

GLOBAL JOURNAL

OF SCIENCE FRONTIER RESEARCH: C

Biological Sciences

Activities of Methylene

Ordination and Classification

Highlights

Acceptance of Sugar-Free

Strategies of Rodent Control

Discovering Thoughts, Inventing Future

Volume 14

Issue 2

Version 1.0



GLOBAL JOURNAL OF SCIENCE FRONTIER RESEARCH: C
BIOLOGICAL SCIENCE

GLOBAL JOURNAL OF SCIENCE FRONTIER RESEARCH: C
BIOLOGICAL SCIENCE

VOLUME 14 ISSUE 2 (VER. 1.0)

OPEN ASSOCIATION OF RESEARCH SOCIETY

© Global Journal of Science
Frontier Research. 2014.

All rights reserved.

This is a special issue published in version 1.0
of "Global Journal of Science Frontier
Research." By Global Journals Inc.

All articles are open access articles distributed
under "Global Journal of Science Frontier
Research"

Reading License, which permits restricted use.
Entire contents are copyright by of "Global
Journal of Science Frontier Research" unless
otherwise noted on specific articles.

No part of this publication may be reproduced
or transmitted in any form or by any means,
electronic or mechanical, including
photocopy, recording, or any information
storage and retrieval system, without written
permission.

The opinions and statements made in this
book are those of the authors concerned.
Ultraculture has not verified and neither
confirms nor denies any of the foregoing and
no warranty or fitness is implied.

Engage with the contents herein at your own
risk.

The use of this journal, and the terms and
conditions for our providing information, is
governed by our Disclaimer, Terms and
Conditions and Privacy Policy given on our
website [http://globaljournals.us/terms-and-condition/
menu-1463/](http://globaljournals.us/terms-and-condition/menu-1463/)

By referring / using / reading / any type of
association / referencing this journal, this
signifies and you acknowledge that you have
read them and that you accept and will be
bound by the terms thereof.

All information, journals, this journal,
activities undertaken, materials, services and
our website, terms and conditions, privacy
policy, and this journal is subject to change
anytime without any prior notice.

Incorporation No.: 0423089
License No.: 42125/022010/1186
Registration No.: 430374
Import-Export Code: 1109007027
Employer Identification Number (EIN):
USA Tax ID: 98-0673427

Global Journals Inc.

(A Delaware USA Incorporation with "Good Standing"; **Reg. Number: 0423089**)

Sponsors: *Open Association of Research Society*
Open Scientific Standards

Publisher's Headquarters office

Global Journals Headquarters
301st Edgewater Place Suite, 100 Edgewater Dr.-Pl,
Wakefield MASSACHUSETTS, Pin: 01880,
United States of America
USA Toll Free: +001-888-839-7392
USA Toll Free Fax: +001-888-839-7392

Offset Typesetting

Global Journals Incorporated
2nd, Lansdowne, Lansdowne Rd., Croydon-Surrey,
Pin: CR9 2ER, United Kingdom

Packaging & Continental Dispatching

Global Journals
E-3130 Sudama Nagar, Near Gopur Square,
Indore, M.P., Pin:452009, India

Find a correspondence nodal officer near you

To find nodal officer of your country, please
email us at local@globaljournals.org

eContacts

Press Inquiries: press@globaljournals.org
Investor Inquiries: investors@globaljournals.org
Technical Support: technology@globaljournals.org
Media & Releases: media@globaljournals.org

Pricing (Including by Air Parcel Charges):

For Authors:

22 USD (B/W) & 50 USD (Color)
Yearly Subscription (Personal & Institutional):
200 USD (B/W) & 250 USD (Color)

INTEGRATED EDITORIAL BOARD
(COMPUTER SCIENCE, ENGINEERING, MEDICAL, MANAGEMENT, NATURAL
SCIENCE, SOCIAL SCIENCE)

John A. Hamilton, "Drew" Jr.,
Ph.D., Professor, Management
Computer Science and Software
Engineering
Director, Information Assurance
Laboratory
Auburn University

Dr. Henry Hexmoor
IEEE senior member since 2004
Ph.D. Computer Science, University at
Buffalo
Department of Computer Science
Southern Illinois University at Carbondale

Dr. Osman Balci, Professor
Department of Computer Science
Virginia Tech, Virginia University
Ph.D. and M.S. Syracuse University,
Syracuse, New York
M.S. and B.S. Bogazici University,
Istanbul, Turkey

Yogita Bajpai
M.Sc. (Computer Science), FICCT
U.S.A. Email:
yogita@computerresearch.org

Dr. T. David A. Forbes
Associate Professor and Range
Nutritionist
Ph.D. Edinburgh University - Animal
Nutrition
M.S. Aberdeen University - Animal
Nutrition
B.A. University of Dublin- Zoology

Dr. Wenying Feng
Professor, Department of Computing &
Information Systems
Department of Mathematics
Trent University, Peterborough,
ON Canada K9J 7B8

Dr. Thomas Wischgoll
Computer Science and Engineering,
Wright State University, Dayton, Ohio
B.S., M.S., Ph.D.
(University of Kaiserslautern)

Dr. Abdurrahman Arslanyilmaz
Computer Science & Information Systems
Department
Youngstown State University
Ph.D., Texas A&M University
University of Missouri, Columbia
Gazi University, Turkey

Dr. Xiaohong He
Professor of International Business
University of Quinnipiac
BS, Jilin Institute of Technology; MA, MS,
PhD,. (University of Texas-Dallas)

Burcin Becerik-Gerber
University of Southern California
Ph.D. in Civil Engineering
DDes from Harvard University
M.S. from University of California, Berkeley
& Istanbul University

Dr. Bart Lambrecht

Director of Research in Accounting and Finance
Professor of Finance
Lancaster University Management School
BA (Antwerp); MPhil, MA, PhD
(Cambridge)

Dr. Carlos García Pont

Associate Professor of Marketing
IESE Business School, University of Navarra
Doctor of Philosophy (Management),
Massachusetts Institute of Technology (MIT)
Master in Business Administration, IESE,
University of Navarra
Degree in Industrial Engineering,
Universitat Politècnica de Catalunya

Dr. Fotini Labropulu

Mathematics - Luther College
University of Regina
Ph.D., M.Sc. in Mathematics
B.A. (Honors) in Mathematics
University of Windsor

Dr. Lynn Lim

Reader in Business and Marketing
Roehampton University, London
BCom, PGDip, MBA (Distinction), PhD,
FHEA

Dr. Mihaly Mezei

ASSOCIATE PROFESSOR
Department of Structural and Chemical
Biology, Mount Sinai School of Medical
Center
Ph.D., Eötvös Loránd University
Postdoctoral Training,
New York University

Dr. Söhnke M. Bartram

Department of Accounting and Finance
Lancaster University Management School
Ph.D. (WHU Koblenz)
MBA/BBA (University of Saarbrücken)

Dr. Miguel Angel Ariño

Professor of Decision Sciences
IESE Business School
Barcelona, Spain (Universidad de Navarra)
CEIBS (China Europe International Business School).
Beijing, Shanghai and Shenzhen
Ph.D. in Mathematics
University of Barcelona
BA in Mathematics (Licenciatura)
University of Barcelona

Philip G. Moscoso

Technology and Operations Management
IESE Business School, University of Navarra
Ph.D in Industrial Engineering and
Management, ETH Zurich
M.Sc. in Chemical Engineering, ETH Zurich

Dr. Sanjay Dixit, M.D.

Director, EP Laboratories, Philadelphia VA
Medical Center
Cardiovascular Medicine - Cardiac
Arrhythmia
Univ of Penn School of Medicine

Dr. Han-Xiang Deng

MD., Ph.D
Associate Professor and Research
Department Division of Neuromuscular
Medicine
Davee Department of Neurology and Clinical
Neuroscience
Northwestern University
Feinberg School of Medicine

Dr. Pina C. Sanelli

Associate Professor of Public Health
Weill Cornell Medical College
Associate Attending Radiologist
NewYork-Presbyterian Hospital
MRI, MRA, CT, and CTA
Neuroradiology and Diagnostic
Radiology
M.D., State University of New York at
Buffalo, School of Medicine and
Biomedical Sciences

Dr. Roberto Sanchez

Associate Professor
Department of Structural and Chemical
Biology
Mount Sinai School of Medicine
Ph.D., The Rockefeller University

Dr. Wen-Yih Sun

Professor of Earth and Atmospheric
SciencesPurdue University Director
National Center for Typhoon and
Flooding Research, Taiwan
University Chair Professor
Department of Atmospheric Sciences,
National Central University, Chung-Li,
TaiwanUniversity Chair Professor
Institute of Environmental Engineering,
National Chiao Tung University, Hsin-
chu, Taiwan.Ph.D., MS The University of
Chicago, Geophysical Sciences
BS National Taiwan University,
Atmospheric Sciences
Associate Professor of Radiology

Dr. Michael R. Rudnick

M.D., FACP
Associate Professor of Medicine
Chief, Renal Electrolyte and
Hypertension Division (PMC)
Penn Medicine, University of
Pennsylvania
Presbyterian Medical Center,
Philadelphia
Nephrology and Internal Medicine
Certified by the American Board of
Internal Medicine

Dr. Bassey Benjamin Esu

B.Sc. Marketing; MBA Marketing; Ph.D
Marketing
Lecturer, Department of Marketing,
University of Calabar
Tourism Consultant, Cross River State
Tourism Development Department
Co-ordinator , Sustainable Tourism
Initiative, Calabar, Nigeria

Dr. Aziz M. Barbar, Ph.D.

