient. Roy (2001) summarized briefly the standard Taguchi Design of Experiment (DOE) procedure as follows:

- Definition of the quality characteristics to be optimized: It is simply the response variable of the output or process. In this experiment quality characteristic is chosen as either the amount (yield) of jojoba extracted or viscosity of jojoba oil.
- Identification of the control parameters and their alternative levels: These control parameters affect the process directly or indirectly such as size of seed, humidity or process temperature/pressure which are adjustable at different level.
- Experiment design of the matrix: Taguchi offers many standard orthogonal arrays to reveal the factors that degrade control parameters. Those orthogonal arrays describe the number of experiments that must be performed using different levels of control parameters chosen and the effect of the noise factors on the quality characteristic.

- Conducting the matrix experiment: Experiments are conducted by using the chosen orthogonal array and results are recorded.
- Analyzing the data and determination of the optimum levels: To analyze the results of the experiments and to determine the effect of control parameters, the Taguchi method uses a statistical measure of performance called signal to noise (S/N). The S/N ratio is the ratio of the mean (signal) to the standard deviation (noise) and could be represented by different ways such as; Smaller-the-better, Nominal-the-best, Larger-the-best

4.2 Design of Experiment and Selection of Levels for Control Factors

This study was emphasized on the optimization of the jojoba oil production yield in a screw expeller followed from Figure 4.1 while retaining the oil quality, i.e. kinematic viscosity. Four control factors, namely seed size, seed humidity level, seed temperature and residual discharge opening shown in Table 4.1 were considered as the factors influencing the yield of jojoba oil. Three levels were considered for each control factors. Degrees of freedom (DOF) of the system were calculated as follows to choose an appropriate orthogonal array:

Degree of Freedom for each factor (DOF): Number of levels -1 = 3 – 1 = 2

Total DOF: 1 for Mean Value + Σ DOF of control factors = 1 + (2x4) = 9

Four independent variables with three levels for each variable required 81 runs (i.e. 3^4) in the traditional factorial design, however, the number of experiments to be run were reduced to 9 when Taguchi design of experiment was applied. The screw expeller was operated nine times with the combinations of the different levels of the influencing control factors as given in Table 4.2. Hence, Taguchi L-9 orthogonal array was convenient for the current survey reducing the number of necessary experiments to 9.

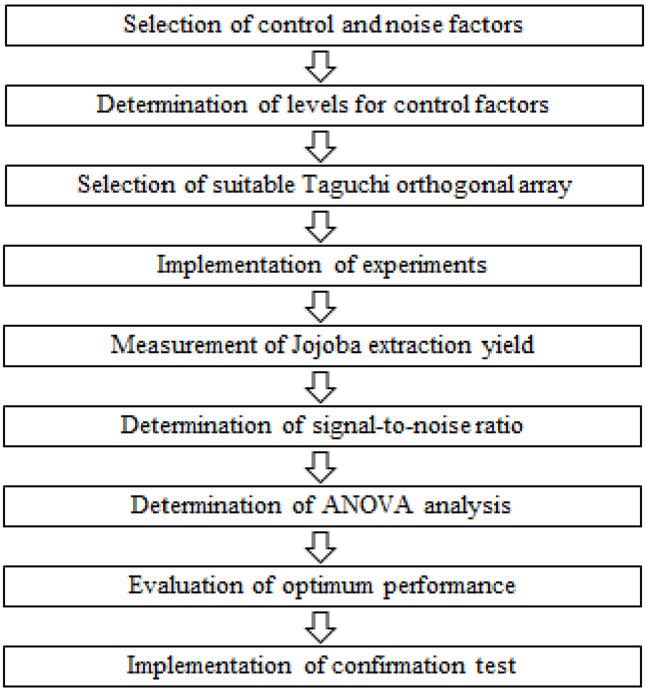


Figure 4.1: Taguchi design of experiment procedure

Table 4.1: Three-levels of the four control factors in the extraction of jojoba oil

Control Factors		Levels		
		1	2	3
A	Seed size	Whole	Half	Quarter
B	Seed humidity level	No drying	Half dried	Fully dried
C	Seed temperature (°C)	22	40	60
D	Residual discharge opening	1/4 open	1/2 open	Fully open

Table 4.2: The orthogonal array design L-9 (3^4) experiment of the study.

Experiment No.	Control factors and levels			
	A	B	C	D
1	1	1	1	1
2	1	2	2	2
3	1	3	3	3
4	2	1	2	3
5	2	2	3	1
6	2	3	1	2
7	3	1	3	2
8	3	2	1	3
9	3	3	2	1

4.3 Experimental Procedure

5kg of jojoba seeds were collected from the local jojoba shrubs in Mesarya Plain. After washing, the seeds were sun dried for two days where the temperature and humidity were varied between 21-23℃ and 56-63 % respectively, then prepared for pressing in a screw expeller. The shape of the jojoba seed is oblong to oval as can be seen in Figure 4.2a. The dimensions of the seeds were measured with 1/20 Vernier caliper (ROHS NORM 2002/95/EC) in mm and weighed with an electronic scale, Figure 3.3 (a). Ten seeds were used to obtain the average dimensions and weight of jojoba seed shown in Table 4.3.

Table 4.3: Physical measurements of a whole Jojoba seed used in the current experiments

Seed No.	1	2	3	4	5	6	7	8	9	10	Ave.
Diameter (mm)	9.87	8.78	8.88	9.38	8.00	9.17	9.08	8.99	8.98	9.10	9.02
Length (mm)	15.64	13.60	14.47	15.64	15.83	14.51	15.48	15.52	14.65	13.73	14.90
Weight (grams)	0.699	0.488	0.560	0.673	0.555	0.578	0.643	0.611	0.571	0.516	0.589

The control factors and their levels given in Table 4.1 were maintained as follows:

4.3.1 Seed size

The three levels of seed size were sectioned and 300 g jojoba seeds were prepared for each level without removing their shells as seen in Figure 4.2. The half and quarter size jojoba seeds were prepared by using a sharp knife.

(a) Whole seed

(b) Half seed

(c) Quarter seed

Figure 4.2: The three levels of seed sizes of jojoba that feed into the screw expeller.

4.3.2 Seed humidity level

Three levels of the seed humidity were considered. A drying method using an oven according to ISTA standards (ISTA, 1996) was used to determine the moisture content of the seeds before pressing. 100 g seeds were placed in the oven (ZILAN-Turkey 220V – 240V, 1.3 KW, 0-230 °C, 0-90 min) that was adjusted to 80°C. The seed samples were taken out from the oven, weighed and noted with 15 minutes intervals. This procedure was repeated until the weight of the seeds unchanged in successive measurements. The results are given in Table 4.4. The moisture content in each stage of drying was calculated using the relation 4.1 below,

$$H = \frac{m_b - m_a}{m_b} \times 100 \quad (4.1)$$

where, H is the moisture content in %, m_b and m_a are the masses of the seeds before and after drying respectively. The moisture content of jojoba seeds was determined to be 6.02 %. Beerens, (2007) stated that optimum moisture content of the oleaginous material is expected to be 6% to 7%.

Table 4.4: The drying period and weight of seeds during moisture removal

Time (minutes)	0	15	30	45	60	75	90	105
Weight (grams)	100	97.85	96.08	95.14	94.52	94.15	93.98	93.98

The jojoba seeds initially involving 6.02% moisture (no drying level) by their mass were half and fully dried before testing. Batches of 300 g seeds at three different humidity levels, namely no drying, half dried and fully dried levels, were fed into the screw expeller. The seeds were heated for 105 minutes for fully dry and 20 minutes for half dry conditions. After 20 minutes of drying the weight of the seeds reduced by 3.8 grams corresponding to 2.22% humidity level and considered as approximately half dried.

4.3.3 Seed temperature

The seeds were supplied at three different temperatures in to the screw expeller. First level of the seeds temperature was ambient temperature (22°C), second and third levels were 40°C and 60°C respectively. The seeds were heated in an electrical oven (1.3 KW) adjusted to the required temperatures and then taken out and directly pressed with the screw expeller.

4.3.4 Residual discharge opening

The process pressure was adjusted indirectly by controlling the residual discharge opening area which corresponded to the areas of 1/4 open (18.8 mm^2), 1/2 open (50.4 mm^2) and full open (100.48 mm^2) positions.

The oil extraction was achieved on a screw that presses the seeds against the wall of a cylindrical chamber to collect the jojoba oil through oil outlet holes at the bottom of the chamber which does not permit the passage of solid press cake. The experiments of Table 4.2 have been performed in a sequence and the extracted jojoba oil samples were left for rest for three days to allow the settlement of debris in it. Each experiment was repeated three times to account for the variations that may occur due to noise factors.

The percent yield of jojoba oil recovery was defined as the ratio of the mass of jojoba oil extracted to the total mass of the jojoba seeds and can be presented as follows (Rama et al., 2011)

$$Y = \frac{m_{oil\ yield}}{m_{seed}} \times 100 \tag{4.2}$$

where, Y is the percent oil yield (%), $m_{oil\ yield}$ is the mass of the jojoba oil produced and m_{seed} is the total mass of the jojoba seeds pressed.

The experiments were analyzed then optimized via the graphical method of signal to noise ratio (S/N ratio). The larger-the-best S/N ratio was used since the aim was to maximize the jojoba oil yield. The S/N ratio was evaluated using the equation below.

$$S/N\ ratio = \eta_i = -10\ log\left(\frac{1}{n}\sum_{i=1}^{n}\left(\frac{1}{y_i}\right)^2\right) \tag{4.3}$$

where n is the number of repetitions of each experiment and y_i is the yield of jojoba oil.

S/N ratio was also used to identify the control factor settings that minimize the variability caused by the noise factors. Each control parameter was considered individually and the interactions at the assigned levels were calculated by taking the average of all the S/N ratios.

Magnitude of the mean S/N ratio gives idea about which parameter and which level on that parameter has more impact on yield of jojoba oil extracted. The larger the S/N ratio will be the higher the jojoba yield. The mean S/N ratio of control parameter A, B, C and D were calculated as follows:

$$\eta_{A1} = (\eta_1 + \eta_2 + \eta_3)/3\ ; \quad \eta_{A2} = (\eta_4 + \eta_5 + \eta_6)/3\ ; \quad \eta_{A3} = (\eta_7 + \eta_8 + \eta_9)/3 \qquad (4.4)$$

$$\eta_{B1} = (\eta_1 + \eta_4 + \eta_7)/3\ ; \quad \eta_{B2} = (\eta_2 + \eta_5 + \eta_8)/3\ ; \quad \eta_{B3} = (\eta_3 + \eta_6 + \eta_9)/3 \qquad (4.5)$$

$$\eta_{C1} = (\eta_1 + \eta_6 + \eta_8)/3\ ; \quad \eta_{C2} = (\eta_2 + \eta_4 + \eta_9)/3\ ; \quad \eta_{C3} = (\eta_3 + \eta_5 + \eta_7)/3 \qquad (4.6)$$

$$\eta_{D1} = (\eta_1 + \eta_5 + \eta_9)/3\ ; \quad \eta_{D2} = (\eta_2 + \eta_6 + \eta_7)/3\ ; \quad \eta_{D3} = (\eta_3 + \eta_4 + \eta_8)/3 \qquad (4.7)$$

where for example η_{A1} is the mean S/N ratio of factor A at level 1, η_{C2} is the mean S/N ratio of factor C at level 2, etc. and η_i are the S/N ratio of the mean yield of i^{th} experiment.

To indicate the relative effect of each factor on the response, the difference between the highest and lowest average response values (Δ) for each factor was calculated and the highest difference was indicated as the first in the ranking and the lowest as the last.

Analysis of Variance (ANOVA) was also used to render the importance and percentage contribution of all process parameters on yield of jojoba oil extracted, since it is a statistical decision making tool used to perceive any differences in mean performance of the group of items analyzed taking variations in to account rather than using pure judgment the analysis was carried out based on S/N ratios data in order to determine the significance of the control factors on jojoba extraction process. The basic property of ANOVA (Lindman, 1992) is that the total sum of the squared deviation SS_T (total variation) and can be calculated as follows:

$$SS_T = \sum_{i=1}^{n} (\eta_i - \eta_m)^2 \qquad (4.8)$$

where n is the number of experiments in the orthogonal array, η_i is the mean S/N ratio for the i^{th} experiment and η_m is the mean S/N ratio of n experiments.
Variation of each factor can be calculated as

$$SS_x = \sum_{j=1}^{3} n\left[(\eta_{xj} - \eta_m)^2\right] \qquad (4.9)$$

where n is the number of experiments at level j of factor x.

The percent effect of each control factor on the jojoba extraction yield identifying the significance of process parameters can then be calculated as:

$$Contribution\ of\ Factor\ X = \frac{SS_x}{SS_T} * 100 \quad (4.10)$$

The viscosity measurements of the samples were also conducted in triplicate at 40°C using an Ubbelohde viscometer according to the EN-ISO 3140 (1994) standard designed to determine the kinematic viscosity of transparent and opaque liquids.

