

**CHEMOMETRIC ANALYSIS OF OIL PALM (*Elaeis guineensis*
Jacq.) GERMPLASM FROM SENEGAL AND GAMBIA**

Hana Saleh Alhadi Abdarhman

(Matric No. 3130043)

Dissertation submitted in partial fulfillment for the degree of

MASTER OF SCIENCE

(FOOD BIOTECHNOLOGY)

Faculty of Science and Technology

UNIVERSITI SAINS ISLAM MALAYSIA

Nilai

May 2015

AUTHOR DECLARATION

I hereby declare that the work in this dissertation is my own except for quotations and summaries which have been duly acknowledged.

Date: 15th May, 2015

Signature:

Name: Hana Saleh Alhadi Abdarhman

Matric No: 3130043

Address: P6-11A-05 Plaza Indah

Sepakat Indah1, Kajang,

43000, Selangor

BIODATA OF AUTHOR

Hana Saleh Alhadi (Matric No. 3130043) was born on 8th February, 1988. She is a Libyan by Nationality. She is currently living at P6-11A-05 Plasa Indah Apartment Sepkat Indah 1, Kajang, Selangor, Malaysia. She obtained her Bachelor of Science (Botany) from 7th October University, Bani Walid, Libya. Being an enthusiastic person, with the purpose of exploring knowledge and skill of the field she enrolled in September, 2013 for her Master Degree in Food Biotechnology at Universiti Sains Islam Malaysia, Bandar Baru Nilai, Malaysia. She can be contacted by email via (hs.zbida@yahoo.com).

ACKNOWLEDGEMENTS

My first and foremost thanks is to Allah (SWT) who has made all things possible. I would like to express my gratitude to my supervisor Emeritus Professor Dr. Jalani Sukaimi for the useful comments, remarks and engagement through the learning process of this master dissertation. Your advice on both research as well as on my career have been priceless. Furthermore, I would like to thank my co-supervisor, Dr. Mohd Sukri Hassan for his supervisor on chemometrics for my thesis.

Also, I would like to thank staff of the Faculty of Science and Technology of the university; the Dean of the faculty, Prof. Bachok Taib, staff of Food Biotechnology, laboratory assistants and technicians of the faculty. I am thankful for their aspiring guidance, invaluable constructive criticism and friendly advice during my study. I am sincerely grateful to them for sharing their truthful and illuminating views on a number of issues related to the research and career.

A special thanks to my family. Words cannot express how grateful I am to my mother, father, brothers and sisters for all of the sacrifices that you've made on my behalf. Your prayer for me was what sustained me thus far. At the end I would like express appreciation to the Government of Libya for financial support of my studies. Without you, my appreciation would not be completed.

UNIVERSITY OF ISLAM

ABSTRAK

Anggaran kepelbagaian genetik dan menentukan hubungan antara koleksi adalah strategi yang penting untuk memastikan pengumpulan dan penggunaan germplasma yang cekap. Bahan germplasma sawit yang dikutip dari Senegal dan Gambia yang ditanam di Stesen Kluang MPOB telah dicirikan mengikut kepelbagaian genetik. Sebanyak 44 ciri - ciri agronomi germplasma sawit ini telah dinilai melalui statistik yang mudah untuk menilai kepelbagaian genetik; dan dua teknik kemometrik (PCA dan analisis Kluster) untuk mengenal pasti sifat - sifat yang menyumbang kepada perubahan keseluruhan dan mengklasifikasikan bahan-bahan itu berdasarkan persamaan. Keputusan profil kepelbagaian itu menunjukkan bahawa germplasma kelapa sawit Senegal dan Gambia mempunyai kebolehubahan yang rendah kepada tinggi untuk pelbagai ciri. Sembilan komponen utama dengan nilai eigen > 1 bersamaan dengan 88% daripada jumlah variasi dengan majoriti variasi itu dikuasai oleh PC1. Kebanyakan ciri-ciri, khususnya, BTS, ABW, BWT, MFW, P / B, M / F, OY, TEP, TDM, BDM, e, S / F, K / F, O / B dan K / B menyumbang kepada kepelbagaian di antara dan dalam germplasma, yang mana menunjukkan bahawa variasi yang luas wujud dalam bahan germplasma yang telah dikaji. Analisis kumpulan Ward adalah berdasarkan keputusan - keputusan PCA yang telah dikumpulkan untuk aksesori 42 minyak kelapa sawit kepada enam kelompok, dan kelompok-VI mempunyai bilangan tertinggi ahli. Tambahan pula, ia tiada kaitan antara kepelbagaian genetik dan asal geografi. Purata ciri-ciri agronomi setiap kelompok menunjukkan bahawa kelompok-III mempunyai nilai purata tertinggi pada sifat hasilnya. Selain itu, kumpulan - kumpulan kelompok yang mempunyai nilai purata yang tinggi bagi ciri-ciri yang diinginkan boleh dipilih untuk ciri-ciri setiap satu. Pengaksesan ini boleh digunakan untuk menghasilkan bahan-bahan kelapa sawit yang berhasil tinggi.