IEEE Senior Member
Chairperson, Department of Computer
Science
AUST - American University of Science &
Technology
Alfred Naccash Avenue – Ashrafieh

PRESIDENT EDITOR (HON.)

Dr. George Perry, (Neuroscientist)

Dean and Professor, College of Sciences

Denham Harman Research Award (American Aging Association)

ISI Highly Cited Researcher, Iberoamerican Molecular Biology Organization

AAAS Fellow, Correspondent Member of Spanish Royal Academy of Sciences

University of Texas at San Antonio

Postdoctoral Fellow (Department of Cell Biology)

Baylor College of Medicine

Houston, Texas, United States

CHIEF AUTHOR (HON.)

Dr. R.K. Dixit

M.Sc., Ph.D., FICCT

Chief Author, India

Email: authorind@computerresearch.org

DEAN & EDITOR-IN-CHIEF (HON.)

Vivek Dubey(HON.)

MS (Industrial Engineering),

MS (Mechanical Engineering)

University of Wisconsin, FICCT

Editor-in-Chief, USA

editorusa@computerresearch.org

Sangita Dixit

M.Sc., FICCT

Dean & Chancellor (Asia Pacific)

deanind@computerresearch.org

Suyash Dixit

(B.E., Computer Science Engineering), FICCTT

President, Web Administration and

Development , CEO at IOSRD

COO at GAOR & OSS

Er. Suyog Dixit

(M. Tech), BE (HONS. in CSE), FICCT

SAP Certified Consultant

CEO at IOSRD, GAOR & OSS

Technical Dean, Global Journals Inc. (US)

Website: www.suyogdixit.com

Email: suyog@suyogdixit.com

Pritesh Rajvaidya

(MS) Computer Science Department

California State University

BE (Computer Science), FICCT

Technical Dean, USA

Email: pritesh@computerresearch.org

Luis Galárraga

J!Research Project Leader

Saarbrücken, Germany

CONTENTS OF THE VOLUME

- i. Copyright Notice
- ii. Editorial Board Members
- iii. Chief Author and Dean
- iv. Table of Contents
- v. From the Chief Editor's Desk
- vi. Research and Review Papers
 1. Functional Properties based Statistical Optimization of Foam Mat Drying Parameters for Potato (Kufri Chandramukhi). **1-10**
 2. Ordination and Classification of Vegetation in Semi Arid Area of Pakistan. **11-19**
 3. Isolation and Phytochemical Characterization of Bioactive Compounds from the Rhizomes of *Cyperus Rotundus*. L. **21-27**
 4. Evaluation of Ovicidal and Larvicidal Activities of Methylene Chloride-Methanol Extract of *Annona Senegalensis* (Annonaceae) Stem Bark on *Heligmosomoides Bakeri* (Nematoda, Heligmosomatidae). **29-39**
 5. Strategies of Rodent Control Methods at Airports. **41-47**
 6. "Plantain of Guinea". The Atlantic Adventure of Banana. **49-65**
- vii. Auxiliary Memberships
- viii. Process of Submission of Research Paper
- ix. Preferred Author Guidelines
- x. Index



GLOBAL JOURNAL OF SCIENCE FRONTIER RESEARCH: C
BIOLOGICAL SCIENCE

Volume 14 Issue 2 Version 1.0 Year 2014

Type : Double Blind Peer Reviewed International Research Journal

Publisher: Global Journals Inc. (USA)

Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Functional Properties based Statistical Optimization of Foam Mat Drying Parameters for Potato (Kufri Chandramukhi)

By Sreemoyee Chakraborty, Soumitra Banerjee & Saikat Mazumder

University Techno, India

Abstract- This study is focussed on statistical optimization of foam mat drying conditions of potato (kufri chandramukhi) based on functional properties of dried powder. During the preparation of the mat maximum foam expansion of 25% was found with interactive effect of 10 minutes of magnetic stirring and 2% concentration of glycerol monostearate (GMS). The range of factors employed for optimization of drying was different concentrations of GMS, temperature, time. The optimum drying condition obtained was at 60°C for 135 minutes with 2% GMS. The value of percentage of final moisture content, coefficient of reconstitution, browning index, and percentage gelatinized starch was 1.89 ± 0.551 , 0.914 ± 0.025 , 0.013 ± 0.00175 and 70.00 ± 1.645 , respectively was found at optimum drying condition. Time and interaction of temperature with time have significant effect on moisture content at $p < 0.05$ level.

Keywords: kufri chandramukhi, foam mat drying, functional properties, regression equation.

GJSFR-C Classification : FOR Code: 829999



Strictly as per the compliance and regulations of :



© 2014. Sreemoyee Chakraborty, Soumitra Banerjee & Saikat Mazumder. This is a research/review paper, distributed under the terms of the Creative Commons Attribution-Noncommercial 3.0 Unported License <http://creativecommons.org/licenses/by-nc/3.0/>), permitting all non commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

Functional Properties based Statistical Optimization of Foam Mat Drying Parameters for Potato (Kufri Chandramukhi)

Sreemoyee Chakraborty ^α, Soumitra Banerjee ^ο & Saikat Mazumder ^ρ

Abstract- This study is focussed on statistical optimization of foam mat drying conditions of potato (kufri chandramukhi) based on functional properties of dried powder. During the preparation of the mat maximum foam expansion of 25% was found with interactive effect of 10 minutes of magnetic stirring and 2% concentration of glycerol monostearate (GMS). The range of factors employed for optimization of drying was different concentrations of GMS, temperature, time. The optimum drying condition obtained was at 60°C for 135 minutes with 2% GMS. The value of percentage of final moisture content, coefficient of reconstitution, browning index, and percentage gelatinized starch was 1.89 ± 0.551 , 0.914 ± 0.025 , 0.013 ± 0.00175 and 70.00 ± 1.645 , respectively was found at optimum drying condition. Time and interaction of temperature with time have significant effect on moisture content at $p < 0.05$ level.

Keywords: kufri chandramukhi, foam mat drying, functional properties, regression equation.

1. INTRODUCTION

Potato (*Solanum tuberosum*), a starchy, tuberous crop from the perennial Nightshade family, is a major food crop, grown in more than 100 countries in the world and also emerged as fourth most important food crop in India. In India different types of potatoes growing are Kufri Sindhuri, Kufri Chandramukhi, Kufri Jyoti, Kufri Muthu, Kufri Lauvkar, Kufri Dewa, Kufri Badshah, Kufri Bahar, Kufri Lalima, Kufri Swarna, Kufri Megha, Kufri Ashoka, Kufri Jawahar and Kufri Sutlej (Indian National Horticulture Database, 2011). Global potato production rate is about 324 million metric tonne per year out of which India contributes to about 36.5 million metric tonne per year as per a study undertaken in 2010. West Bengal contributes to about 32% of India's total harvest. Due to inadequate storage facilities and processing units about 17-20% is wasted and due to its perishability more than 50% of states surplus is wasted during transportation, finally only and due to its perishability more than 50% of states surplus is wasted during transportation, finally only about 5% of

the world's potato crop is traded internationally (Food Processing Industries Survey, West Bengal).

Foam- mat drying (originally developed by Morgan et al. in 1959 at the Western Regional Research Laboratory of the U.S. Department of Agriculture) is a promising new development in the field of drying aqueous foods. It is a process in which the transformation of products from liquid to stable foam follows air drying at relatively low temperatures to form a thin porous honey-comb sheet or mat which is disintegrated to yield a free-flowing powder having better reconstitution properties than drum dried and spray dried products (Kadam et. al., 2010).

Kufri Chandramukhi is a perennial type of potato, grown in Hoogly district of West Bengal, India, is recorded to have higher carbohydrate content than most other varieties. Foam mat drying of potato of Chandramukhi variety for development of potato powder this investigation has been carried out with the specific objective of optimization of the concentration of foaming agent (glycerol monostearate), drying time and temperature for effective foam mat drying of cooked potato mash.