4.4. Results and Discussion

The results of each experiment for yield and viscosity of jojoba oil extracted can be followed in Table 4.5. The kinematic viscosity of the jojoba oil extracted with respect to eight experimental runs varied between 25.04 to 25.52 mm^2/s as seen in Table 4.5. The values were in close agreement with the literature (Allawzi et al., 1998) and close to the viscosity of the meadow foam seed oil that has been claimed as an alternative to the jojoba oil in cosmetics (Elementis Specialities, 2009). On the other hand, these values were below the viscosities of common plant oils including jatropha (34-36 mm^2/s), soybean (31 mm^2/s), cotton seed (36 mm^2/s), and sunflower (43 mm^2/s) oils (Beerens, 2007). It can be noted that the difference between the maximum and minimum values of the kinematic viscosity of jojoba oil extracted was 0.63 mm^2/s, i.e. the viscosity remained almost unaffected of the levels of the control factors utilized to increase the extraction yield.

It was found that the mean yields of jojoba oil extracted reached to (41.2%) in the experiment no. 8 whereas the lowest yields (17.3%) were observed in the experiment no. 3. The overall average yield of the experiments was calculated as 29.1%. The S/N ratios calculated for the nine sets of experiments are shown in Table 4.6. The levels of control parameters of experiment no. 8 can be chosen as the optimum since the largest S/N ratio was obtained in addition to the highest mean jojoba oil yield.

Table 4.5: Experimental data obtained using the Taguchi design

Exp. No.	Extraction Yield (%)				Kinematic viscosity (mm^2/s)			
	Run 1	Run 2	Run 3	Mean	Run 1	Run 2	Run 3	Mean
1	32.8	33.6	32.6	33.0	25.19	25.25	25.36	25.26
2	19.1	22.0	18.9	20.0	25.42	25.49	25.52	25.48
3	16.2	17.0	18.7	17.3	25.48	25.50	25.51	25.50
4	39.4	38.1	37.4	38.3	25.17	25.16	25.04	25.12
5	28.0	27.2	27.6	27.6	25.23	25.17	25.23	25.21
6	27.8	31.1	30.5	29.8	25.21	25.24	25.20	25.22
7	30.7	28.1	28.2	29.0	25.82	25.92	25.93	25.89
8	41.8	39.5	42.3	41.2	25.42	25.34	25.37	25.37
9	25.6	26.0	26.4	26.0	25.67	25.63	25.63	25.64

Table 4.6: S/N ratios of the nine experiments

Exp. No.	S/N ratio for yield	S/N ratio for kinematic viscosity
1	30.370	28.049
2	26.021	28.123
3	24.761	28.131
4	31.664	28.002
5	28.818	28.031
6	29.484	28.034
7	29.248	28.262
8	32.298	28.088
9	28.299	28.179

All of the statistical analyses in the study were conducted by Minitab Software. Mean S/N ratio for each level of the four influential parameters are summarized in Table 4.7. The main effects plot for S/N ratio of control factors is also given in Figure 4.3. It is clear that all control parameters have significant effect on response characteristic. It appears that the process temperature of the seeds was the most influential parameter on the yield of jojoba oil while residual discharge opening (process pressure) had the least effect. The second and the third influencing parameters were size of seeds and seed humidity level, respectively. The best response based on the highest S/N ratio was at level 2 (half seed) for seed size, at level 1 (no drying) for seed humidity level, at again level 1 (22°C) for seed temperature and finally at level 3 (full open) for residual discharge opening.

Table 4.7: Mean S/N ratio of control parameters and levels

Control Factors		Level 1	Level 2	Level 3	Δ	Rank
A	Seed size	27.05	29.99*	29.95	2.94	2
B	Seed humidity level	30.43*	29.05	27.51	2.91	3
C	Seed temperature (°C)	30.72*	28.66	27.61	3.11	1
D	Residual discharge opening	29.16	28.25	29.57*	1.32	4

*The best response level of control parameters

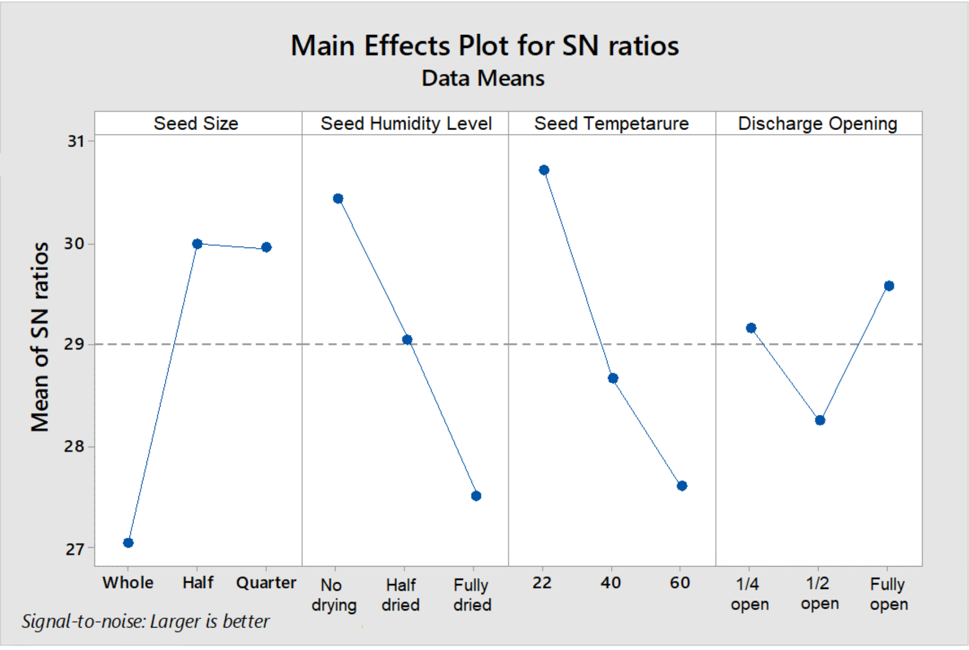


Figure 4.3: Main effects plot for S/N ratios of control factors

Table 4.8 shows the summary of ANOVA results indicating the percentage contributions of the control factors to the S/N ratio concerning the jojoba extraction efficiency. It was observed that the seed size was the most significant parameter with 35.85 % contribution on the jojoba extraction yield. Contribution of seed temperature with 31.57 % was too closed to seed size contribution and followed by seed humidity level with 26.80 % contribution. The residual discharge opening was the least influencing process parameter with 5.79 % contribution.

ANOVA and S/N ratio analyses showed difference on ranking of influential parameters. While for mean S/N ratio analysis seed temperature was the most influential parameter as depicted in Table 4.7, for ANOVA seed size had the highest contribution. It must be noted that the influence of size, humidity level and temperature of the seeds on oil yield were close to each other but higher than the influence of residual discharge opening.

The optimum levels of control parameters were determined with the aid of Minitab software and are given in Table 4.9. The jojoba oil extraction yield was predicted as 41.8 % with an S/N ratio of 32.414. The mean yield of confirmation tests was obtained as 41.5 % with an S/N ratio of 32.361 closely matching with that of theoretically predicted value.

Table 4.8: Percentage contribution of process parameters

Control Factors	% Contribution
Seed size	35.85
Seed humidity level	26.80
Seed temperature (°C)	31.57
Residual discharge opening	5.79

Table 4.9: Optimum levels of control parameters

Control Factors	**Levels**
Seed size	2 (Half seed)
Seed humidity level	1 (No drying)
Seed temperature (°C)	1 (22°C)
Residual discharge opening	3(Fully open)

4.5 Conclusions

The aim in this part of the work was to maximize the yield of jojoba oil extraction of the seeds harvested from Mesarya Plain in a screw expeller without degrading the oil quality, i.e. kinematic viscosity. The Taguchi method involving L9 orthogonal array was applied with control factors including seed size, seed humidity level, seed temperature and residual discharge opening each at three levels. It was determined that the viscosity of the extracted jojoba oil was not influenced in the experiments conducted and had an average of 25.41 mm^2/s. S/N ratio analysis showed that the seed temperature had the strongest influence on the jojoba oil recovery followed by seed size, seed humidity level and finally residual discharge opening. ANOVA is resulted with a similar order however seed size was in the first place and seed temperature in the second. It can be concluded that residual discharge opening which directly affects the process pressure during oil extraction had minor influence on maximizing the oil yield. Seed size, temperature and humidity level were the dominating control parameters. The maximum jojoba oil recovery was found when the seeds were halved, not dried but kept at room temperature (22°C) and the residual discharge opening of the expeller in fully open position. The agreement between the theoretically predicted and experimentally determined yield at the optimum conditions validated the results obtained. The yield was maximized to 41.5 % which was 12.4 % above the average (29.1 %). It may be beneficial to note that all the optimum parameters except halving the seeds are factors reducing the cost of oil extraction.

CHAPTER 5
PRODUCTION OF BIODIESEL FROM JOJOBA OIL AND TESTING

Biodiesel is an alternative fuel for diesel engines that can be manufactured from the renewable vegetable oil or animal fats. Research stated that biodiesel can be considered as a possible substitute of conventional diesel fuel. Numerous vegetable oils can be used as raw material in biodiesel production such as canola, jojoba, sunflower, safflower, soybean waste frying oil etc. (Alshanableh, 2017). Used cooking oils can also be turned into biodiesel as well as can fats and tallow. Jojoba oil that produced from its seeds is one of this oil sources for biodiesel production (Huzayyin et al., 1994). There are four primary options for production of biodiesel from oils and fats.

- Direct use and blending
- Microemulsions
- Thermal cracking (pyrolysis)
- Transesterification

Among these four different options, transesterification method (Figure 5.1) is the most commonly used method due to its simplicity and advantages. It is a chemical process that glycerol molecule is cracked and replaced with an alcohol molecule. In other word transesterification is the displacement of alcohol from an ester in a process similar to hydrolysis, except that alcohol is used instead of water. Sodium hydroxide as a catalyst and methanol or ethanol as an alcohol is used in the transesterification method. Actually, this reaction is an equilibrium reaction however a large amount of methanol is used to shift the reaction equilibrium to the right side and produce more proposed product as methyl esters, i.e., biodiesel. This process is widely used to reduce the high viscosity of triglycerides. If methanol is used in this process it is called methanolysis of triglyceride.

There are different routes for transesterification process, namely (Demirbaş, 2006):

1. Catalytic transesterification process: Oil with large amount of alcohol and catalyst.
2. Supercritical alcohol transesterification: These can also be grouped into two.
   - Non-catalytic supercritical methanol transesterification
   - Catalytic supercritical methanol transesterification
3. Biocatalysed transesterification: The process is not yet completely commercialized. It involves the use of enzymes to catalyze the transesterification process.

$$\begin{array}{lcl}
\begin{array}{l} CH_2\text{-}COOR_1 \\ | \\ CH\text{-}COOR_2 \\ | \\ CH_2\text{-}COOR_3 \end{array} + 3\,CH_3OH & \rightleftharpoons & \begin{array}{l} CH_2OH \\ | \\ CHOH \\ | \\ CH_2OH \end{array} + \begin{array}{c} R_1COOCH_3 \\ + \\ R_2COOCH_3 \\ + \\ R_3COOCH_3 \end{array}
\end{array}$$

Triglycerides Methanol Glycerol Fatty Acid Methyl-Ester (FAME)

Figure 5.1: The chemical equation of the transesterification reaction (Alshanableh, 2017).

5.1 Biodiesel Production from Jojoba Oil Using Supercritical Methanol Method

In supercritical alcohol transesterification method methyl or ethyl alcohols are usually used. Figure 5.2 shows the schematic diagram of the one step supercritical methanol method (Shiro and Minami, 2006). Generally, the reactor is charged with required amount of test oil and liquid methanol and then heated by a heating element. Electric power is adjusted to give appropriate temperature while a pressure valve is used to control the pressure in the reactor.

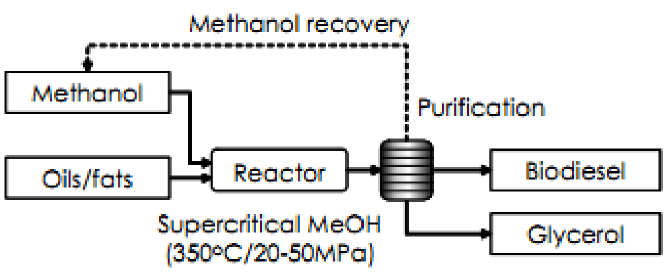


Figure 5.2: Schematic diagram of one-step supercritical methanol method

The biodiesel production using the jojoba oil produced from the seeds in Mesarya Plain was carried out by using non-catalytic supercritical methanol transesterification method. Flow chart of the process is given in Figure 5.3 and schematic diagram of the set-up used is shown in Figure 5.4. Nitrogen gas, being an inert gas makes it impossible to react with the reactants and also with the products during production. It is supplied from the nitrogen tube (1) to provide pressure. The pressure is controlled by the pressure regulator (2). A flexible high pressure hose (3) is used to make the connection to the autoclave (4). Autoclave is produced using a single piece stainless steel material and has an approximately volume of 600 cc. The external heater and insulator (5) were used to heat the contents of autoclave and minimize the heat loss to the surroundings, respectively. A picture of the reactor is given in the Figure 5.5. The heater is controlled by an AC power supply (8), as shown in Figure 5.6. The reactor used J-type (iron-constantan) thermocouple (10) to measure the temperature of the mixture in the vessel. The thermocouple is connected to the Tumtes Meter Pro 04 electronic process controller (7), shown in Figure 5.7 for digital display of the measured temperature in degrees centigrade. Hiedolph MR Hi-Tec electromagnetic stirrer (6) shown in Figure 5.8 was used to mix the methanol together with the oil. Meanwhile, the condenser (12) shown in Figure 5.9 which is a laboratory type double pipe heat exchanger, condenses the methanol using water as a cooling fluid to retrieve excess methanol.