Kata kunci: Kelapa sawit, germplasma, kepelbagaian genetik, kimometrik, analisis komponen utama, analisis kelompok.

ABSTRACT

Estimation of genetic diversity and determination of the relationships between collections are useful strategies for ensuring efficient germplasm collection and utilization. Oil palm germplasm materials collected from Senegal and Gambia maintained at the MPOB Kluang Station were characterized for genetic diversity. A total of 44 agronomic traits of these oil palm materials were subjected to simple statistics to evaluate the genetic variability; and two chemometric techniques (PCA and Cluster analysis) to identify the characters contributing to the overall variation and classify the materials based on similarity. Results of the variability profile showed that the Senegal and Gambia oil palm germplasm exhibited low to high variability for the various traits. Nine principal components with eigenvalue >1 accounted for 88 % of the total variation with PC1 capturing majority of the variation. Most of the traits especially, FFB, ABW, BWT, MFW, P/B, M/F, OY, TEP, TDM, BDM, e , S/F, K/F, O/B and K/B contributed to divergence between and within the germplasm, indicating that wide variation exists in the germplasm materials studied. Ward's cluster analysis based on the PCA results grouped the 42 oil palm accessions into six clusters with cluster-VI having the highest number of members. Furthermore, there was no association between genetic diversity and geographical origin. Means of the agronomic traits of each cluster showed that cluster-III had the highest mean value of yield traits. Also, the cluster groups having high mean values for desired traits could be selected for the traits per se. These accessions could be used to produce high yielding oil palm materials.

Keywords: Oil palm, germplasm, genetic diversity, chemometrics, principal component analysis, cluster analysis.

ملخص البحث

تقدير التنوع الوراثي وتحديد العلاقات بين المجموعات هي استراتيجيات مفيدة لضمان جمع المادة الوراثية والاستفادة منها. تميزت مواد الأصول الوراثية لنخيل الزيت التي تم جمعها من السنغال وغامبيا من محطة MPOB Kluang في الحفاظ على التنوع الجيني. وتعرض 44 من الصفات الزراعية لزيت النخيل لإحصاءات بسيطة لتقييم التباين الوراثي. وتقنيات تحليل المكون الرئيسي (PCA) والتحليل العنقودي (CA) للتعرف على الشخصيات المساهمة في الاختلاف الكلي وتصنيف المواد على أساس التشابه. وأظهرت نتائج تحليل المكون الرئيسي (PCA) أن الأصول الوراثية لنخيل الزيت من السنغال وغامبيا عرضت تفاوت كبير لمختلف الصفات. تسعة عناصر رئيسية مع القيمة الذاتية > 1 تمثل 88% من التباين الكلي وأغلب الاختلاف من PC1. ساهم معظم الصفات خاصة، MFW, BWT, ABW, FFB، K / B و O / B , K / F , S / F , BDM, TDM, TE, P OY, M /, F P / B, مشيراً إلى أن تباين واسع موجود في مواد الأصول الوراثية المدروسة. التحليل العنقودي (CA) وارد بناء على نتائج تحليل المكون الرئيسي (PCA) حيث تم تقسيم 42 من نخيل الزيت إلى ست مجموعات. كتلة 5 تميزت بوجود أكبر عدد من الأعضاء. وعلاوة على ذلك لم يكن هناك ارتباط بين التنوع الجيني والأصل الجغرافي. وأظهرت الصفات الزراعية أن الكتلة 3 تميزت بوجود أعلى قيمة لمتوسط العائد من الصفات أيضاً. ويمكن استخدام هذه المجموعات لإنتاج زيت النخيل ذات بعوائد عالية.

الكلمات المفتاحية للبحث : الأصول الوراثية لزيت النخيل، التنوع الجيني، chemometrics، تحليل المكون الرئيسي و التحليل العنقودي.

CONTENT PAGE

Contents	Page
AUTHOR DECLARATION	i
BIODATA OF AUTHOR	ii
ACKNOWLEDGEMENTS	iii
ABSTRACT	v
ABSTRACT	vi
ABSTRACT	vii
CONTENT PAGE	viii
LIST OF TABLES	xi
LIST OF FIGURES	xii
LIST OF APPENDICES	xiii
ABBREVIATION	xiv
CHAPTER I: INTRODUCTION	1
1.1 Problem Statement	2
1.2 Aim	3
1.3 Research Questions	3
1.4 Objectives	3
CHAPTER II: LITERATURE REVIEW	4
2.1 HISTORY OF THE GENUS ELAEIS	4
2.1.1 Evolution of the Genus <i>Elaeis</i>	5
2.1.2 Morphology and Biology of <i>E. guineensis</i>	6
2.1.3 Infra Specific Classification of <i>E. guineensis</i>	7
2.1.4 Ecology and Morphology of <i>E. guineensis</i>	9
2.2 PLANT GENETIC RESOURCES	13