In this study, foam mat drying of potato is the function of percentage of GMS, temperature and time. The parameters were optimized in this study using factorial design of 3^2 and 3^3 levels at $p < 0.05$. The functional properties of dried powder such as final moisture content, coefficient of reconstitution, percentage gelatinized starch and browning index are used as a key players for deciding of optimum condition for foam mat drying.

The easiest and most widely used approach to study linear and interaction of different factors have been response surface methodology (RSM). RSM is a collection of mathematical and, statistical technique useful for analyzing and optimizing the response of multivariate system. In RSM, generally attempts are made to identify the responses of system as a function of explanatory variables. In this study, different linear and interactive effect of different factors has been studied.

Author ^{α ρ}: Department of Food Technology, Techno India, Salt Lake, Kolkata, West Bengal, India.

e-mails: sreemoyee.chakraborty1989@gmail.com,
bitsouban04@yahoo.co.in, saikat.23.1989@gmail.com

II. MATERIAL & METHODS

a) Collection and Preparation of Raw material

Potatoes used in this study were of Chandramukhi variety freshly collected from local market of South Kolkata (cultivated in Tarakeswar, Hoogly district, West Bengal, India). The potatoes had initial moisture content of 82.34gm of moisture/100gm wet weight. The potato samples were washed with running tap water and distilled water respectively to make it free from dirt and soil and blotted with a tissue paper for removal of excess surface water. The potato samples were then peeled and cut into slices of equal thickness of 10 ± 0.3 mm each. The sliced potato samples were blanched in hot water (Temperature- $90 \pm 2^\circ$ C) containing 2 gm NaCl/100 gm of water of sodium chloride (NaCl) and 2mg of potassium metabisulphate/1000gm of water for 10 minutes and followed by preparation of mash in a mixer grinder. The potato mash was gelatinized in an autoclave at 10 psig pressure for 15 minutes (Chakraborty et. al., 2013).

b) Optimization of Stirring Time for Effective Foaming of GMS (Foaming Agent)

At first glycerol monostearate (GMS) was weighed in different amounts (1%, 2%, and 3% respectively) then mixed with a refined vegetable oil and water in a ratio of 2:1:10 respectively and heated in boiling water bath (90° - 100° C) and stirred till GMS gets evenly dispersed to form slurry. The potato mash and water was added (in a ratio of 10:1 respectively) to the three different slurries and stirred at 300 rpm for 5, 10 and 15 minutes in a magnetic stirrer (Eltek, Model – 2011) to form a thick foam slurry. Optimization of stirring time was done in terms of measurement of foaming properties i.e. maximum foam expansion (i.e., maximum foam volume) and maximum foam stability (i.e. minimum drainage volume). The water was added because due to high viscosity of the cooked potato mash proper foaming was not being possible. GMS also acted as a stabilizer of the foam for different cases.

The foam expansion was measured as described by Akiokato et. al., (1983).

$$FE = \{(V_1 - V_0) / V_0\} * 100$$

Where FE is the foam expansion (%), V_1 is the final volume of foamed potato slurry (ml) and V_0 is the initial volume of potato slurry (ml).

A criterion for good foam stability was its uniformity and the lack of fluid drainage in 60 minutes after its preparation. (Kadam et. al., 2010). The foam obtained from the potato slurries were filled into a transparent graduated cylinder and kept at room temperature (i.e. 25° C) for 3 hours. The reduction in foam volume was measured as an index for the foam stability. The foamed slurry prepared at optimized stirring time condition used further for drying parameters optimization.

c) Optimization of Drying Parameters

Drying of foamed potato mash was done on the basis of variation of drying time-temperature-percentage GMS profile. The experiments were carried out on the basis of experimental design at 3^3 and 3^2 full factorial design. Functional effect of interacting factors (i.e. time, temperature and percentage GMS) for 3^3 full factorial design and functional effect of interacting factors (i.e. time, temperature) for 3^2 was studied.

A batch type tray drier was run intermittently in order to stabilize the desired temperature (i.e. 50° C, 55° C, 60° C respectively) inside the chamber. The homogeneous foamed potato slurry as well as the non foamed potato slurry was poured over muslin cloth and spread to an equal thickness of 10 mm. similar samples were poured to Petri plate to equal thickness and kept along with the sheets for drying. These sheets were kept in an aluminium tray size of 80X40 cm having 7 mm diameter holes. The trays were then placed on the tray stand in position for drying. The foamed and non-foamed potato slurries were dried at different time-temperatures profile. The Petri plates were taken out of the drying chamber at different time intervals for determination of weight loss. Moisture content was recorded using Dhona balance having least count of 0.1 mg on initial and final weight basis. Drying was stopped at the required times (5hrs, 6hrs, and 7hrs). Final moisture content of each of the sample was obtained by A.O.A.C method. A crispy flaky powder was obtained which was grounded to a fine powder and packed in LDPE zip pouches separately and functional properties of powders were determined.

Primary optimization of effective drying condition was done on the basis of superior functional properties of the powder. At primary optimization % of GMS and drying temperature was optimized, time was not optimized though time was included in the experimental design because the superior functional properties may develop before the pre-set time of primary optimization. The study was performed in this method to properly focus on the optimization condition. So, a set of foamed potato slurry prepared at optimum foaming condition was dried at primary optimized drying condition and samples were withdrawn at 15 minutes interval for determination of functional properties, on the basis of superior functional properties the final drying time required for effective foam mat drying was optimized.

i. Design of Experiment for Drying

The factorial design with three levels of treatment temperature, time and percentage of GMS respectively was assigned for 3^3 full factorial designs and three level of temperature and time respectively, for 3^2 full factorial designs in case of drying without GMS and the designs leads to 27 sets and 9 sets of experiments respectively. The factorial design was

applied to estimate the relationship between variables of foam mat drying of potato mash. The three range level of factors are 50°C, 55°C, 60°C for temperature (-1, 0, +1 level respectively), 5 hours, 6 hours, 7 hours for time (-1, 0, +1 level respectively), 1%, 2%, 3% for percentage of GMS (-1, 0, +1 level respectively).

ii. *Determination of Functional Properties*

The functional properties of dried powder such as moisture content, co-efficient of reconstitution, browning index, and gelatinized starch was determined. All the experiments were performed on triplicates basis.

iii. *Final Moisture Content*

The moisture content was determined according to A.O.A.C method, gravimetrically at 130°C for 2 hours and then to constant weight.

iv. *Determination of Co-efficient of Reconstitution*

1gm of dried potato powder sample was taken in a previously weighed and dried centrifuge tube mixed thoroughly with 25ml of distilled water for 5 minutes by a vortex mixer and finally centrifuged at 3000rpm for 15 minutes. The supernatant was drained off and the final weight was taken. The co-efficient of reconstitution can be calculated by the following formulas:

Co-efficient of reconstitution = [Rehydration Ratio / Dehydration Ratio]

Rehydration Ratio = [Weight of Rehydrated Material / Weight of Dehydrated Material]

Dehydration Ratio = [Weight of prepared material before drying / Weight of dried material]

v. *Determination Browning Index*

The browning index was determined using the procedure described by Hendel et. al., (1955). 2gm of grinded sample was extracted with 20 ml of 2% acetic acid solution and then filtered through a filter paper (Whatman No. 3). An aliquot of the filtrate was mixed with an equal volume of acetone and filtered again. The absorbance of the extracted colour solution was measured at 420 nm using a double beam UV-VIS spectrophotometer (Chemito Spectrascan UV 2700, Thermo Fisher Scientific) using a 1 cm cell. The results are expressed in terms of the optical density (Leeratanarak et. al., 2005).

vi. *Determination of Gelatinized Starch*

Gelatinized starch was determined by modified Chiang and Johnson (1977) method followed by Dextrose Equivalent titration method.

0.2gm of powdered sample was measured accurately and transferred to a conical flask and 5ml distilled water was added to it. Then 1ml of α -amylase solution (4unit/ml) and 8ml of glucoamylase solution (4unit/ml) was added to the conical flask. After proper mixing of the contents, the test tube was incubated in a hot water bath for 30 minutes at 40°C with occasional

shaking. After that, the enzymes were inactivated by holding the conical flask in boiling water for about 1-2 minutes. The final volume is measured. The enzymes break the starch to reducing sugar which was then estimated by Lane- Eynon method i.e. by Dextrose Equivalent titration method.

d) *Proximate Analysis of Potato Powder*

The potato powder prepared at optimized drying condition was used for proximate composition analysis. Moisture content, ash content, fat content, total protein, crude fibre content, and total starch content were done according to A. O. A. C method.

e) *Localization study*

In localization study contour plots were obtained by using Statistica (version 7) (Stat Soft, Inc., USA). The Contour plot describing combined effect between pair of time-temperature, GMS content-temperature, and GMS content-time on various functional properties was studied.

f) *Determination of Regression Equation*

RSM Modelling

Functional relationships between the independent variables (percentage GMS, temperature, time) and dependent variables (final moisture content, coefficient of reconstitution, and browning index) were studied. The regression equation were determined using multiple regression technique by fitting second order regression equation (Khuri and Cornell, 1987) of the following type

$$Y = \beta_0 + \sum_{i=1}^n \beta_i X_i + \sum_{i=1}^n \beta_{ii} X_i^2 + \sum_{i=1}^n \sum_{j=i+1}^{n-1} \beta_{ij} X_i X_j + e$$

where β_0 , β_i , β_{ii} , β_{ij} are regression coefficients of variables for intercept, linear, quadratic and interaction terms, respectively, X_i , X_j are the independent variables, Y is the dependent variables n is number of independent variables.