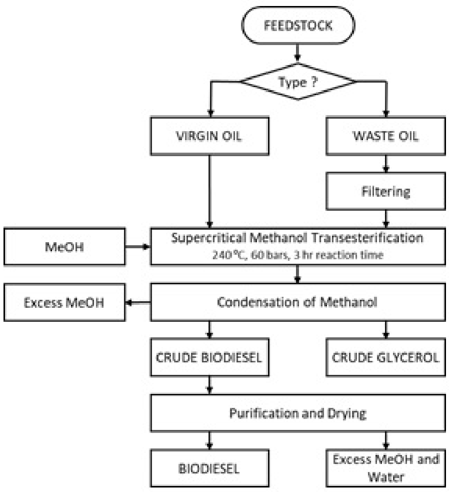
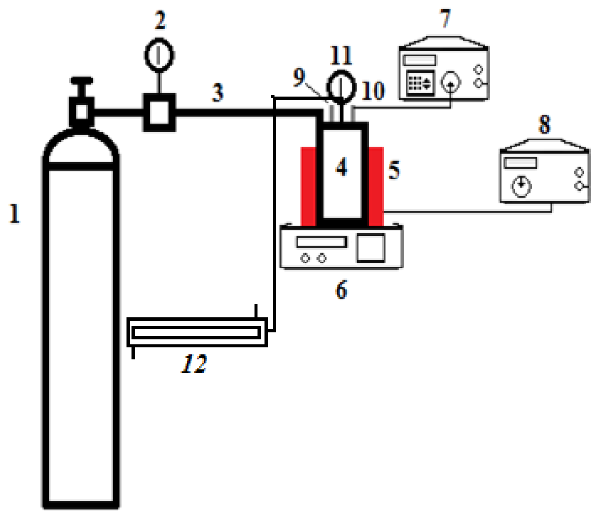
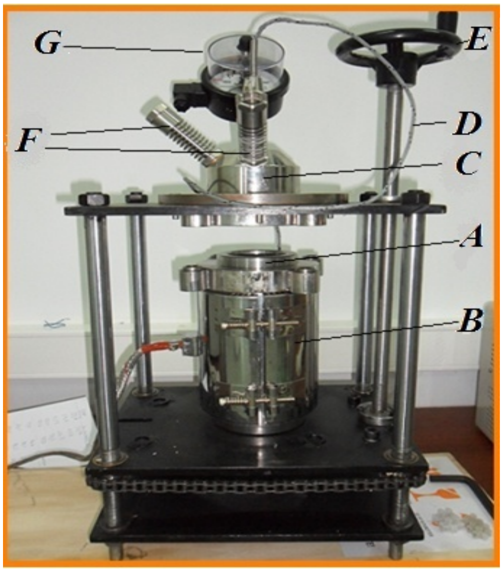


Figure 5.3: Flowchart of the current biodiesel production route via SCM transesterification



1: Nitrogen tube (200 bar)
2: Pressure regulator
3: Flexible high pressure nitrogen line
4: Autoclave
5: Heater & Insulation
6: Magnetic Stirrer
7: Electronic Processes controller
8: Power supply of heater
9: Release & Safety valves
10: J type thermocouple
11: Pressure indicator
12: Condenser

Figure 5.4: Schematic diagram of one-step non-catalytic supercritical production set-up.



A: Vessel or Autoclave (4)
B: Electrical external heater (5)
C: Hatch (vessel cover)
D: Thermocouple (10)
E: Adjusting lever
F: Extruded fins
G: Reactor pressure gauge (11)

Figure 5.5: The reactor of one-step non-catalytic supercritical method

Figure 5.6: AC power supplier controller

Figure 5.7: The electronic process controller

Figure 5.8: Electromagnetic stirrer

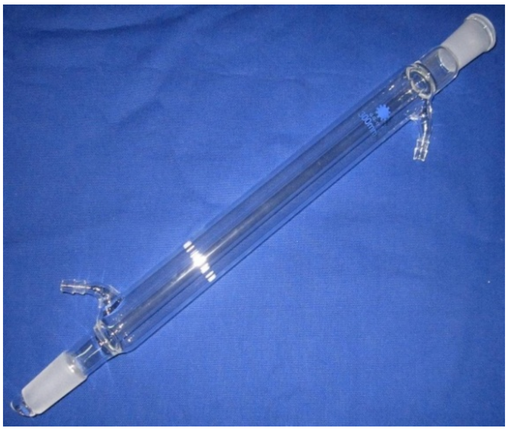


Figure 5.9: The condenser

After the transesterification the product is left to cool and separated to yield biodiesel and glycerin. It must be noted that jojoba oil is not very suitable oil for biodiesel production, because of its fatty acid compositions–shown in Table 3.6. The content of saturated fatty acids (palmitic, palmitoleic) constituted approximately 1.96% and that of unsaturated fatty acids (oleic, stearic. arachidic, eicosenoic, behenic, erucic, nervonic) was 97% and other fatty acids 1.04% of the total fatty acids. In some industries, such as biodiesel manufacturing, fatty acid composition is important because it directly determines the properties of the product. As a rule, the seeds with a high proportion of palmitic, oleic and stearic acids are suitable to produce better quality biodiesel (Vaknin et al., 2011). Actually, jojoba oil is not an oil but it is a wax. Because of its liquidity is named as oil.

5.2 Determination of Cold Flow Properties and Viscosity of the Biodiesel Produced

The cloud point and pour point are measured as described in ASTM, D 2500-09 and ASTM D 97-05, respectively. The setup mainly consists of a glass test jar, metal cylinder and a cooling bathing of alcohol. The glass jar / test tube is placed in the metal cylinder and immersed into an alcohol cooling bath that can operate at a temperature of down to -20℃. The assembly used for measuring the cloud point and pour point is shown in Figure 5.10 and called cloud point and pour point measurement setup. The corked test-tube filled (A) with desire biodiesel sample is placed in a metal cylinder (B) and then immersed into the insulated cooling bath (D) filled with alcohol (E) via the opening (C). The cooling bath is operated by a refrigeration system (F) with automatic temperature control. The sample is being checked at the require interval to observe if it has reached the cloud point or pour point. The temperature for the cloud point and pour point are recorded accordingly with a thermocouple placed inside the test-tube, close to the top for pour point and close to the base for cloud point.

ASTM D 446 requires the kinematic viscosity of biodiesel to be between the ranges of 1.9 – 6.0 mm^2/s at a temperature of 40°C. Viscosity measurements were conducted as described in Section 3.4.3

The kinematic viscosity, cloud point and pour point of the two biodiesel samples produced were measured and are given in Table 5.1. The viscosity, cloud point and pour point of the biodiesel sample are relatively high according to ASTM standards.

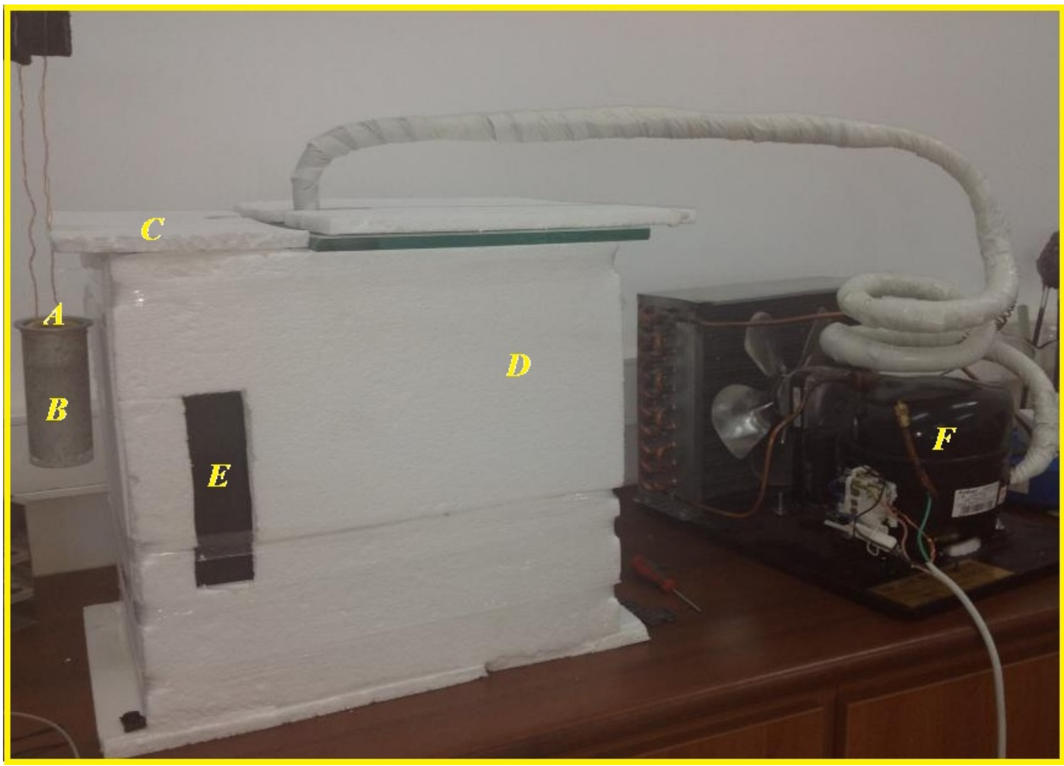


Figure 5.10: Set-up for measuring cold flow properties.

Table 5.1: Experimental test result of biodiesel samples from jojoba oil

	Kinematic Viscosity (mm^2/s) (ASTM D446)	**Cloud Point (˚C)**	**Pour Point (˚C)**
Standard Requirement	1.9 – 6.0		
Sample 1	21.228	10.0	8.1
Sample 2	21.402	9.8	8.6

5.3 Estimation of Cold Flow Properties of Biodiesel Produced from Jojoba Oil Using ANFIS Based Model

The aim of this section of the study was to evolve a process to forecast the cold flow properties namely, cloud point, pour point and cold filter plugging point of biodiesel sample produced from jojoba oil extracted from the seeds harvested in Mesarya Plain. Jojoba based biodiesel samples were produced by supercritical methanol transesterification method. Experimental data sets were traced from the literature including FA compositions of biodiesel feedstock and CFP of their resulting biodiesel product. The current ANFIS prediction models were generated using MATLAB R2015 Neuro-Fuzzy Designer

The most common nine FA components of the biodiesel feedstocks were chosen for modelling, namely lauric acid (C12:0), myristic acid (C14:0), palmitic acid (C16:0), stearic acid (C18:0), oleic acid (C18:1), linoleic acid (C18:2), linolenic acid (C18:3), arachidic acid (C20:0) and gadoleic acid (C20:1). The distributions of FA components in the data sets can be seen in Figure 5.11. Nevertheless, FA components were grouped under SFA, MUFA and PUFA to reduce the number of independent input variables for a smaller number of rules and less computational time. The equations (1) to (3) were used to evaluate total SFA, MUFA and PUFA components, i.e. ΣSFA, ΣMUFA and ΣPUFA, respectively. A total of 75 data sets were used for training and verification in the ANFIS modelling.

$$\Sigma SFA = \Sigma \text{ (wt \% Cxx:0)} \quad (5.1)$$

$$\Sigma MUFA = \Sigma \text{ (wt \% Cxx:1)} \quad (5.2)$$

$$\Sigma PUFA = \Sigma \text{ (wt \% Cxx:2)} + \Sigma \text{ (wt \% Cxx:3)} \quad (5.3)$$

Figure 5.12 illustrated the architecture of the proposed ANFIS model for the prediction of cold flow properties. The current ANFIS prediction models were generated using MATLAB R2015 Neuro-Fuzzy Designer (The MathWorks Inc 2015). An extensive number of simulations were carried out during the development of CP, PP and CFPP prediction models. The best models achieved were applied to estimate the CP, PP and CFPP temperatures of the biodiesel samples produced with in the present study.