2.2.1 Genetic Diversity	13
2.2.2 Characterization of Genetic Diversity	14
2.3 CHEMOMETRICS	15
2.3.1 Principal Components Analysis (PCA)	16
2.3.1 Clustering Analysis	18
2.3.1.1 Types of Clustering	20
2.4 PREVIOUS STUDIES	21
CHAPTER III: MATERIALS AND METHODS	27
3.1 Breeding Materials and Site Location	27
3.2 Data Collection	27
3.2.1 Yield and Yield Components	27
3.2.2 Bunch Analysis	28
3.2.3 Vegetative Measurements and Physiological Characters	30
3.2.4 Fatty Acid Traits	31
3.3 Statistical Analyses	32
3.3.1 Variability Profile	32
3.3.2 Principal Components Analysis (PCA)	33
3.3.3 Cluster Analysis	34
CHAPTER IV: RESULTS	36
4.1 Variability Profile	36
4.2 Principal Components Analysis (PCA)	36
4.2.1 Scores Plot	38
4.2.2 Loadings	38
4.2.3 Scores	42
4.2.4 Bi-Plot	42
4.3 Cluster Analysis	45
4.3.1 Genetic Distance	49
CHAPTER V: DISCUSSION	50
5.1 PCA	50

5.1.1 Scores Plot	51
5.1.2 Loadings	51
5.1.3 Scores	53
5.1.4 Bi-Plot	54
5.2 Cluster Analysis	54
5.2.1 Genetic Distance	56
CHAPTER VI: CONCLUSIONS AND RECOMMENDATIONS	57
REFERENCES	59
APPENDIX	65

LIST OF TABLES

	Page
Table 1: Extent of Variation	36
Table 2: Variability profile of Senegal and Gambian oil palm germplasm as analyzed by descriptive statistics	37
Table 3: Principal components analysis for Senegal and Gambia oil palm germplasm based on 46 agronomic traits	39
Table 4: Scores of the 42 Senegal-Gambian oil palm germplasm on the extracted PCs	43
Table 5: Characteristics means of six clusters generated by Ward's cluster analysis based on 46 agronomic traits	48
Table 6: Inter cluster distance as analyzed by proximity matrix of squared Euclidean distance	49

LIST OF FIGURES

	Page
Figure 1: Scores plot where PCs 1 and 2 are orthogonal to each other	18
Figure 2: Clustering pattern	19
Figure 3: Scores plot of principal component analysis between percentage variance and number of principal components	38
Figure 4: Scattered diagram of 46 oil palm germplasm traits for first two components contributing almost half of the total variability	41
Figure 5: Scattered diagram of 46 oil palm germplasm traits showing correlation to the first two components	41
Figure 6: Two dimensional ordinations of 42 Senegal-Gambian oil palm accessions on principal axes 1 and 2	44
Figure 7: Bi-plot of 46 oil palm agronomic traits and 42 oil palm accessions on PC 1 and PC 2	44
Figure 8: The relationship among the oil palm germplasm reflected by cluster analysis	46

LIST OF APPENDICES

	Page
Appendix 1: Proximity Matrix of Squared Euclidean Distance	66

UNIVERSITI SAINS ISLAM MALAYSIA
جامعة العلوم الإسلامية
ISLAMIC SCIENCE UNIVERSITY OF MALAYSIA

ABBREVIATION

ABW	average bunch weight
BNO	bunch number
BWT	bunch weight
BDM	bunch dry matter
BI	bunch index
C12:0	lauric acid
C14:0	myristic acid
C16:0	palmitic acid
C16:1	palmitoleic acid
C18:0	stearic acid
C18:1	oleic acid
C18:2	linoleic acid
C18:3	linolenic acid
C20:0	arachidic acid
DIAM	diameter of trunk
<i>e</i>	radiation conversion efficiency
<i>f</i>	fractional interception of radiation
F/B	fruit/bunch
FFB	fresh fruit bunch
FP	frond production
GAM	Gambia
HT	height
IV	iodine value
K/B	kernel/bunch
K/F	kernel/fruit
KY	kernel yield
LA	leaf area

LAI	leaf area index
LL	leaflet length
LN	number of leaflet
LW	leaf width
MARDI	Malaysian agricultural research and development institute
M/F	mesocarp/fruit
MFW	mean fruit weight
MNW	mean nut weight
MPOB	Malaysian palm oil board
NAR	net area ratio
NIFOR	Nigerian institute for oil palm research
O/B	oil/bunch
O/DM	oil/dry mass
O/WM	oil/wet mass
OY	oil yield
P/B	parthenocarpic fruit/bunch
PCA	principal component analysis
PC(s)	principal component(s)
PCS	petiole cross section
PORIM	palm oil research institute of Malaysia
RL	rachis length
RRS	reciprocal recurrent selection
SEN	Senegal
S/F	shell/fruit
TEP	total economic product
TDM	total dry mass
UPGMA	unpair weighted group method using arithmetic averages
VDM	vegetative dry mass
WHCA	Ward's hierarchical clustering analysis