The relationships between the responses were judged by correlation coefficients of determination (R^2). The significance or P-value was decided at a probability level of 0.05.

III. RESULTS & DISCUSSIONS

a) Optimization of Optimum concentration of GMS and Stirring Time

Table 1 : Effect of different percentage of GMS and Stirring Time on Foam Expansion & Stability

Percentage of Glycerol Monostearate (%)	Stirring Time (minutes)	Foam Expansion (%)	Reduction of foam volume w. r. t initial foam volume (in ml) after a time interval of					
			30 min	60 min	90 min	120 min	150 min	180 min
1	5	15	0	0	1	3	7	10
2	5	20	0	0	0	0	1	1
3	5	20	0	0	0	0	2	5
1	10	20	0	0	0	1	3	5
2	10	25	0	0	0	0	0	0
3	10	25	0	0	0	0	0	0
1	15	18	0	1	2	5	9	13
2	15	23	0	0	0	0	0	0
3	15	23	0	1	1	2	2	3

Highest foam expansion is observed when the stirring time was increased from 5 to 10 minutes. Similarly the foam stability increases when stirring time is increased from 5 minutes to 10 minutes but decreases thereafter when the stirring time is increased to 15 minutes.

Foaming capacity as well as foam stability increased with increase in GMS concentration excepting in the case of addition of 3gm of GMS / 100gm of potato mash along with 15 minutes stirring in which a steady

drainage of foam was noted. So, 10 minutes is determined as the optimum condition for effective foaming.

b) Optimization of Drying Parameters

Drying experiments were carried out on the basis of experimental design at 3³ and 3² full factorial design. The factors were % GMS, temperature, and time. All the experiments conducted were repeated three times.

Table 2 : Functional Properties of Dried Powder at Different Drying Conditions

3** (2-0) full factorial design, 1 block, 9 runs						
Drying Condition Parameters			Functional Properties			
% of GMS	Temperature (°C)	Time (hrs)	Final Moisture Content (%)	Co-efficient of Reconstitution	Browning Index (Optical Density)	% Gelatinized Starch
-	50	5	7.37 ± 0.282	0.626 ± 0.061	0.019 ± 0.00115	60.57 ± 1.687
-	50	6	6.41 ± 0.285	0.644 ± 0.055	0.074 ± 0.00057	60.57 ± 1.658
-	50	7	5.98 ± 0.531	0.645 ± 0.064	0.091 ± 0.00152	61.76 ± 1.715
-	55	5	6.67 ± 0.504	0.747 ± 0.043	0.021 ± 0.00173	61.76 ± 2.345
-	55	6	5.77 ± 0.319	0.769 ± 0.056	0.077 ± 0.00115	63.00 ± 1.725
-	55	7	5.33 ± 0.526	0.765 ± 0.065	0.095 ± 0.00117	63.00 ± 1.739
-	60	5	4.94 ± 0.496	0.773 ± 0.076	0.023 ± 0.00151	63.00 ± 2.080
-	60	6	4.88 ± 0.227	0.691 ± 0.058	0.080 ± 0.00157	61.76 ± 1.612
-	60	7	4.85 ± 0.230	0.677 ± 0.077	0.099 ± 0.00155	59.43 ± 1.635
3** (3-0) full factorial design, 1 block, 27 runs						
% of GMS	Temperature (°C)	Time (hrs)	Final Moisture Content (%)	Co-efficient of Reconstitution	Browning Index (Optical Density)	% Gelatinized Starch
1	50	5	2.53 ± 0.195	0.757 ± 0.043	0.012 ± 0.00115	58.33 ± 1.773
1	50	6	2.42 ± 0.431	0.760 ± 0.065	0.038 ± 0.00119	57.27 ± 2.645
1	50	7	2.35 ± 0.291	0.761 ± 0.081	0.067 ± 0.00100	59.43 ± 3.139
1	55	5	2.23 ± 0.325	0.770 ± 0.092	0.015 ± 0.00152	64.28 ± 2.086
1	55	6	2.20 ± 0.449	0.793 ± 0.034	0.039 ± 0.00157	68.47 ± 0.983
1	55	7	2.17 ± 0.247	0.791 ± 0.011	0.069 ± 0.00100	65.62 ± 2.732
1	60	5	2.01 ± 0.345	0.811 ± 0.075	0.013 ± 0.00155	70.00 ± 1.556
1	60	6	2.00 ± 0.111	0.789 ± 0.065	0.040 ± 0.00143	65.62 ± 2.385
1	60	7	2.00 ± 0.135	0.785 ± 0.039	0.075 ± 0.00123	58.33 ± 3.335
2	50	5	2.49 ± 0.333	0.868 ± 0.047	0.012 ± 0.00165	58.33 ± 1.347

2	50	6	2.40 ± 0.346	0.871 ± 0.021	0.040 ± 0.00117	59.43 ± 2.775
2	50	7	2.33 ± 0.224	0.873 ± 0.033	0.072 ± 0.00173	61.76 ± 3.644
2	55	5	2.21 ± 0.292	0.888 ± 0.055	0.012 ± 0.00157	67.02 ± 3.414
2	55	6	2.17 ± 0.211	0.907 ± 0.078	0.042 ± 0.00145	68.47 ± 1.715
2	55	7	2.11 ± 0.398	0.899 ± 0.083	0.075 ± 0.00111	67.02 ± 1.670
2	60	5	1.89 ± 0.551	0.914 ± 0.025	0.013 ± 0.00175	70.00 ± 1.645
2	60	6	1.89 ± 0.526	0.895 ± 0.037	0.046 ± 0.00125	65.62 ± 3.188
2	60	7	1.89 ± 0.778	0.866 ± 0.056	0.076 ± 0.00100	57.27 ± 2.414
3	50	5	2.47 ± 0.299	0.827 ± 0.096	0.013 ± 0.00167	58.33 ± 1.371
3	50	6	2.39 ± 0.270	0.837 ± 0.075	0.039 ± 0.00178	59.43 ± 1.612
3	50	7	2.31 ± 0.234	0.841 ± 0.083	0.076 ± 0.00154	50.57 ± 2.713
3	55	5	2.19 ± 0.259	0.831 ± 0.043	0.013 ± 0.00185	64.28 ± 2.152
3	55	6	2.15 ± 0.398	0.835 ± 0.065	0.044 ± 0.00152	68.47 ± 1.713
3	55	7	2.15 ± 0.253	0.829 ± 0.034	0.075 ± 0.00188	63.00 ± 2.515
3	60	5	1.91 ± 0.324	0.813 ± 0.061	0.014 ± 0.00193	68.47 ± 3.162
3	60	6	1.91 ± 0.268	0.811 ± 0.045	0.048 ± 0.00102	64.28 ± 1.174
3	60	7	1.91 ± 0.481	0.801 ± 0.065	0.078 ± 0.00187	57.27 ± 0.987

From table: 2 it is observed that there is a decrease in percentage of final moisture content of potato foam with the increase in temperature-time and GMS profile of drying with the least moisture content of 1.89gm/100gms of potato powder belonging to the slurry subjected to drying for 5hrs at 60°C and treated with 2gm GMS/100gm of potato mash. So, it can be concluded that effective foaming and foam stability leads to proper moisture removal from the sample.

From Table 2 it is observed that with increase in temperature and time of drying there is an initial increase in co-efficient of reconstitution but when the temperature- time profile of drying increases to 55°C 7 hours from 55°C 6 hours a slight decline in co-efficient of reconstitution is observed but the co-efficient further increases when temperature-time profile changes to 60°C 5hours again after which there is a considerable drop in co-efficient of reconstitution. This phenomenon may be due to the combined effect of temperature and time of drying as higher heat absorption may affect the structure of the matrix and hence the reconstitutability. Sometimes in cases of heat sensitive products like potato high temperature and prolonged heating time negatively affects the product characteristics thereby decreasing its reconstitutable properties as well as its nutritive values thus decreasing its market acceptability.

From table: 2 it is observed that with increase in time of drying there is an increase in browning index at any particular temperature as well as at any particular time with increase in temperature there is an increase in browning index in some cases. The interactive effect of time-temperature on browning of the product shows that least browning occurs at the heat exposure of 5hrs and remains unaffected by change in combined effect of temperature and GMS concentration however samples not containing GMS i.e. non foamed samples show higher browning effect.