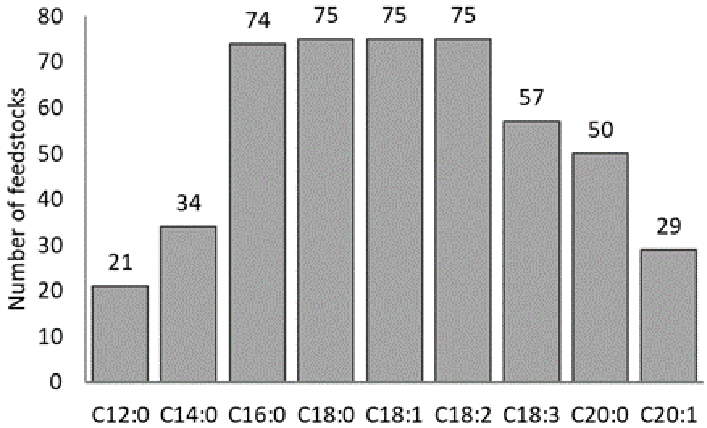


Figure 5.11: Distribution of the FA components of 75 feed stocks from literature

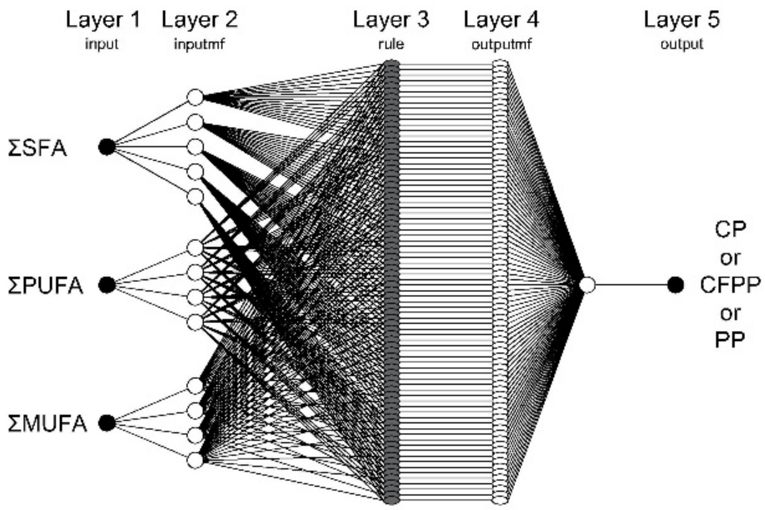


Figure 5.12: Structure of the ANFIS model used to predict the CFP of a biodiesel sample

The models created using ANFIS were assessed by testing with the statistical indices given in equations (5.4) to (5.9) including standard deviation (SD), coefficient of determination (R^2), root mean square error (RMSE), sum of squared error (SSE) methods, standard error (SE) and maximum error or deviation from linearity (ME), respectively. In the equations, *n* was the total number of experimental values, $y_{exp,i}$ was the experimental value, $y_{p,i}$ was the predicted value, $y_{exp,ave}$ was the average experimental value, $y_{fitted,i}$ was linear value at a fitted line and m was the number of input variables.

$$SD = \frac{1}{n}\sum_{i=1}^{n}(y_{exp,i} - y_{exp,ave})^2 \quad (5.4)$$

$$R^2 = 1 - \frac{\sum_{i=1}^{n}(y_{exp,i} - y_{p,i})^2}{\sum_{i=1}^{n}(y_{p,i} - y_{exp,ave})^2} \quad (5.5)$$

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(y_{p,i} - y_{exp,i})^2} \quad (5.6)$$

$$SSE = \sum_{i=1}^{m}(y_{exp,i} - y_{p,i})^2 \quad (5.7)$$

$$SE = \sqrt{\frac{1}{n-2}\sum_{i=1}^{n}(y_{p,i} - y_{fitted,,i})^2} \quad (5.8)$$

$$ME = Max\left|y_{p,i} - y_{fitted,,i}\right| \quad (5.9)$$

FA compositions of the feedstock utilized are given in Table 5.2. The biodiesel samples produced were tested for their fuel characteristics and the results are shown collectively in Table 5.3 together with their CFP. The calculated R^2 of the ANFIS models were 0.984, 0.989 and 0.983 for the CP, PP and CFPP predictions, respectively. The test performances of generated models in terms of RMSE were found as 1.109, 1.369 and 1.048 for CP, PP and CFPP, shown in Table 5.4 respectively which indicates very high precisions. A highly non-linear relation between CFP and ΣSFA, ΣMUFA and ΣPUFA was noted. The estimation of the CFP of a biodiesel fuel from a potential feedstock may become important because it may reduce the experimental work and allows also investigation of the extreme situations.

Table 5.2: FA compositions of biodiesel feedstock used in the current work

Fatty acid	FA Composition (wt %)					
	WF	**CA**	**CO**	**SB**	**SF**	**JO**
Caprylic(C8:0)	0.05	0.0	0.0	0.0	0.0	0.0
Capric (C10:0)	0.33	0.0	0.0	0.0	0.0	0.0
Lauric (C12:0)	1.18	0.08	0.0	0.0	0.06	0.0
Myristic (C14:0)	0.10	0.0	0.0	0.0	0.0	0.0
Palmitic (C16:0)	39.3	5.63	12.5	11.8	5.8	1.89
Palmitoleic (C16:1)	0.14	0.0	0.0	0.7	0.4	0.07
Stearic (C18:0)	4.04	1.57	3.0	3.53	3.14	0.46
Oleic (C18:1)	40.4	63.0	24.1	23.8	18.2	12.3
Linoleic (C18:2)	13.8	21.3	32.8	53.4	72.5	0.21
Linolenic (C18:3)	0.18	6.99	0.0	6.7	0.0	0.59
Arachidic (C20:0)	0.0	0.46	0.0	0.0	0.0	0.13
Gadoleic (C20:1)	0.0	1.00	0.0	0.0	0.0	71.1
Erucic (C22:1)	0.0	0.0	0.0	0.0	0.0	11.7
Nervonic (C24:1)	0.0	0.0	0.0	0.0	0.0	1.15
ΣSFA	45.0	7.70	15.5	15.3	9.0	2.48
ΣMUFA	40.6	64.0	24.1	24.5	8.6	96.3
ΣPUFA	14.0	28.3	32.8	60.1	72.5	0.80

Table 5.3: Fuel properties of biodiesel samples produced in the current experimental work

	Method	**Limits**	**WFME**	**CAME**	**COME**	**SBME**	**SFME**	**JOME**
Kinematic viscosity at 40 ˚C (mm^2/s)	ASTM D 445	1.9-6.0	4.666	4.582	4.214	4.302	4..228	5.210
Higher heating value (MJ/kg)	ASTM D 4809	--	40.1	39.2	42.4	39.2	40.8	44.3
Free glycerin (wt %, max.)	EN 14105	0.02	0.006	0.003	0.004	0.003	0.003	0.004
Total glycerin (wt %, max.)	EN 14105	0.25	0.248	0.196	0.199	0.192	0.187	0.190
Mono glyceride (wt %, max.)	EN 14105	0.70	0.62	0.64	0.63	0.65	0.61	0.61
Diglyceride (wt %, max.)	EN 14105	0.20	0.20	0.20	0.20	0.20	0.18	0.20
Triglyceride (wt %, max.)	EN 14105	0.20	0.20	0.1	0.1	0.1	0.1	0.2
Ester contents (wt %, max.)	EN 14103	96.5	96.5	97.0	97.4	96.8	97.4	97.8
Linoleic acid methyl esters (wt %, max.)	EN 14103	12.0	0.2	6.8	7.2	7.9	10.8	0.4
Iodine value (g I_2 / 100 g, max)	EN 14111	120	110	66	98	112	108	54
Cloud point (˚C)	ASTM D 2500	--	15	-3.5	-3	4	1.5	12
Cold filter plugging point (˚C)	ASTM D 6371	--	14	-7.5	-6	0	-2	10
Pour point (˚C)	ASTM D 97	--	12	-10	-7	-2	-3.2	8.6

Table 5.4: A comparison of the measured and the predicted CFP temperatures of the test samples

CFP	**Experimental Results**	**ANFIS Predictions**	**RMSE**	**R^2**
CP	12.0°C	10.6°C	1.109	0.984
CFPP	10.0°C	8.1°C	1.048	0.983
PP	8.6°C	5.9°C	1.369	0.989

CHAPTER 6
CONCLUSIONS & RECOMMENDATIONS

6.1 Conclusions

Tourism and education are the backbone of the economy in TRNC. Agriculture could be a potential alternative sector for the development of the economy. Jojoba shrub can be an alternative plant for cultivation in the semi-arid Mesarya Plain. Prior to the experimental work, an analysis of investment and yield of jojoba agriculture on the 200000 decares of dormant of Mesarya Plain was conducted. A cost-benefit estimation in a 12 years period indicated that the revenue from jojoba seed crop can be eight times more than benefit of barley. Moreover, it appeared that the total benefits of jojoba oil would be more than twenty-two times of the barley and 2.6 times of the jojoba seed.

For oil extraction a simple mechanical press was designed and manufactured. The extracted jojoba oil was subjected to various tests and examinations in accredited laboratories and also in NEU laboratories. The test results of jojoba oil from Mesarya Plain were examined and compared with the other surveys across the world and also that of IJEC standards.

It was noted that the density of jojoba oil was sensitive to temperature and decreased slightly with increasing temperature within the range of analyses. Heating the jojoba oil to a temperature higher than 50°C was sufficient to ensure that density remained below 0.84 g/ml.

Lubricity tests of jojoba oil at 25°C and 60°C were revealed that the lubrication capability of jojoba oil was excellent and satisfactory since the wear scars were below the limit values of the TS EN ISO 12156-1.

Viscosity values of the jojoba oil extracted were determined to be about 25 mm^2/s at 40°C and 6.5 mm^2/s at 100°C. The values were within the acceptable ranges. It is worth to note that the oil extraction parameters including seed size, humidity and temperature and also expeller pressure had negligible effects on the viscosity values.

The moisture contents of jojoba seeds were monitored using a standard drying method and recorded as 6%. The results of corrosivity tests of jojoba oil approved that jojoba oil did not have any corrosive effect.

Fatty acid and wax esters of the jojoba oil were in good agreement with the standards given by IJEC and also the products of other jojoba oil producing countries.

The Taguchi analysis was employed to maximize the yield of jojoba oil during extraction in the screw expeller without degrading the oil quality, i.e. kinematic viscosity. The Taguchi method involving L9 orthogonal array was applied with control factors including seed size, seed humidity level, seed temperature and residual discharge opening each at three levels. It was determined that the viscosity of the extracted jojoba oil was not influenced in the experiments conducted and had an average of (25.41 mm^2/s). The S/N ratio analysis showed that the seed temperature had the strongest influence on the jojoba oil recovery followed by seed size, seed humidity level and finally, residual discharge opening. The ANOVA revealed a similar order however, seed size appeared in the first place followed by seed temperature. It was found that residual discharge opening which directly affected the extraction pressure had minor influence on maximizing the oil yield. Thus seed size, temperature and humidity level were the dominating control parameters. The maximum jojoba oil recovery was found when the seeds were halved, not dried and kept at room temperature (22°C) and also the residual discharge opening of the expeller was in fully open position. As a result, the oil yield could be maximized to 41.5 % which was 12.4 % above the average yield (29.1 %). It can be argued that all the optimum parameters except halving the seeds are factors reducing the cost of oil extraction.

6.2 Future Work and Recommendations

Jojoba shrub can be an important asset for the arid and semi-arid lands to evaluate the unused soil. United Nations supports the countries to apply the projects of jojoba cultivation. This would affect the economy of an undeveloped country positively. TRNC administration would encourage the jojoba cultivation particularly, those unused dormant lands to improve both agricultural economy and trade and also to reduce unemployment. Following the high yield of jojoba oil and the revenues will improve the total industrial activity.

It has been claimed that the meadowfoam seed oil may be an alternative to the jojoba oil (Elementis Specialities, 2009). Although it is native to Oregon, USA, agriculture of the meadowfoam (Limnanthes Alba) plant may be a worthy trial in the TRNC.

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APPENDICES

APPENDIX 1

THE ANALYSIS REPORT OF SOIL IN MESARYA PLAIN PROVIDED BY MINISTRY OF AGRICULTURE AND NATURAL SOURCES OF TRNC, GÜZELYURT SOIL AND WATER LABRATORY

KUZEY KIBRIS TÜRK CUMHURİYETİ
TARIM VE DOĞAL KAYNAKLAR BAKANLIĞI
TARIM DAİRESİ MÜDÜRLÜĞÜ
GÜZELYURT TOPRAK-SU LABORATUVARI
Tel:0392-714 32 94 Fax:0392-714 67 92

Tarih:22/05/2017

Sayı: TS Lab. 88/11-GTS-17-10/69
Konu: Toprak Analizi sonucuhk.

Laboratuvarımızda Sami Ortaç adına yapılmış olan 1 adet toprak analiz sonucu ekte sunulduğu gibidir.

Bilgilerinize saygı ile arz ederiz.

TARIM VE DOĞAL KAYNAKLAR BAKANLIĞI TARIM DAİRESİ

Nazlı Saygıner Serçin
Ziraat Mühendisi

Not:Bu belge üreticinin isteği üzerine verilmiştir.

Üretici Adı : Sami Ortaç
Rapor No : 64
Lab No : 173
Ürün : Jojoba (100 dönüm)
Bölge : Meriç
Rapor Tarihi : 22.05.2017
Numune Tarihi: 16.05.2017

Toprak	Özellikleri	Analiz sonucu (0-30)	Değerlendirme
Saturasyon	%	53	killi-tın
pH		8,0	kuvvetli alkali
Kireç	%	39,0	çok fazla kireçli
Toplam Tuz	%	0,04	tuzsuz
Organik Mad	%	0,8	çok düşük
Yarayışlı fosfor	kg P_2O_5/da	1,0	çok düşük
Yarayışlı potas	kg K_2O/da	94	iyi

Toprak orta bünyeli, çok fazla kireçli, tuzsuz ve besin yönünden zayıf bir topraktır.