Table : 2 also indicate the effect of time temperature profile of drying on yield of gelatinized starch of the dried potato powder. Before drying the

mash was initially pressure cooked which leads to gelatinization of the starch present in potato. A slight decrease in gelatinized starch content was also noted with excessive heat absorption this can be explained by the fact that with the change in enthalpy of the product there is a mild retrogradation of the starch.

From table: 2 primary optimization of drying condition is 2% GMS concentration, 60°C, 5 hours where the functional properties are superior than other.

c) Study of Changes in Functional Properties during drying under Optimized Condition

From the table: 2, drying at 60°C for 5 hrs with 2% GMS is primarily optimized (table: 2) to be the ideal condition for foam mat drying of potato mash. A set of foamed potato slurry prepared at optimum foaming condition was dried at primary optimized drying condition and samples were withdrawn at 15 minutes interval for determination of functional properties. The changes in the functional properties as a function of the interactive effects of temperature of drying and concentration of GMS at different time intervals were studied further under the optimized condition (table: 3). All experiments were done on a triplicate basis.

Table 3 : Changes in Functional Properties at 15 Minutes Interval

Time (min)	Moisture Content (%)	Rehydration Ratio	Dehydration Ratio	Co-efficient of Reconstitution	Browning Index (Optical Density)	Gelatinized Starch (%)
15	66.722 ± 3.41	1.069 ± 0.117	1.339 ± 0.099	0.798 ± 0.013	0.013 ± 0.00180	67.90 ± 1.721
30	37.115 ± 2.97	1.275 ± 0.124	1.816 ± 0.143	0.702 ± 0.019	0.013 ± 0.00170	68.47 ± 1.552
45	26.391 ± 2.33	1.650 ± 0.098	2.256 ± 0.092	0.731 ± 0.015	0.014 ± 0.00210	68.81 ± 1.151
60	17.069 ± 2.71	2.185 ± 0.081	2.858 ± 0.088	0.764 ± 0.023	0.014 ± 0.00200	69.01 ± 1.691
75	6.981 ± 1.95	3.207 ± 0.133	4.014 ± 0.093	0.798 ± 0.011	0.014 ± 0.00140	69.19 ± 1.334
90	4.391 ± 1.31	3.737 ± 0.109	4.480 ± 0.089	0.834 ± 0.014	0.015 ± 0.0018	69.35 ± 1.362
105	3.473 ± 0.88	4.068 ± 0.087	4.672 ± 0.095	0.871 ± 0.021	0.015 ± 0.0016	69.78 ± 1.717
120	2.435 ± 0.76	4.386 ± 0.132	4.906 ± 0.121	0.894 ± 0.022	0.015 ± 0.0014	69.90 ± 1.258
135	2.135 ± 0.82	4.461 ± 0.091	4.983 ± 0.137	0.895 ± 0.017	0.015 ± 0.0011	69.90 ± 1.258
180	2.108 ± 0.37	4.471 ± 0.094	4.990 ± 0.112	0.896 ± 0.019	0.015 ± 0.0013	69.91 ± 1.324
240	2.077 ± 0.29	4.482 ± 0.099	4.998 ± 0.131	0.896 ± 0.016	0.015 ± 0.0017	69.91 ± 1.324
300	1.998 ± 0.53	4.501 ± 0.111	5.018 ± 0.105	0.896 ± 0.021	0.015 ± 0.00110	69.91 ± 1.324

From the observations made in table 3 it can be concluded that the changes in the functional properties and the moisture content becomes somewhat constant after 2hrs 15 minutes (135 minutes) of drying at 60°C and hence the drying time of 5hrs becomes uneconomical. So the final optimization for foam mat drying of potato is 2% GMS, 60°C, 2hrs 15 minutes (135 minutes).

d) Proximate Analysis of Potato Powder Prepared under Optimized Condition

The potato powder prepared at optimized drying condition was used for proximate composition analysis. Moisture content, ash content, fat content, total protein, crude fibre content, and total starch content were done according to A.O.A.C method. All the experiments were performed on triplicate basis

Table 4 : Proximate Composition of Dried Potato Powder

Parameters	Potato Powder (gm wt/100gm of potato powder)	
	Wet Basis	Dry Basis
Moisture Content	1.932±0.248	1.968±0.257
Ash Content	4.961±0.308	5.059±0.325
Fat Content	1.932±0.201	1.970±0.205
Total Protein	2.854±1.134	2.912±1.156
Crude Fibre	2.873±0.937	2.929±1.231
Total Starch	82.113±1.342	83.731±1.576

e) Localization study

Fig- 1 shows that final moisture content of 3³ full factorial design of experiments (table: 2) as a function of

time and temperature. It indicates that the reduction of percentage moisture content is more dependable on increment on temperature rather than increment of time.

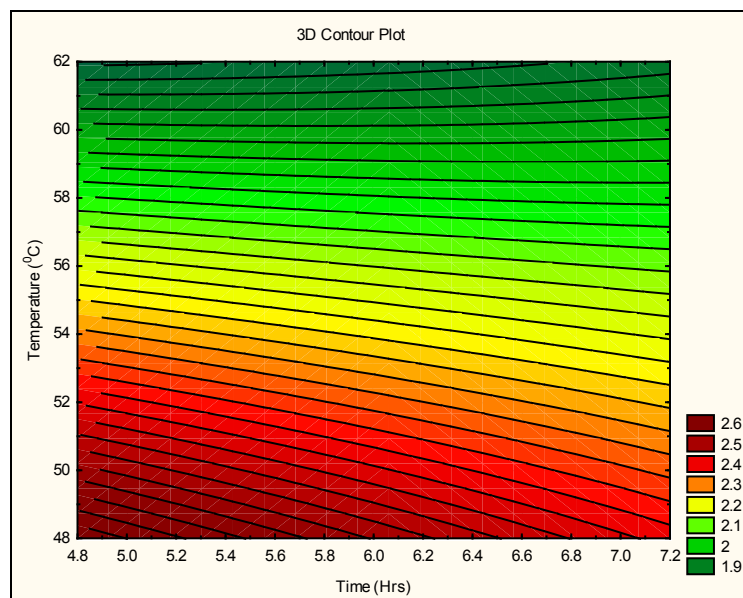


Figure 1 : Contour plot of the combined effect of time and temperature on Percentage of Final Moisture Content

Fig- 2 shows that co-efficient of reconstitution of 3^3 full factorial design of experiments (table: 2) as a combined function of percentage of GMS and

temperature. It is clearly indicates that value co-efficient of reconstitution is superior at mid level of percentage of GMS and higher level of temperature.

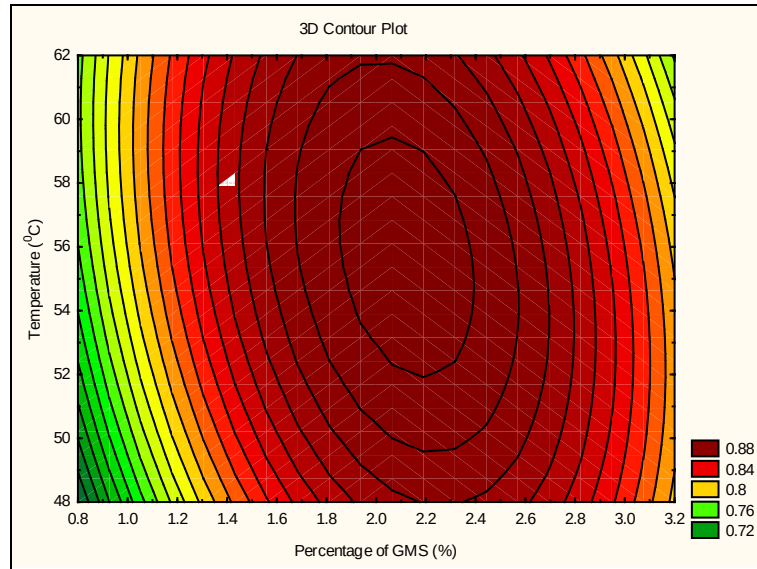


Figure 2 : Contour plot of the combined effect of percentage of GMS and temperature on co-efficient of reconstitution

Fig- 3 & 4 shows that browning index of 3^3 full factorial design of experiments (table: 2) as a combined function of time and temperature, time and percentage

GMS respectively. Both the figure 3 & 4 clearly indicates that value browning index is mainly dependent on the period of heating time.

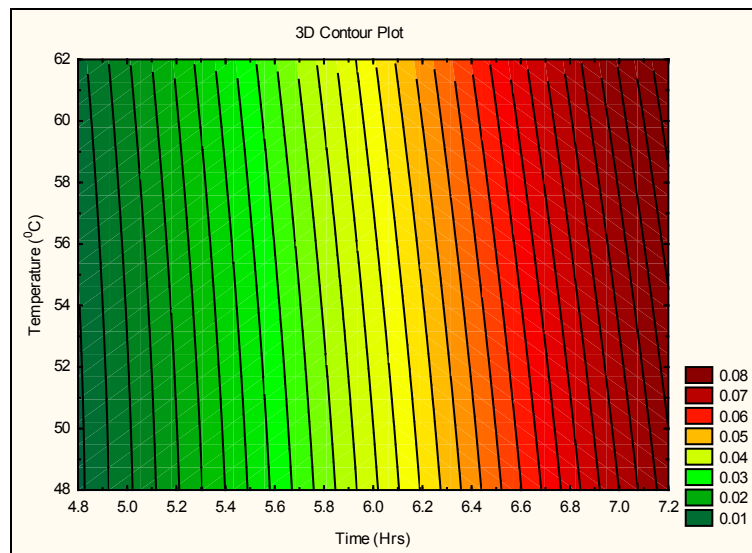


Figure 3 : Contour plot of the combined effect of time and temperature on browning index

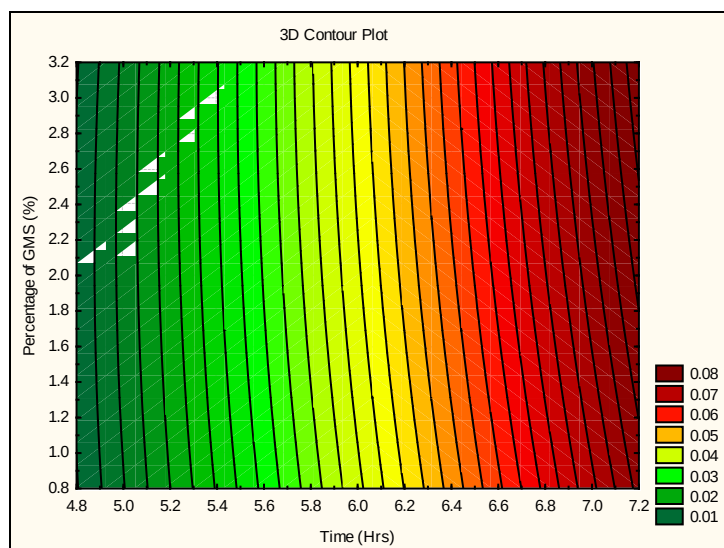


Figure 4 : Contour plot of the combined effect of time and percentage GMS on browning index

Fig- 5 shows that percentage of gelatinized starch of 3^3 full factorial design of experiments (table: 2) as a combined function of temperature and percentage of GMS. It is clearly indicates that value percentage of

gelatinized starch is superior at mid level of percentage of GMS and slightly higher level than mid level of temperature.

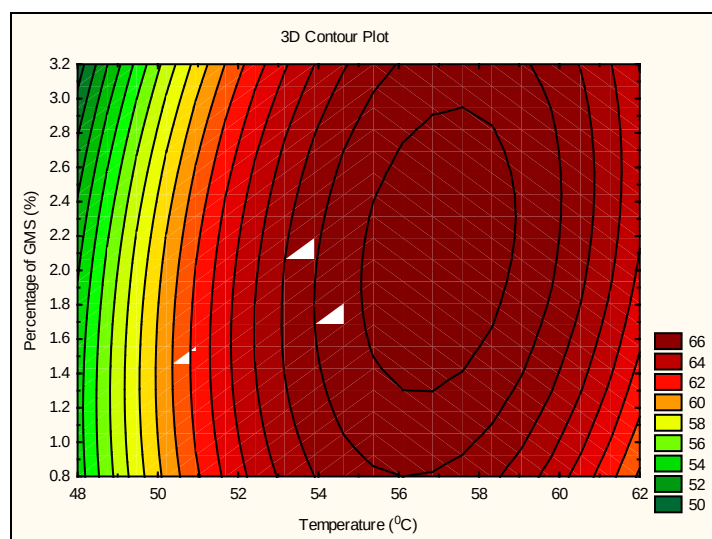


Figure 5 : Contour plot of the combined effect of temperature and percentage GMS on percentage of gelatinized starch

f) Determination of Regression Equation (RSM)

The second order model was fitted to response data of percentage of final moisture content, Co-efficient of Reconstitution, and browning index respectively of 3^3 full factorial design of experiments (table: 2) at a significance level of 0.05. Where the drying parameters percentage GMS, temperature, and time are independent variable and percentage of final moisture content, Co-efficient of Reconstitution, and browning index are dependent variable respectively.

It has been found that square term of GMS, time, interactive effect percentage GMS with temperature and interactive effect of temperature and

time have significant effect at $p < 0.05$ level on percentage of final moisture content (table: 5).

It was also found that except square term of time and interactive effect of temperature with time all other linear, quadratic, and interaction of different drying parameters have significant effect at $p < 0.05$ for Coefficient of Reconstitution (table: 5).

For browning index square term of time and interaction of percentage GMS with time have significant effect at $p < 0.05$ level.

Table 5 : Estimation of Regression Parameters, p value, and t value

Percentage of Final Moisture Content			
Effect	Parameter	p	t
Intercept	7.428889	0.000004 ^b	6.64351 ^b
% GMS	-0.036389	0.657073 ^a	-0.45187 ^a
% GMS*% GMS	0.030000	0.002079 ^b	3.62785 ^b
Temperature (°C)	-0.076889	0.053982 ^a	-2.07015 ^a
Temperature*Temperature (°C)	-0.000133	0.691903 ^a	-0.40309 ^a
Time (Hrs)	-0.556944	0.000214 ^b	-4.68306 ^b
Time*Time (Hrs)	0.005000	0.553403 ^a	0.60464 ^a
% GMS* Temperature (°C)	-0.002500	0.047360 ^b	-2.13773 ^b
% GMS* Time (Hrs)	0.004167	0.485774 ^a	0.71258 ^a
Temperature (°C)*Time (Hrs)	0.008167	0.000002 ^b	6.98325 ^b
Co-efficient of Reconstitution			
Effect	Parameter	p	t
Intercept	-1.99819	0.001331 ^b	-3.8334 ^b
% GMS	0.53136	0.00000 ^b	14.1552 ^b
% GMS*% GMS	-0.08444	0.00000 ^b	-21.9068 ^b
Temperature (°C)	0.06849	0.001020 ^b	3.9558 ^b
Temperature*Temperature (°C)	-0.00046	0.008606 ^b	-2.9689 ^b
Time (Hrs)	0.14525	0.017920 ^b	2.6201 ^b
Time*Time (Hrs)	-0.00394	0.320518 ^a	-1.0233 ^a
% GMS* Temperature (°C)	-0.00312	0.000025 ^b	-5.7172 ^b
% GMS* Time (Hrs)	0.00008	0.975966 ^a	0.0306 ^a
Temperature (°C)*Time (Hrs)	-0.00182	0.003944 ^b	-3.3325 ^b
Browning Index			
Effect	Parameter	p	t
Intercept	-0.002963	0.975348 ^a	-0.031360 ^a
% GMS	-0.006361	0.362943 ^a	-0.934876 ^a
% GMS*% GMS	-0.000444	0.533188 ^a	-0.636091 ^a
Temperature (°C)	-0.001733	0.587515 ^a	-0.552325 ^a
Temperature*Temperature (°C)	0.000009	0.754324 ^a	0.318045 ^a
Time (Hrs)	-0.001417	0.889542 ^a	-0.140980 ^a
Time*Time (Hrs)	0.001556	0.039805 ^b	2.226317 ^b
% GMS* Temperature (°C)	0.000017	0.868048 ^a	0.168669 ^a
% GMS* Time (Hrs)	0.001500	0.007458 ^b	3.036042 ^b
Temperature (°C)*Time (Hrs)	0.000183	0.080969 ^a	1.855359 ^a

a- not significant at $p < 0.05$ level, b- significant at $p < 0.05$ level

The student's t-test was performed to determine the significance of the regression co-efficient. The results of statistical analysis including the regression co-efficient, t and p values for linear, quadratic and combined effects of the variables were given in the table 5. The larger the magnitude of the t-value and the

smaller the p-value, indicate more significant of the corresponding coefficient and its effect on functional properties as well as foam mat drying of potato mash. The p-values are used as a tool to check the significance of each of the coefficients and to understand the interactions between the best variables.

Table 6 : Multiple R, Multiple R², and Adjusted R² of Different Regression Equation

Regression Model Equation of	Multiple R	Multiple R ²	Adjusted R ²
Percentage of Final Moisture Content	0.996811	0.993632	0.990261
Co-efficient of Reconstitution	0.987038	0.974243	0.960607
Browning Index	0.998516	0.997033	0.995463

Joglekar and May (1987) have suggested for a good fit of a model, regression coefficient (R^2) should be at least 80%. All the R^2 values are the proportion of variation in the response attributed to the model was > 0.80 (table: 6), this means that this model fitted well with the experimental data.