APPENDIX 2

SOIL REFERENCES

TOPRAK ANALİZ REFERANSLARI

Suyla doygunluk %	Bünye
< 30	kumlu
31-50	tınlı
51-70	killi tınlı
71-100	killi
> 110	ağır killi

Organik Madde %	Org. Mad. Durumu
< 1.0	çok az
1.0 - 2.0	az
2.0 - 3.0	orta
3.0 - 4.0	iyi
> 4	yüksek

Toplam Tuz	Tuzluluk Derecesi
0.0 - 0.15	tuzsuz
0.15 - 0.35	hafif tuzlu
0.35 - 0.65	orta derecede tuzlu
> 0.65	çok fazla tuzlu

Yarayışlı Fosfor kg P_2O_5/da	Değerlendirme
0 - 3	çok az
3.0 - 6.0	az
6.0 - 9.0	orta
> 9	yüksek

Kireç Kapsamı	Kireç Durumu
< 1.0	çok az kireçli
1.0 - 5.0	az kireçli
5.0 - 15.0	orta kireçli
15.0 - 25.0	fazla kireçli
> 25.0	çok fazla kireçli

Yarayışlı Potas kg K_2O/da	Değerlendirme
0 - 10	çok az
10 -- 20	az
20 - 25	orta
25 - 30	yeter
> 30	yüksek

pH	Toprak Reaksiyonu
< 4.0	çok kuvvetli asit
4.0 - 4.9	kuvvetli asit
5.0 - 5.9	orta derecede asit
6.0 - 6.9	hafif asit
7.0	nötür
7.0 - 7.9	hafif alkali
8.0 - 8.9	kuvveli alkali
9.0 - 9.9	çok kuvvetli alkali

APPENDIX 3

THE ANALYSIS REPORT OF FATTY ACID COMPOSITIONS OF JOJOBA OIL PROVIDED BY THE MINISTRY OF HEALTH DIRECTORATE OF THE STATE LABORATORY IN TRNC

KKTC - SAĞLIK BAKANLIĞI - DEVLET LABORATUARI DAİRESİ MÜDÜRLÜĞÜ - LEFKOŞA
TRNC - MINISTRY OF HEALTH - DIRECTORATE OF THE STATE LABORATORY - LEFKOŞA

AB-0500-T
9120
05-14

Deneyin Yapıldığı Bölüm : Besin Analizleri Şubesi
Department

Numunenin Alındığı Tarih: -
Sample Receipt Date

İlgi : 21.05.2014 tarihli Deney Talep Formu
Reference No

Mühür : Mühürsüz
Seal

DENEY SONUÇLARI *TEST RESULTS*

Marka Etiketi: Jojoba Yağı
2. Part (Oil) 170 g.

A)

Asidite (% m/m Oleik Asit Cinsinden	0.8

B)

	Yağ Asitleri Kompozisyonu (Toplam yağ asitleri yüzdesi olarak) (%)
Palmitat	0.5
Oleat	5.9
Linolenat	37.8
Eicosatrienoat	24.0
Tricosanoat	6.5

Analiz Metodları:

Parametre	Metod
Yağ Asitleri Kompozisyonu (Toplam Yağ asitleri % olarak)	COI/T-20 DOC no 24
Asidite (%m/m Oleik Asit cinsinden	AOAC 940.28

Deneyi Yapan
Person in charge of analysis

Değer Haydar
Gıda Yük. Müh.

Bu rapor sadece konu örnek için geçerlidir.
Türkak tarafından akredite edilmiş parametreler * sembolü ile işaretlenmiştir.
İş bu rapor 27.05.2014 tarihinde 2 sayfa ve 2 nüsha olarak düzenlenmiştir.
This report is valid for this sample (s).
Parameters accredited by Turkak are labeled with * symbol.
This report was arranged as 2 pages and 2 copies at 27.05.2014

4

... 01/03.07.2012 Sayfa 2/2

APPENDIX 4

THE LUBRICITY AND VISCOSITY ANALYSIS REPORTS OF JOJOBA OIL PROVIDED BY EGE UNIVERSITY LABORATORY-TURKEY

TÜRKAK
TÜRK AKREDİTASYON KURUMU
TURK ACCREDITATION AGENCY
tarafından akredite edilmiş

Ege Üniversitesi Akredite Akaryakıt Analiz Laboratuvarı
(EGE-PAL)

Ankara Cad. Ege Üniversitesi Kampüsü
Fen Fakültesi Kimya Bölümü Zemin Kat

Deney Raporu
Testing Report

Müşterinin adı/adresi : (Customer name/adres)	Ali Üren , Yakın Doğu Üniveristesi
İstek/Rapor Numarası : (Order No)	18050301
Numunenin adı ve tarifi : (Name and identity of test item)	Jojoba Yağı, Mühürsüz 25 ml + 13 ml plastik şişe
Numunenin kabul tarihi : (The date of receipt of test item)	03.05.2018 10:56
Açıklamalar : (Remarks)	
Deneyin yapıldığı tarih : (Date of Test)	07.05.2018 - 08.05.2018
Raporun Sayfa Sayısı : (Number of pages of the Report)	2

Deney ve/veya ölçüm sonuçları, genişletilmiş ölçüm belirsizlikleri (olması halinde) ve de ney metodları bu sertifikanın tamamlayıcı kısmı olan takip eden sayfalarda verilmiştir.

The testing and/or measurement results, the uncertainties (if applicable) with confidence interval and test methods are given on the following pages which are part of this report.

Mühür (Seal)	Tarih (Date)	Laboratuvar Koordinatörü/Teknik Yönetici (Person in charge of test)	Laboratuvar Müdürü (Head of Testing Laboratory)
EGE - PAL Akredite Akaryakıt Analiz Laboratuarı	01.06.2018	Doç.Dr.Hasan ERTAŞ	Prof.Dr.Mehmet Balcan

(Yükümlüler tarafından imzalanacaktır.)
Alınan akaryakıtın niteliği ve niceliği değiştirilmemiştir.
Bu analiz raporu (.............) tarihi ve (.............) sayılı (faturama/gümrük giriş beyannameme/depo çıkış tutanağına)konu edilen akaryakıta aittir.

İMZA

(I. Yeniden satışta Yükümlüler tarafından doldurulup imzalanacaktır.)

Alınan akaryakıtın niteliği ve niceliği değiştirilmemiştir. Bu analiz raporu (................) tarihi ve (............) sayılı (faturama /gümrük giriş beyanname/depo çıkış tutanağına)konu edilen akaryakıta aittir.

İMZA

(II. Yeniden satışta yükümlüler tarafından doldurulup imzalanacaktır.)

Alınan akaryakıtın niteliği ve niceliği değiştirilmemiştir. Bu analiz raporu (................) tarihi ve (............) sayılı (faturama /gümrük giriş beyanname/depo çıkış tutanağına)konu edilen akaryakıta aittir.

İMZA

(Harmanlamaya tabi tutulan petrolde doldurulacaktır.)

Harmanlanan Ürünün Adı :

Harmanlama Oranı (% v/v) :

Akaryakıt harmanlama sonrasında teknik düzenlemelere uygundur. İMZA

LK.FR.140/03/15.12.2011

EGE ÜNİVERSİTESİ AKREDİTE AKARYAKIT ANALİZ LABORATUVARI (EGE-PAL)

Sayfa No : 2 / 2

İçerik Analiz Raporu

Numune	Alınan	Yükümlünün Adı Soyadı/Unvanı			
	Alanın	Adı, Soyadı/Unvanı			
		Şirketi ve Adresi	Yakın Doğu Üniveristesi		
	Alımının	Yöntemi		Tarihi	03.05.2018
		Yeri			
Teslim	Edenin	Adı, Soyadı/Unvanı	Ali Üren		
		Şirketi ve Adresi	Yakın Doğu Üniveristesi		
	Tarihi ve Saati		03.05.2018 - 10:56	No	18050301

ÖZELLİK	ÖZELLİK KODU	BİRİM	REFERANS SINIR DEĞERLERİ		ÖLÇÜM DEĞERİ	ÖLÇÜM BELİRSİZLİĞİ	DENEY YÖNTEMİ
			EN AZ	EN ÇOK			
Yağlama Özelliği*	840	µm	-	-	183,0	-	TS EN ISO 12156-1-Temmuz.2016
Viskozite (Akmazlık) 15 C*	110_	mm^2/s	-	-	-	-	TS 1451 EN ISO 3104+T1 Aralık.2005 TS ISO 3105 Nisan.2007
Renk ve Görünüş*	130	-	-	-	-	-	-
PH Değeri*	0.	-	-	-	-	-	-
Solvent*	21	-	-	-	-	-	-
Metal Analizleri*	0	-	-	-	-	-	-
Ester*	670	% (m/m)	-	-	-	-	TS EN 14103
Linolenik asit metil esteri *	680	% (m/m)	-	-	-	-	TS EN 14103
Çoklu Doymamış Metil Esterleri*	700	% (m/m)	-	-	-	-	TS EN 15779
Kül *	510	% (m/m)	-	-	-	-	TS EN ISO 6245-Mart.2006
Karbon Kalıntısı(% 10 damıtma kalıntısından)*	330	% (m/m)	-	-	-	-	TS EN ISO 10370-Şubat.2015
XRF 'de Kükürt Tayini *	540.	mg/kg	-	-	-	-	TS EN ISO 8754-Ekim.2006
Yoğunluk*	100	kg/m^3	-	-	-	-	TS EN ISO 12185-Temmuz.2007 ASTM D4052-16
Viskozite (Akmazlık) 40 C*	110	mm^2/s	-	-	24,72	±0,02	TS 1451 EN ISO 3104+T1 Aralık.2005 TS ISO 3105 Nisan.2007
Viskozite(Akmazlık) 100 C*	110-	mm^2/s	-	-	6,4505	-	TS 1451 EN ISO 3104+T1 Aralık.2005 TS ISO 3105 Nisan.2007
Viskozite İndeksi (Akmazlık)*	110.	-	-	-	235	-	D 2270
Parlama Noktası *	200	°C	-	-	-	-	TS EN ISO 2719 Aralık.2016
Damıtma IBP *	---	% (V/V)	-	-	-	-	TS EN ISO 3405-Nisan.2011
Damıtma 5 *	.	% (V/V)	-	-	-	-	TS EN ISO 3405-Nisan.2011
Damıtma 15*	-	-	-	-	-	-	TS EN ISO 3405-Nisan.2011
Damıtma 20*	--	% (V/V)	-	-	-	-	TS EN ISO 3405-Nisan.2011
Karl Fiisher Su Tayini *	500.	mg/kg	-	-	-	-	TS 6147 EN ISO 12937 Nisan.2002 ASTM 6304-16
Katı Madde*	..	% ağ.	-	-	-	-	D 1259-06
Azeotropik Damıtma Yöntemi ile Su Tayini *	500	% (V/V)	-	-	-	-	-
U.V ' de Kükürt Tayini *	540	mg/kg	-	-	-	-	TS EN ISO 20846-Mart.2012
Katı Madde Cinsi*	...	% ağ.	-	-	-	-	FTIR spektrofotometre
İyot Sayısı*	620	g.iyot/100g	-	-	-	-	TS EN 14111-Haziran.2007
Net Yanma Isısı*	920	MJ/Kg	-	-	-	-	TS 1740 -Aralık.2006 DIN 51900-2

* Analiz akredite değildir.

Açıklamalar: Bu rapor 2 (iki) sayfadan oluşmaktadır ve laboratuvarın izni olmadan kısmen kopyalanıp çoğaltılamaz. İmzasız ve mühürsüz raporlar geçersizdir. Deney sonuçları analizi yapılan numuneye ait olup, deney sonuçlarına 3 ay (bu süre şahit saklama süresi dikkate alınarak verilmeli) içinde itiraz edilebilir.

Ulusal Marker Ege-Pal ve TUBİTAK Laboratuvarlarında aynı anda analizlenmektedir.

Açıklamalar: Numunede istenen analizler yapılmış elde edilen sonuçlar yukarıda verilmiştir.