The regression model equations from the parameters of table 5 for different responses of percentage of final moisture content, coefficient of reconstitution, and browning index have used to predict the data for different responses. Correlation of experimental and predicted data provided an

observation that a good relationship exist between experimental and calculated data means high values of correlation coefficient (r) and coefficient of determination (R^2) (table: 7).

Table 7 : Correlation of Experimental vs. Predicted values

Responses	Correlation Co-efficient (r)	Coefficient of Determination (R^2)
Percentage of Final Moisture Content	0.9931	0.9966
Co-efficient of Reconstitution	0.9870	0.9743
Browning Index	0.9987	0.9975

IV. CONCLUSION

The interactive effect of concentration of foaming agent, time and temperature of drying on the reconstitutability, browning index, final moisture content and percentage of gelatinized starch present in the product was conducted. The process which yielded the superior functional properties is drying at 60°C for 2hrs 15 minutes and foamed with 2% glycerol monostearate. It can also be concluded that GMS as a foaming agent has properly good effect on functional properties as well as drying.

Joglekar and May (1987), have suggested for good fit of a model, regression coefficient (R^2) should be at least 80%, all the R^2 value of different modelling equation in this study are more 80% (i.e. $R^2 > 0.80$) and also a high similarity was observed between the predicted and experimental results of different cases, which reflected the accuracy and applicability of regression equations or regression model equation of the study.

V. ABBREVIATIONS

°C - Degree centigrade
Psig- Pounds per square inch gauge
KMS -Potassium metabisulphite
GMS- Glycerol monostearate
NaCl – Sodium Chloride
p - Significance level
 R^2 – Coefficient of determination
r- Correlation coefficient

REFERENCES RÉFÉRENCES REFERENCIAS

- Akintoye, O.A and A.O. Oguntunde, 1991, Preliminary investigation on the effect of foam stabilizers on the physical characteristics and reconstitution properties of foam-mat dried soymilk, Drying Technology, 9(1): 245-262
- Akiokato, A.T., N. Matsudomi, K. Kobayashi, 1983, Determination of foaming properties of egg white by conductivity measurements, Journal Food Science and Technology, 48(1):62-65
- Chakraborty S., Banerjee S. and Mazumder S., 2013, Statistical optimization of process parameters for gelatinization of potato (Chandramukhi variety), IJRET, Volume 2, Issue 11, November 2013, Pages 170-179
- Chiang B.Y. and Johnson J.A., 1977, Measurement Of Total and Gelatinized starch by Glucoamylase and O-Toluidine Reagent, Cereal Chem, 54 (3): 429-435
- Hendel, C. E., Silveira, V. G., & Harrington, W. O. (1955). Rates of non-enzymatic browning of white potato during dehydration. Food Technology, 9, 433-438.
- Joglekar A M, May A T. (1987). Product excellence through design of experiments [J]. Cereal Foods Word, 32:857–868.
- Kadam, D. M.; Patil, R.T. and Kaushik, P. Foam Mat Drying of Fruit and Vegetable Products, in Drying of Foods, Vegetables and Fruits - Volume 1, Ed. Jangam, S. V., Law, C. L. and Mujumdar, A.S. , 2010, ISBN - 978-981-08-6759-1, Published in Singapore, pg 111-124
- Kadam, D. M., R.A. Wilson and S. Kaur, 2010, Determination of biochemical properties of foam mat dried mango powder, International Journal of Food Science and Technology, 45(8): 626-1632
- Khuri, A. I., and Cornell, J. A., (1987), Response Surfaces, Marcel Dekker, New York, NY
- Leeratanarak N., Devahastin S., Chiewchan N., 2005, Drying kinetics and quality of potato chips undergoing different drying techniques, Journal of Food Engineering, Volume 77, Issue 3, December 2006, Pages 635-643
- Khuri, A. I., and Cornell, J. A., (1987), Response Surfaces, Marcel Dekker, New York, NY
- Morgan, A.I., R.P. Graham, L.F. Ginnette and G. Williams, 1961, Recent developments in foam-mat drying, Food Technology, 15: 37-39.



GLOBAL JOURNAL OF SCIENCE FRONTIER RESEARCH: C
BIOLOGICAL SCIENCE

Volume 14 Issue 2 Version 1.0 Year 2014

Type : Double Blind Peer Reviewed International Research Journal

Publisher: Global Journals Inc. (USA)

Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Ordination and Classification of Vegetation in Semi Arid Area of Pakistan

By Musharaf Khan, Farrukh Hussain, Faridullah & Shahana Musharaf

Federal Government College Mardan, Pakistan

Abstract- A survey of natural vegetation of Tehsil Takht-e- Nasrati, District Karak was undertaken in spring 2010-2011. Total 66 species were recorded during spring. Hierarchical Cluster Analysis (HCA), and Detrended Correspondence Analysis (DCA) were used for the plant community analysis. Plant species of each community type are presented together with the information on dominance and sub-dominance species. Four plant communities association i.e. Prosopis- Fagonia-Saccharum association, Zizyphus-Saccharum-Acacia association, Fagonia-Zizyphus-Eragrostis association and Aeluropus-Acacia-Cymbopogon association were recognized. Classification and ordination techniques provided very similar results based on the floristic composition and communities similarity. The results produced the source for the mapping division of plant life communities.

Keywords: HCA, DCA, spring, community association, tehsil takht-e-nasrati.

GJSFR-C Classification : FOR Code: 961306



Strictly as per the compliance and regulations of :



Ordination and Classification of Vegetation in Semi Arid Area of Pakistan

Musharaf Khan ^α, Farrukh Hussain ^σ, Faridullah ^ρ & Shahana Musharaf ^ω

Abstract- A survey of natural vegetation of Tehsil Takht-e-Nasrati, District Karak was undertaken in spring 2010-2011. Total 66 species were recorded during spring. Hierarchical Cluster Analysis (HCA), and Detrended Correspondence Analysis (DCA) were used for the plant community analysis. Plant species of each community type are presented together with the information on dominance and sub-dominance species. Four plant co- mmunities association i.e. Prosopis-Fagonia-Saccharum association, Zizyphus-Saccharum-Acacia association, Fagonia-Zizyphus-Eragrostis association and Aeria-Acacia-Cymbopogon association were recognized. Classification and ordination techniques provided very similar results based on the floristic composition and communities similarity. The results produced the source for the mapping division of plant life communities.

Keywords: HCA, DCA, spring, community association, tehsil takht-e-nasrati.

I. INTRODUCTION

Ordination techniques are commonly used in phytosociology. This may be done either by arranging the points along the axis or by forming the scatter diagram with two or more axis. Detrended Correspondence Analysis (DCA), an indirect gradient analysis technique in which the distribution of species is not controlled by environmental variables rather, it focuses to analyze the pattern of species distribution. Environmental data for DCA is not required and species data is used to assume the gradients (Sagers & Lyon, 1997). Ordination techniques are widely used by the ecologists to study the relationship between vegetation and environment. Khaznadar et al., (2009) conducted a study in Chott El Beida wetland, a RAMSAR site in Setif, Algeria to study distribution of plants community and environmental factors. The collection was done from sixty vegetation plots. TWINSpan and Detrended Correspondence Analysis (DCA) were used as the analysis techniques. A similar study was conducted by Ahmad et al., (2010) along motorway (M-2), Pakistan using multivariate techniques i.e., DECORANA. Results showed two major and sixteen sub-communities from 397 quadrats. The study was helpful for implementation

and conservation planning and for the improvement of road sides. To study the relationship between vegetation and environment, a study was conducted by He et al., (2007) in the Alxa Plateau of Inner Mongolia, China which resulted in the detection of six characteristics vegetation groups by using the Detrended correspondence analysis (DCA). Ahmad (2009) studied the herbaceous vegetation in Margalla Hills National Park, Islamabad, Pakistan. Four vegetation groups were recognized by TWINSpan. El-Bana et al., (2009) studied *Juniperus phoenicea* L. and associated vegetation at three mountains in Egypt, resulted in the recognition of four vegetation types along with juniper by TWINSpan and DCA analysis techniques. Jabeen and Ahmad (2009) conducted a study to analyze the vegetation and environment data of Ayub National Park, Rawalpindi. PCOrd 5 and CANOCO 4.5 were used and data was recorded by quadrat method. 44 plants species from 30 quadrats were recorded. Many researchers (Dasti & Malik, 1998; Malik & Hussain, 2008; Saima et al., 2009; Ahmad, 2009; Ali & Malik, 2010; Ahmad et al., 2010; Khan & Hussain, 2012) have studied different aspects of vegetation structure and classification and ordination distribution patterns in different parts of Pakistan. Classification and ordination is an invaluable method for vegetation survey and assessment involving investigation of characteristics of plant communities using simple and rapidly employing field techniques (El-Ghanim et al., 2010). In the present study, an effort has been made to investigate and analyse correlation of communities with key environmental factors. The Tehsil Takht-e-Nasrati comprises one of the richest and most interested ecosystems on earth. The community structure and distribution patterns of research area have not been given due attention till the date by the plant ecologists, and hence poorly understood (Khan, 2012). The particular objectives of present study include quantifying the vegetation in spring season of Tehsil Takht-e-Nasrati, District Karak using ordination techniques for upcoming conservation and providing base line data of ecological important area.