EGE - PAL
Akredite Akaryakıt
Analiz Laboratuarı

Mühür

Tarih
01.06.2018

Laboratuar Sorumlusu
Doç.Dr.Nur Aksuner

Laboratuvar Koordinatörü/Teknik Yönetici
Doç.Dr.Hasan ERTAŞ

LK.FR.263/00/27.07.2016

APPENDIX 5

THE ANALYSIS REPORTS OF JOJOBA OIL FATTY ACID COMPOSITIONS, WAX ESTERS, REFRECTIVE INDEX AND SAPONIFICATION VALUE PROVIDED BY EGE UNIVERSITY LABORATORY-TURKEY

EGE ÜNİVERSİTESİ
İLAÇ GELİŞTİRME VE FARMAKOKİNETİK
ARAŞTIRMA & UYGULAMA MERKEZİ
AR-GE LABORATUVARLARI
BORNOVA/İZMİR
EGE UNIVERSITY
CENTER FOR R & D AND PHARMACOKINETIC APPLICATIONS
R&D LABORATORIES
BORNOVA/ IZMIR

Telefon / Phone + 90 232 339 21 60 Faks / Fax +90 232 374 23 90 E-posta / E- mail cevregida@mail.ege.edu.tr

ANALİZ RAPORU
Analysis Report

Rapor No/ *Report Number* : **AR – 18080** **Tarih /** *Date* : **07-05-2018**

ANALİZ BİLGİLERİ/ *TEST INFORMATION/ REMARKS*	
Analiz Başlangıç/Bitiş Tarihi *Date of Beginning/ End of Analysis*	: 03-05-2018– 07-05-2018
Analiz Yöntemi *Analysis Method*	: Kurum İçi Metot
Kullanılan Cihazlar/Ekipman *Instruments*	: GC-FID (Yağ Asitleri Analizi)

Yapılan Analizler / *Analysis*	**Sonuç** / *Result*
Yağ Asitleri Kompozisyonu (%)	Rapor ve Kromatogramlar Ektedir
Kırılma Indisi	**1.4661**
Sabunlaşma Sayısı	**92.6**
Wax Analizi	**C40 :** 28.2×10^4 mg/kg **C42 :** 46.3×10^4 mg/kg **C44 :** 8.0×10^4 mg/kg **C46 :** 0.5×10^4 mg/kg

Rapor Sonu / *End of Report*

Analizi Yapan
Yük. Kim. Veysel Umut ÇELENK

Onaylayan
Dr. Biyo. Murat GÜRSOY

Mühür ve Tarih
Seal and Date 07 Mayıs 2018

Analiz Raporu Sayfa/Toplam Sayfa Sayısı : **2/2**
Number / Total Number of Pages of the Analys Report
L-GE-R-F-01 00/ 28.05.2010

Data File C:\CHEM32\...\2018\+ARGE 2018\04-NISAN\02-JOJOBA OIL\FAME\2018-04-28\JOJOBAOIL.D
Sample Name: JojobaOil

```
=====================================================================
Acq. Operator   : Veysel Umut Çelenk              Seq. Line :   3
Acq. Instrument : Instrument 1                     Location : Vial 202
Injection Date  : 5/4/2018 5:40:38 PM                   Inj :   1
                                                 Inj Volume : 1 µl
Acq. Method     : C:\CHEM32\1\DATA\2018\+ARGE 2018\04-NISAN\02-JOJOBA OIL\FAME\2018-04-28
                  \FAME-WORKING.M
Last changed    : 5/4/2018 3:54:16 PM by Veysel Umut Çelenk
Analysis Method : C:\CHEM32\1\METHODS\FAME-QUAN.M
Last changed    : 4/29/2018 1:10:01 PM by Veysel Umut Çelenk
Additional Info : Peak(s) manually integrated
=====================================================================
```

Peak #	RetTime [min]	Type	Width [min]	Area [pA*s]	Area %	Name
12	18.897	MM	0.0417	12.73053	1.88739	12) Palmitic Acid (C16:0)
13	20.111	MM	0.0498	4.97931e-1	0.07382	13) Palmitoleic Acid (C16:1)
14	20.700		0.0000	0.00000	0.00000	14) Heptadecanoic Acid (C17:0)
15	21.300		0.0000	0.00000	0.00000	15) cis-10-Heptadecanoic Acid (C17:1)
16	22.181	MM	0.0447	3.09738	0.45921	16) Stearic Acid (C18:0)
17	22.850		0.0000	0.00000	0.00000	17) Trans Oleic Acid (C18:1n9t)
18	23.188	MM	0.0423	82.80704	12.27675	18) Oleic Acid (C18:1n9c)
19	24.000		0.0000	0.00000	0.00000	19) Trans Linoleic Acid (C18:2n6t)
20	24.673	MM	0.0509	1.41415	0.20966	20) Linoleic Acid (C18:2n6c)
21	25.248	MM	0.0487	8.42467e-1	0.12490	21) Arachidic Acid (C20:0)
22	25.700		0.0000	0.00000	0.00000	22) Trans Linolenic Acid (C18:3n6)
23	26.212	MF	0.0526	479.54492	71.09602	23) Gondoic Acid (C20:1)
24	26.345	FM	0.0714	3.99716	0.59261	24) Linolenic Acid (C18:3n3)
25	26.705	MM	0.0454	3.67899e-1	0.05454	25) Heneicosanoic Acid (C21:0)
26	27.600		0.0000	0.00000	0.00000	26) cis-11,14-Eicosadienoic Acid (C20:2)
27	28.067	MM	0.0414	1.16310	0.17244	27) Behenic Acid (C22:0)
28	28.600		0.0000	0.00000	0.00000	28) cis-8,11,14-Eicosatrienoic Acid (C20:3n6)
29	28.944	MM	0.0428	78.80145	11.68289	29) Erucic Acid (C22:1n9)
30	29.086	MM	0.0571	1.48307	0.21988	30) cis-11,14,17-Eicosatrienoic Acid (C20:3n3)
31	29.337		0.0000	0.00000	0.00000	31) Tricosanoic Acid (C23:0)
32	29.400		0.0000	0.00000	0.00000	32) Arachidonic Acid (C20:4n6)
33	30.200		0.0000	0.00000	0.00000	33) cis-13,16-Docasadienoic Acid (C22:2)
34	30.500		0.0000	0.00000	0.00000	34) Lignoceric Acid (C24:0)
35	31.000		0.0000	0.00000	0.00000	35) cis-5,8,11,14,17-Eicosapentaenoic Acid (C2
36	31.553	MM	0.0496	7.75606	1.14989	36) Nervonic Acid (C24:1)
37	35.000		0.0000	0.00000	0.00000	37) cis-4,7,10,13,16,19-Docasahexaenoic Acid (
Totals :				674.50316	100.0000	

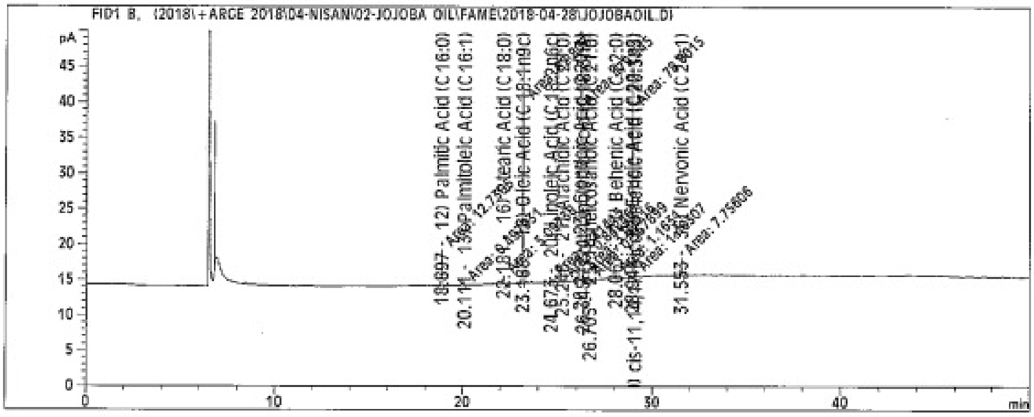
15 Warnings or Errors (10 first messages follow) :

```
Warning : Calibration warnings (see calibration table listing)
Warning : Calibrated compound(s) not found
Warning : Invalid calibration curve, (12) Palmitic Acid (C16:0))
Warning : Invalid calibration curve, (13) Palmitoleic Acid (C16:1))
Warning : Invalid calibration curve, (16) Stearic Acid (C18:0))
Warning : Invalid calibration curve, (18) Oleic Acid (C18:1n9c))
Warning : Invalid calibration curve, (20) Linoleic Acid (C18:2n6c))
Warning : Invalid calibration curve, (21) Arachidic Acid (C20:0))
Warning : Invalid calibration curve, (23) Gondoic Acid (C20:1))
Warning : Invalid calibration curve, (24) Linolenic Acid (C18:3n3))
=====================================================================
```

Instrument 1 5/7/2018 11:48:47 AM Veysel Umut Çelenk Page 2 of 2

Data File C:\CHEM32\...\2018\+ARGE 2018\04-NISAN\02-JOJOBA OIL\FAME\2018-04-28\JOJOBAOIL.D
Sample Name: JojobaOil

```
=====================================================================
Acq. Operator    : Veysel Umut Çelenk              Seq. Line :   3
Acq. Instrument  : Instrument 1                     Location : Vial 202
Injection Date   : 5/4/2018 5:40:38 PM                   Inj :   1
                                                  Inj Volume : 1 µl
Acq. Method      : C:\CHEM32\1\DATA\2018\+ARGE 2018\04-NISAN\02-JOJOBA OIL\FAME\2018-04-28
                   \FAME-WORKING.M
Last changed     : 5/4/2018 3:54:16 PM by Veysel Umut Çelenk
Analysis Method  : C:\CHEM32\1\METHODS\FAME-QUAN.M
Last changed     : 4/29/2018 1:10:01 PM by Veysel Umut Çelenk
Additional Info  : Peak(s) manually integrated
=====================================================================
```




```
=====================================================================
                        Area Percent Report
=====================================================================

Sorted By              :      Signal
Calib. Data Modified   :      4/29/2018 1:09:35 PM
Multiplier             :      1.0000
Dilution               :      1.0000
Use Multiplier & Dilution Factor with ISTDs
```

Signal 1: FID1 B,

Peak #	RetTime [min]	Type	Width [min]	Area [pA*s]	Area %	Name
1	7.006		0.0000	0.00000	0.00000	01) Butyric Acid(C4:0)
2	7.300		0.0000	0.00000	0.00000	02) Caproic Acid(C6:0)
3	8.200		0.0000	0.00000	0.00000	03) Caprylic Acid (C8:0)
4	10.000		0.0000	0.00000	0.00000	04) Capric Acid (C10:0)
5	11.060		0.0000	0.00000	0.00000	05) Undecanoic Acid (
6	12.410		0.0000	0.00000	0.00000	06) Lauric Acid (C12:0)
7	13.900		0.0000	0.00000	0.00000	07) Tridecanoic Acid (C13:0)
8	15.600		0.0000	0.00000	0.00000	08) Myristic Acid (C14:0)
9	17.000		0.0000	0.00000	0.00000	09) Myristoleic Acid (C14:1)
10	17.200		0.0000	0.00000	0.00000	10) Pentadecanoic Acid (C15:0)
11	18.700		0.0000	0.00000	0.00000	11) Cis-10-Pentadecanoic Acid (C15:1)

APPENDIX 6

THE ANALYSIS REPORTS OF PHYSICAL AND CHEMICAL PROPERTIES OF JOJOBA OIL PROVIDED BY BURSA TEST AND ANALYSIS LABORATORY BUTAL-TURKEY

TÜBİTAK

BUTAL

AB-0494-T

GT20170218

13/12/2017

TÜBİTAK
BURSA TEST VE ANALİZ LABORATUVARI

TÜRKAK
TÜRK AKREDİTASYON KURUMU
tarafından akredite edilmiştir

DENEY RAPORU

Müşterinin Adı/Adresi :YAKIN DOĞU ÜNİVERSİTESİ / Yakın Doğu Bulvarı PK 99138 / Lefkoşe / KIBRIS

T/F:(392) 223-64-24/ / (392) 223-64-61

İlgi Tarih/Sayı :08/12/2017

Numune Tanımı :Jojoba Yağı

Numune Kabul Tarihi :11/12/2017 **Numune Geliş Şekli**:Elden

Rapor Sayfa Sayısı: 3 **Nüsha Sayısı**:1

Açıklama : Numune alma işlemi ve numune tanımı müşteri tarafından yapılmıştır.

Deney sonuçları, metotları ve diğer bilgiler, bu raporun tamamlayıcı kısmı olan, takip eden sayfalarda verilmiştir.
Bu rapor ve sonuçları, talepte bulunan müşteri tarafından reklam amacı ile kullanılamaz.
Bu rapor bir bütün halinde verildiğinden, rapordan bölümler halinde alıntı yapılamaz. TÜBİTAK-BUTAL'in yazılı izni olmadan kısmen kopyalanıp çoğaltılamaz.
Deney sonuçları deneyi yapılan numuneye aittir.
Raporda (A) işaretli deneyler TS EN ISO/IEC 17025 kapsamında akreditedir.
İmzasız ve mühürsüz raporlar geçersizdir.

TÜRKAK deney raporlarının tanınması konusunda Avrupa Akreditasyon Birliği (EA) ve Uluslararası Laboratuvar Akreditasyon Birliği (ILAC) ile karşılıklı tanınma antlaşmasını imzalamıştır.

Mühür	Tarih	Laboratuvarlar Sorumlusu	MÜDÜR
TÜBİTAK BURSA TEST VE ANALİZ LAB. MÜDÜRLÜĞÜ	13/12/2017	Anıl ÇETİNOĞLU	Sedat AKTAŞ

Gaziakdemir Mah. Merinos Cad. No. 11, 16190, Osmangazi BURSA
T. 0 224 233 94 40 F. 0 224 233 94 45 - 0 224 234 57 06
www.butal.tubitak.gov.tr e-posta: butal@tubitak.gov.tr

BTA-P003-F003/Rev.01

TÜBİTAK BUTAL

Akreditasyon Numarası	AB-0494-T
Rapor Numarası	GT20170218
Rapor Çıkış Tarihi	13/12/2017

Sayfa **2 / 3**

Deney Tarihi : 11-13.12.2017

Numune Tanımı : Jojoba Yağı Numune 1

Deney Adı	Birim	Deney Metodu	Deney Sonucu Ortalama ± s
İyot Sayısı	Wijs g/100g yağ	EN ISO 3961	88,9 ± 0,7
Sabunlaşma Sayısı	mg KOH /g yağ	BS EN ISO 3657	96 ± 1
Kırılma İndisi (20°C)	nD	TS 4960 EN ISO 6320	1,4664 ± 0,0001
Özgül Ağırlık (20°C)	g/cm3	TS 4959	0,8578 ± 0,0001
Asitlik*	mg KOH /g yağ	(A) EN ISO 660	0,5 ± 0,1
Asitlik (Oleik asit Cinsinden)*	%	(A) EN ISO 660	0,27 ± 0,01
Peroksit Değeri *	Meq O_2/kg	(A) EN ISO 27107	<1
Sabunlaşmayan Madde	%	TS 4963	0,15 ± 0,05
Nem ve Uçucu Maddeler	%	TS 1607 EN ISO 662	0,05 ± 0,01

(*) Belirsizlik Değeri u (k=2) alınmıştır.

Deneyi Yapan/Yapanlar	Deney Sorumlusu/Sorumluları	Birim Sorumlusu
Sibel TAŞKESEN Uzm. Teknisyen Güler ÇELİK Araştırmacı	Güler ÇELİK Araştırmacı	Aziz ÇETİNOĞLU Uzman Arş.

BTA-P003-F003/Rev.01

TÜBİTAK BUTAL

Akreditasyon Numarası	AB-0494-T
Rapor Numarası	GT20170218
Rapor Çıkış Tarihi	13/12/2017

Deney Adı	Birim	Deney Metodu	Deney Sonucu Ortalama ± u(k=2)
Bütirik Asit (C4:0)	%	(A)TS EN ISO 12966-2 (A)TS EN ISO 12966-4	<0,38
Kaproik Asit (C6:0)	%		<0,05
Kaprilik Asit (C8:0)	%		<0,06
Kaprik Asit (C10:0)	%		<0,05
Undekanoik Asit (C11:0)	%		<0,05
Laurik Asit (C12:0)	%		<0,07
Tridekanoik Asit (C13:0)	%		<0,11
Miristik Asit (C14:0)	%		<0,05
Miristoleik Asit (C14:1)	%		<0,05
Pentadekanoik (C15:0)	%		<0,05
Pentadekonoik C15:1	%		<0,05
Palmitik Asit (C16:0)	%		1,6 ± 0,1
Palmitoleik Asit (C16:1)	%		<0,05
Margarik Asit (C17:0)	%		<0,05
Heptadesenoseik (C17:1)	%		<0,05
Stearik Asit (C18:0)	%		<0,05
trans Elaidik Asit (C18:1t)	%		<0,05
Oleik Asit (C18:1c)	%		14,2 ± 1,1
trans Linolelaidik Asit (C18:2t)	%		<0,05
Linoleik Asit (C18:2c)	%		<0,05
trans Linolenik Asit (C18:3t)	%		<0,05
γ Linolenik Asit (C18:3n6)	%		<0,05
Arişidik Asit (C20:0)	%		<0,05
α-Linolenik Asit (C18:3n3)	%		0,56 ± 0,01
Eikosenoik (C20:1)	%		36,8 ± 0,1
Heneikosanoik (C21:0)	%		<0,05
Eikosadienoik (C20:2)	%		<0,05
Eikosatrienoik (C20:3n6)	%		<0,05
Behenik Asit (C22:0)	%		<0,05
Eikosatrienoik (C20:3n3)	%		<0,05
Erusik Asit (C22:1)	%		18,0 ± 0,1
Araşidonik (C20:4)	%		11,0 ± 0,1
Trikosanoik C23:0	%		<0,05
Dokosadienoik (C22:2)	%		<0,05
Eikosapentaenoik (C20:5)	%		<0,05
Lignoserik Asit (C24:0)	%		<0,05
Nervonik Asit (C24:1)	%		17,3 ± 0,1
Dokosahegzaenoik (C22:6)	%		<0,05
Doymuş Yağ Asitleri	%		1,6 ± 0,3
Tekli Doymamış Yağ Asitleri	%		86,0 ± 2,7
Çoklu Doymamış Yağ Asitleri	%		11,7 ± 0,6

Deneyi Yapan/Yapanlar	Deney Sorumlusu/Sorumluları	Birim Sorumlusu
Sibel TAŞKESEN Uzm. Teknisyen Güler ÇELİK Araştırmacı	Güler ÇELİK Araştırmacı	Anıl ÇETİNOĞLU Uzman Arş.

APPENDIX 7

THE ANALYSIS REPORTS OF VISCOSITY AND LUBRICITY OF JOJOBA OIL PROVIDED BY VİTSAN LABORATORY TURKEY

VİTSAN GÖZETİM MÜMESSİLLİK VE TİCARET A.Ş.

Dilovası Organize Sanayi Bölgesi 1. Kısım D 1009 Sok.

No.16 41455 Dilovası / Kocaeli

VL-0856/14
05-14

Deney Raporu

Müşterinin Adı/Adresi	Çetin ALTUNKAYA- Gönyeli / LEFKOŞA
İstek Numarası	0856/2014
Numunenin Adı ve Tarifi	Jojoba Yağı
Numune Şişesi ve Hacmi	1x0.25 Lt Plastik Şişe
Numunenin Alındığı Nokta	-
Numunenin Kabul Tarihi	06.05.2014
Deneyin Yapıldığı Tarih	06.05.2014-07.05.2014

SONUÇLAR

Test	Metot	Birim	Sonuç
Viskozite@40°C	TS 1451 EN ISO 3104	mm^2/s	24.55
Yağlama Özelliği	TS EN ISO 12156-1	µm	166

AÇIKLAMALAR

* Numune müşteri tarafından getirilmiştir. Şahit numune bulunmamaktadır. Deney tekrarı mümkün değildir.

Mühür	Tarih	Laboratuvar Şefi	Laboratuvar Müdürü
VİTSAN GÖZETİM A.Ş.	09.05.2014	Cihan DANACI	Serhan YÖRÜK

Beyan edilmiş genişletilmiş ölçüm belirsizliği, standart belirsizliğin k=2 olan genişletme katsayısı ile çarpımı sonucunda % 95 oranında güvenilirlik seviyesi sağlamaktadır.
Yukarıda verilen sonuçlar anılan numuneye ait sonuçlardır.
Bu rapor, laboratuvarın yazılı izni olmadan kısmen kopyalanıp çoğaltılamaz.
İmzasız ve mühürsüz raporlar geçersizdir.

VL-FO-031/05-05/11

Sayfa No 1/1

APPENDIX 8

THE ANALYSIS REPORTS OF VISCOSITY AND LUBRICITY OF JOJOBA OIL PROVIDED BY TÜPRAŞ LABORATORY TURKEY

Tüpraş

Türkiye Petrol Rafinerileri A.Ş.

Dok. No	: BAT.KSM.FRM.0026
Yayın Tarihi	: 19.02.2007
Rev. No	: 5
Rev. Tarihi	: 22.03.2018
Sayfa No	: 1/1

LABORATUVAR ÖZEL ANALİZ RAPORU

Tarih: 04.12.2018

NUMUNE ADI : Jojoba Bitki Yağı

NUMUNENİN GELDİĞİ YER : Yakın Doğu Üniversitesi

NUMUNE İSTEK NO : 35829

NUMUNE GELİŞ TARİHİ : 30.11.2018

ANALİZ SONUÇLARI

ÖZELLİK	BİRİM	ANALİZ SONUCU	DENEY YÖNTEMİ
Yağlayıcılık Özelliği Aşınma İzi Çapı (WSD) 60°Cta	µm	416	TS EN ISO 12156-1
Viskozite (Akmazlık) (100°Cta)	mm^2/s	6,417	TS 1451 EN ISO 3104

8066
Laboratuvar Şefi

Hizmete Özel / Confidential

APPENDIX 9

THE ANALYSIS REPORT OF THE FIRST COMMERCIAL JOJOBA OIL HARVESTED FROM MESARYA PLAIN

MRL

T.C.
GIDA TARIM ve HAYVANCILIK BAKANLIĞI
ÖZEL MRL MERKEZ ARAŞTIRMA VE KONTROL LABORATUVARI
(TURKISH REPUBLIC MINISTRY OF FOOD AGRICULTURE AND LIVESTOCK PRIVATE MRL CENTRAL RESEARCH AND CONTROL LABORATORY)
MUAYENE VE ANALIZ RAPORU
(ANALYSIS REPORT)

T.C. GIDA TARIM VE HAYVANCILIK BAKANLIĞI

TÜRKAK
Test
TS EN ISO/IEC 17025
AB-0184-T

AB-0184-T
11607876
26.09.2016

Rapor No *(Report No)* : 11607876 — **Tarih** *(Date)* : 26.09.2016

Analiz Amacı *(Reason of Analysis)* : ÖZEL İSTEK *(PRIVATE REQUEST)*
Numuneyi Gönderen / Adres *(Sample sent by / Address)* : ORYAS KUYUMCULUK PAZARLAMA VE TİC. LTD. ŞTİ./İSTANBUL
Numune Alma Tutanağının Tarihi / Sayısı *(...te and Number of Sampling Protocol)* : - / -
...umunenin *(Sample's)*
Cinsi *(Type)* : Yem (Jojoba Çekirdeği) *(Feed)*
Miktarı/Adedi *(Amount/Pieces)* : 420 g
Ambalajı *(Package)* : Kapalı Poly Ambalaj *(Closed Poly Pack)*
Seri No / Parti No / Mühür No *(Serial No / Lot No / Seal No)* : - / - / -
Üretici-Firma Adı / Kodu *(Producer-Firm Name / Code)* : - / -
Marka *(Brand)* : -
Üretim ve Son Kullanma Tarihi *(Production and Expire Date)* : - / -
Alındığı Yer ve Tarih *(Location and Date of Sampling)* : - / 19.09.2016
Numuneyi Alan *(Sample taken by)* : -
Numune Kod Numarası *(Sample Code Number)* : -
Analiz Başlama ve Bitiş Tarihi *(Date of Beginning and End of Analysis)* : 22.09.2016 / 26.09.2016
Laboratuvara Geliş Şekli ve Tarihi *(Delivery of sample / Date of receipt)* : Elden *(by Hand)* / 22.09.2016 15:47

Yapılan Analizler *(Analyses)*	Sonuç *(Result)*	Ölçüm Limiti *(LOQ)*	Birim *(Unit)*	Geri Kazanım *(Recovery)*	Analiz Metodu *(Analyses Method)*
Ham Yağ *(Crude Fat)* [1]	46.13	0.06	%		AOAC 2003.06, 2010

Yapılan muayene ve analiz sonucunda yukarıda belirtilen değerler tespit edilmiştir. *(Above mentioned values have been determined from the analytical work performed)*
Deney laboratuvarı olarak faaliyet gösteren MRL Merkez Kalıntı Araştırma Laboratuvarı, TÜRKAK'tan AB-0184-T ile TS EN ISO/IEC 17025:2012 standardına göre akredite edilmiştir. *(MRL Central Research and Control Laboratory accredited by TÜRKAK under registration number AB 0184-T for TS EN ISO/IEC 17025:2012 as test laboratory.)*
Notlar *(Notes)*
- Bu analiz raporu adli-idari işlemlerde ve reklam amacıyla kullanılamaz. *(This report shall not be used in the execütive-judicial processes and for advertising purposes)*
- Bu analiz raporunun hiç bir bölümü tek başına veya ayrı ayrı kullanılamaz. *(This report with all parts is a whole, no part of this report can be used separately)*
- Analiz sonuçları yukarıda belirtilen numune için geçerlidir. *(Results of analysis belong to sample mentioned above)*
- ...nimiz alınmadan raporlarımız çoğaltılamaz ve yayınlanamaz. İmzasız ve mühürsüz raporlar geçersizdir. *(No copy or no publish without permission. The report without signature and seal are invalid)*
- LOQ: Minimum Ölçüm Limiti *(LOQ: Limit Of Quantitation)*

Açıklamalar *(Description)*
[1] :Bu analiz akreditasyon kapsamındadır. *(This analyze covered by accreditation.)*

Numune Kabul ve Raporlama Böl. Sorumlusu
(Head of Sample Admisson and Reporting Dept.)
Gıda Mühendisi *(Food Engineer)*
FATMA YILDIZ

Analitik Kimya Bölüm Sorumlusu
(Head of Analytical Chemistry Department)
Kimyager *(Chemist)*
A. MULLA BİRER

26.09.2016
Tasdik Olunur *(Approved by)*
Laboratuvar Müdürü *(Laboratory Manager)*
Gıda Yüksek Mühendisi *(Food Engineer M.Sc.)*
ORHAN GÖZEN

MRL

T.C.
GIDA TARIM ve HAYVANCILIK BAKANLIĞI
ÖZEL MRL MERKEZ ARAŞTIRMA VE KONTROL LABORATUVARI
(TURKISH REPUBLIC MINISTRY OF FOOD AGRICULTURE AND LIVESTOCK PRIVATE MRL CENTRAL RESEARCH AND CONTROL LABORATORY)

MUAYENE VE ANALİZ RAPORU
(ANALYSIS REPORT)

T.C. GIDA TARIM VE HAYVANCILIK BAKANLIĞI

TÜRKAK Test TS EN ISO/IEC 17025 AB-0184-T

AB-0184-T
11607878
27.09.2016

Rapor No *(Report No)* : 11607878 — **Tarih** *(Date)* : 27.09.2016

Analiz Amacı *(Reason of Analysis)* : ÖZEL İSTEK *(PRIVATE REQUEST)*
Numuneyi Gönderen / Adres *(Sample sent by / Address)* : ORYAS KUYUMCULUK PAZARLAMA VE TİC. LTD. ŞTİ./İSTANBUL
Numune Alma Tutanağının Tarihi / Sayısı *(… and Number of Sampling Protocol)* : - / -
N…unenin *(Sample's)*
- **Cinsi** *(Type)* : Jojoba Yağı *(Jojoba Oil)*
- **Miktarı/Adedi** *(Amount/Pieces)* : 462 g
- **Ambalajı** *(Package)* : Kapaklı Plastik Şişe *(Covered Plastic Bottle)*
- **Seri No / Parti No / Mühür No** *(Serial No / Lot No / Seal No)* : - / - / -
- **Üretici-Firma Adı / Kodu** *(Producer-Firm Name / Code)* : - / -
- **Marka** *(Brand)* : -
- **Üretim ve Son Kullanma Tarihi** *(Production and Expire Date)* : - / -
- **Alındığı Yer ve Tarih** *(Location and Date of Sampling)* : - / 19.09.2016
- **Numuneyi Alan** *(Sample taken by)* : -

Numune Kod Numarası *(Sample Code Number)* : -
Analiz Başlama ve Bitiş Tarihi *(Date of Beginning and End of Analysis)* : 22.09.2016 / 26.09.2016
Laboratuvara Geliş Şekli ve Tarihi *(Delivery of sample / Date of receipt)* : Kargo *(by Cargo)* / 22.09.2016 15:48

Yapılan Analizler *(Analyses)*	Sonuç *(Result)*	Ölçüm Limiti *(LOQ)*	Birim *(Unit)*	Geri Kazanım *(Recovery)*	Analiz Metodu *(Analyses Method)*
Kırılma İndisi(nD 20 C) *(Refractive Index)* [1]	1.4650				AOAC 921.08, 2010
Ham Yağ *(Crude Fat)* [1]	97.43	0.1	%		Foss Tecator Soxtec Application Note
Bağıl Yoğunluk (Özgül Ağırlık) *(Bağıl Yoğunluk (Özgül Ağırlık))*	0.8624				AOAC 985.16, 2010

Yapılan muayene ve analiz sonucunda yukarıda belirtilen değerler tespit edilmiştir. *(Above mentioned values have been determined from the analytical work performed)*
Deney laboratuvarı olarak faaliyet gösteren MRL Merkez Kalıntı Araştırma Laboratuvarı, TÜRKAK'tan AB-0184-T ile TS EN ISO/IEC 17025:2012 standardına göre akredite edilmiştir. *(MRL Central Research and Control Laboratory accredited by TÜRKAK under registration number AB-0184-T for TS EN ISO/IEC 17025:2012 as test laboratory.)*

N… *(Notes)*
- …naliz raporu adli-idari işlemlerde ve reklam amacıyla kullanılamaz. *(This report shall not be used in the executive judicial processes and for advertising purposes)*
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- İznimiz alınmadan raporlarımız çoğaltılamaz ve yayınlanamaz. İmzasız ve mühürsüz raporlar geçersizdir. *(No copy or no publish without permission. The report without signature and seal are invalid)*
- LOQ: Minimum Ölçüm Limiti *(LOQ: Limit Of Quantization)*

Açıklamalar *(Description)*
[1] :Bu analiz akreditasyon kapsamındadır. *(This analyze covered by accreditation.)*

Numune Kabul ve Raporlama Böl. Sorumlusu
(Head of Sample Admisson and Reporting Dept.)
Gıda Mühendisi *(Food Engineer)*
FATMA YILDIZ

Analitik Kimya Bölüm Sorumlusu
(Head of Analytical Chemistry Department)
Kimyager *(Chemist)*
A. MULLA BİRER

27.09.2016
Tasdik Olunur *(Approved by)*
Laboratuvar Müdürü *(Laboratory Manager)*
Gıda Yüksek Mühendisi *(Food Engineer M.Sc.)*
ORHAN GÖZEN

MRL

T.C
GIDA TARIM VE HAYVANCILIK BAKANLIĞI

T.C.
GIDA TARIM ve HAYVANCILIK BAKANLIĞI
ÖZEL MRL MERKEZ ARAŞTIRMA VE KONTROL LABORATUVARI
(TURKISH REPUBLIC MINISTRY OF FOOD AGRICULTURE AND LIVESTOCK
PRIVATE MRL CENTRAL RESEARCH AND CONTROL LABORATORY)

MUAYENE VE ANALIZ RAPORU
(ANALYSIS REPORT)

TÜRKAK
Test
TS EN ISO/IEC 17025
AB-0184-T

AB-0184-T
11608191
30.09.2016

Rapor No *(Report No)* : 11608191 **Tarih** *(Date)* : 30.09.2016

Analiz Amacı *(Reason of Analysis)* : ÖZEL İSTEK *(PRIVATE REQUEST)*
Numuneyi Gönderen / Adres *(Sample sent by / Address)* : ORYAS KUYUMCULUK PAZARLAMA VE TİC. LTD. ŞTİ./İSTANBUL
Numune Alma Tutanağının Tarihi / Sayısı *(Date and Number of Sampling Protocol)* : - / -
Numunenin *(Sample's)*
- **Cinsi** *(Type)* : Jojoba Yağı *(Jojoba Oil)*
- **Miktarı/Adedi** *(Amount/Pieces)* : 344 g
- **Ambalajı** *(Package)* : Kapaklı Plastik Şişe *(Covered Plastic Bottle)*
- **Seri No / Parti No / Mühür No** *(Serial No / Lot No / Seal No)* : - / - / -
- **Üretici-Firma Adı / Kodu** *(Producer-Firm Name / Code)* : - / -
- **Marka** *(Brand)* : -
- **Üretim ve Son Kullanma Tarihi** *(Production and Expire Date)* : - / -
- **Alındığı Yer ve Tarih** *(Location and Date of Sampling)* : - / -
- **Numuneyi Alan** *(Sample taken by)* : -

Numune Kod Numarası *(Sample Code Number)* : -
Analiz Başlama ve Bitiş Tarihi *(Date of Beginning and End of Analysis)* : 29.09.2016 / 30.09.2016
Laboratuvara Geliş Şekli ve Tarihi *(Delivery of sample / Date of receipt)* : Kargo *(by Cargo)* / 27.09.2016 16:54

Yapılan Analizler *(Analyses)*	Sonuç *(Result)*	Ölçüm Limiti *(LOQ)*	Birim *(Unit)*	Geri Kazanım *(Recovery)*	Analiz Metodu *(Analyses Method)*
Yağ Asitleri Profili *(Fatty Acid Profile)*					COI/T.20/Doc.no.17/Rev. 1, 2001
Toplam Doymuş Yağ Asitleri *(Saturated Fatty Acids)*	40.80		%		
Tekli Doymamış Yağ Asitleri *(Mono-Unsaturated Fatty Acids)*	44.42		%		
Çoklu Doymamış Yağ Asitleri *(Polyunsaturated Fatty Acids)*	14.78		%		
Toplam Trans Yağ Asitleri *(Total Trans Fatty Acids)*	Tespit Edilemedi (<0.05) *(Not Detected (<0.05))*		%		

MRL

TÜRKAK
Test
TS EN ISO/IEC 17025
AB-0184-T

Rapor No *(Report No)* : 11608191 **Tarih** *(Date)* : 30.09.2016

Yapılan Analizler *(Analyses)*	**Sonuç** *(Result)*	**Ölçüm Limiti** *(LOQ)*	**Birim** *(Unit)*	**Geri Kazanım** *(Recovery)*	**Analiz Metodu** *(Analyses Method)*

Yapılan muayene ve analiz sonucunda yukarıda belirtilen değerler tespit edilmiştir. *(Above mentioned values have been determined from the analytical work performed)*
Deney laboratuvarı olarak faaliyet gösteren MRL Merkez Kalıntı Araştırma Laboratuvarı, TÜRKAK'tan AB-0184-T ile TS EN ISO/IEC 17025:2012 standardına göre akredite edilmiştir. *(MRL General Research and Control Laboratory accredited by TÜRKAK under registration number AB-0184-T for TS EN ISO/IEC 17025:2012 as test laboratory.)*

Notlar *(Notes)*
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- Analiz sonuçları yukarıda belirtilen numune için geçerlidir. *(Results of analysis belong to sample mentioned above)*
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- LOQ: Minimum Ölçüm Limiti *(LOQ: Limit Of Quantitation)*

Açıklamalar *(Description)*
[1] :Bu analiz akreditasyon kapsamındadır.*(This analyze covered by accreditation.)*

Numune Kabul ve Raporlama Böl. Sorumlusu
(Head of Sample Admisson and Reporting Dept.)
Gıda Mühendisi *(Food Engineer)*
FATMA YILDIZ

Kimya Bölüm Sorumlusu
(Head of Chemical Department)
Kimyager *(Chemist)*
AHMET TAŞKIRAN

30.09.2016
Tasdik Olunur *(Approved by)*
Laboratuvar Müdürü *(Laboratory Manager)*
Gıda Yüksek Mühendisi *(Food Engineer M.Sc.)*
ORHAN GÖZEN

APPENDIX 9

CURRICULUM VITAE

CURRICULUM VITAE

PERSONAL INFORMATION

Surname Name : Bilin, Metin
Nationality :Turkish Cypriot
Date and Place of Birth :12 December 1956, Lefke
Marital Status : Married
Phone : +90 392 223 64 64 (ext. 285)
Fax : +90 392 223 66 24
E-Mail : metin.bilin@neu.edu.tr

EDUCATION

Degree	**Instution**	**Year of Graduation**
PhD	Near East University – TRNC Department of Mechanical Engineering	2020
M.Sc	Near East University – TRNC Department of Electrical and Electronic Engineering	2003
B.Sc	Çukurova University-Turkey Department of Mechanical Engineering	1978

WORK EXPERIENCE

Year	**Place**	**Enrollment**
Sept, 1998-present	Member of the Teaching Staff in NEU Department of Mechanical Engineering	Senior Lecturer
Nov, 1984	Cyrus Turkish Industrial Enterprises Ltd.	Factory Manager
Dec, 1983	Volkswagen Factory -Wolfsburg	Scholarship
Oct, 1981	Cyrus Turkish Industrial Enterprises Ltd.	Mech. Engineer

FOREIGN LANGUAGES

English, German, Greek

MEMBERSHIP OF PROFESSINOAL ORGANIZATIONS

- *Member*, Chamber of the Mechanical Engineering of TRNC.

PUBLICATIONS IN INTERNATIONAL REFEREED JOURNALS (IN COVERAGE OF SSCI/SCI-EXPANDED AND AHCI)

- Alshanableh, F., Bilin, M., Evcil, A., Savaş, M.A. (2019). Estimation of cold flow properties of biodiesel using ANFIS-based models. *Energy Sources Part A: Recovery Utilization and Environmental Effects*. https://doi.org/10.1080/15567036.2019.1672832

BULLETING PRESENTED IN INTERNATIONAL ACADEMIC MEETING AND PUBLISHED IN PROCEEDINGS BOOKS:

- Bilin, M., Alshanableh, F., Evcil, A., Savaş, M.A. (2018). A comperative Examination of the Quality of Jojoba Seed Oil Harvested on the Mesaoria Plain of Cyprus Island. *2nd International Symposium on Multidisciplinary Studies and Innovative Technologies (ISMSIT)* 19-21 October 2018, Ankara/Turkey.

- Bilin, M., Alshanableh, F., Evcil, A., Savaş, M.A. (2018). A comperative Examination of the Quality of Jojoba Seed Oil Harvested on the Mesaoria Plain of Cyprus Island. IEEE Xplore Digital Library, doi: 10.1109/ISMSIT. 2018. 8567052 10 Dec. 2018

BULLETING PRESENTED IN NATIONAL ACADEMIC MEETING AND PUBLISHED IN PROCEEDINGS BOOKS:

- Bilin, M. (2013). KKTC için Stratejik Endüstriyel Bir Bitki Jojoba ve Biyodizel, Kendi Yakıtımızı Üretelim. Kıbrıs Gazetesi ekonomi eki, pp 13 (8 Nisan-2013).

ONLINE PUBLICATIONS

- A Comperative Examination of the Quality of Jojoba Seed Oil Harvested on the Mesaoria Plain of Cyprus Island.

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- Manufacturing Technology II
- Introduction to Mechanical Engineering
- Mechanical Engineering Orientation
- Technical Drawing
- Quality Control
- Summer Training Coordinator

- Manufacturing Technology I (Turkish)
- Manufacturing Technology II (Turkish)
- Mechanical Engineering Orientation (Turkish)
- Technical Drawing (Turkish)
- Quality Control (Turkish)
- Summer Training coordinator (Turkish)

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