II. RESEARCH AREA

The Tehsil Takhti Nasratti is situated at 32.47o to 33.28o North and 70.30 o to 71.30o East. The Tehsil is bounded by Tehsil Banda Dawood Shah on the North West, Tehsil Karak on the North East, District Mianwali and District Lakki Marwat on the South East, and Tribal

Author α: Department of Biological Science, Federal Government College Mardan, Pakistan.

Author σ: Department of Botany, Bacha Khan University Charsadda, Pakistan.

Author ρ: PCSIR Laboratories Peshawar, Pakistan.

Author ω: Department of Chemistry, Government Girls Degree College, Sheikh Maltoon, Mardan, Pakistan.

area Adjoining District Bannu on the South West (Fig. 1). The total area of Tehsil is about 613.66 Sq. kilometer. Majority of the area consists of rigged dry hills and rough fields areas i.e. 323.97 Sq. kilometers and agriculture land is about 289.7 Sq. kilometer. The major income source of the people is Agriculture, which is rain depended. The area is situated at 340 m above the sea level. In the year 2010, 62.5 mm. y-1 of rainfall recorded. The area is very hot in summer and very cold in winter. June and July are the hottest months, where as

December and January are the coldest months. In the year 2010 the mean maximum temperature was 39.5 Co, in the month of the May, where as the mean minimum temperature was as low as 4 C o, in the month of January. The wind speed was different in different years. In the year 2009 the wind speed was high 6 Km per hour (h) in the month of July whereas in the year 2010 it was high in the month of April 7.2 Km. h-1 (Table 1).

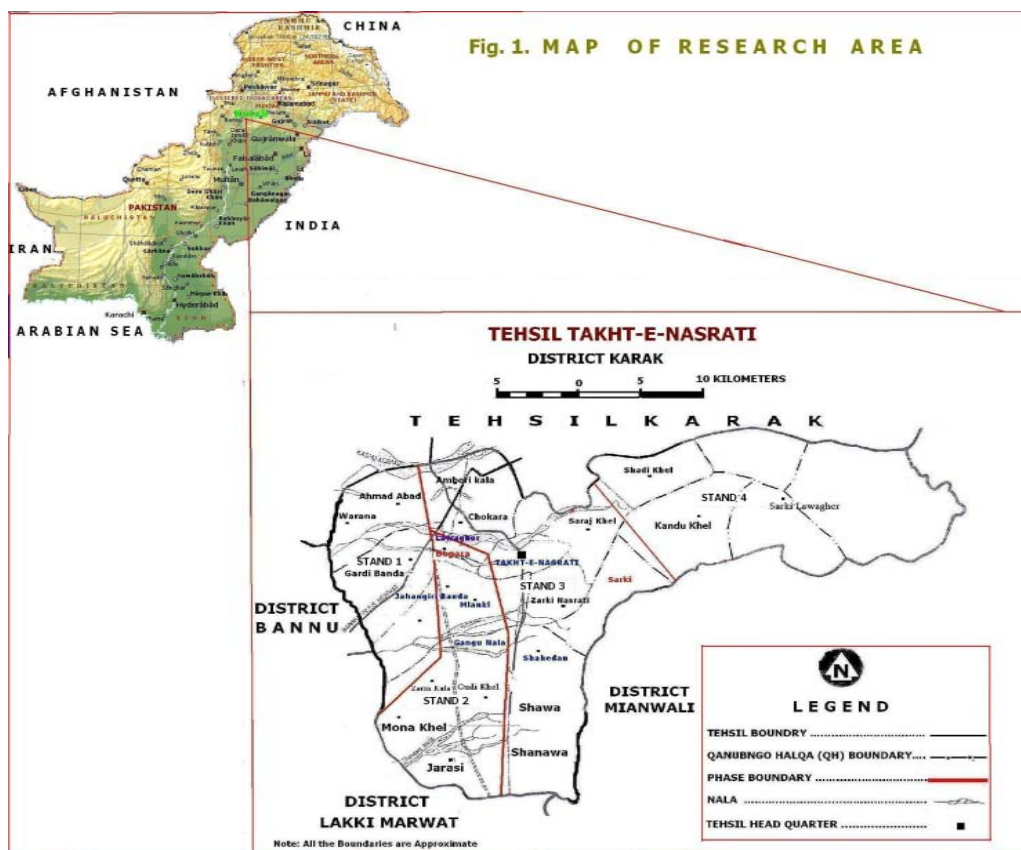


Figure 1 : Map of Tehsil Takht-e- Nasrati showing research spots.

Table 1 : Meteorological data of Tehsil Takht-e –Nasrati, District Karak for the year 2001-2010.

Months	Temperature (C°)		Humidity (%)		Rainfall (mm)	Soil temperature (C°) Average	Wind speed (Km Per Hour)
	Max	Min	Max	Min			
January	19.18	4.26	75.80	35.24	27.43	7.03	2.9
February	21.69	7.29	77.39	42.23	37.72	9.14	3.2
March	28.20	12.06	75.38	35.23	37.17	13.89	3.5
April	34.74	17.94	66.12	29.42	36.54	19.02	5.2
May	38.32	22.33	59.66	30.73	31.6	21.87	5.4
June	39.50	25.9	59.96	32.89	74.24	25.78	5.5
July	38.44	25.76	73.33	38.76	121.6	26.77	5.2
August	36.66	25.29	75.68	42.61	108.3	26.37	4.1
September	35.47	21.95	77.21	39.29	61.58	23.49	3.7
October	32.33	16.79	71.55	35.51	15.13	20.09	3.5
November	26.71	10.01	71.56	36.66	5.80	14.10	3.2
December	21.93	5.67	75.20	35.90	15.38	8.96	3.1
Mean	31.1	16.27	71.57	36.21	47.71	18.04	4.04

Source : Agricultural Research Farm Ahmad Wala Karak.

III. MATERIALS AND METHODS

a) Field data collection

Floristic data were collected from 22 randomly selected sites from 4 stand selected on the basis of altitude. Quadrat method was used for the collection of vegetation data. Each field site comprised of 10 Quadrats for each plant layer i.e. tree (10X10m), shrubs (5X5m) and herbs (1X1m). The latitude and longitudes were recorded for each site using a Global Positioning System (GPS). Sampling was completed in spring season. The spring season starts in March -April, when most of the plants are in flowering stages. Collected samples were pressed, dried and transported to herbarium of University of Peshawar Khyber Pakhtunkhawa, Pakistan, where they were identified and classified following Stewart (1972) and Nasir and Ali (1972) and a fraction of angiosperms of Tehsil Banda Daud Shah by Khan, (2004).

b) Data analysis

Vegetation attributes including frequency, density and cover were recorded along with environmental coordinates like latitude, longitude, altitude and slope using GPS. The importance value of each species was compiled adding RD, RF and RC following Hussain (1989). On the basis of the highest importance values of the first three dominant species from each layer, the communities were established and named. All the species data, as well as the field sites communities, were used for the analysis. The data was classified using standard methods Hierarchical Cluster Analysis (HCA) and Detrended Correspondence Analysis (DCA) (Hill, 1979) to summarize biological records and position of communities in groups during spring. The plant life associations were named after the highest value of three dominant species. DCA ordination offered two significant ordination axes on the basis of weight for communities. Detrended Correspondence Analysis (DCA) were performed to describe compositional gradients in the vegetation. All analysis was performed using the software PCORD ver. 4.16 (McCune & Mefford, 1999).

IV. RESULTS

The arrangement of plant life record is commonly vegetation orientation and main query disquiets the classification and explanation of the vegetation in addition to inconsistency of ecological arrangement. Distinctive multivariate techniques are generally fruitful and commonly used for plant life arrangement position. Though, distinctive multivariate analyses do not directly take into explanation relations in their computation and are not particularly designed to vegetation structures rationalization. The ordination may be defined as the position of communities designed to set apart group types, location, relative position,

standing of communities in a season of particular area. In other words, the ordination is the sound or clear arrangement of split communities or species in a season of a particular area. In present work the ordination of communities in spring is given as follows:

a) Hierarchical Cluster Analysis

In spring season, 66 species were present in 22 communities in 4 different stands on the basis of altitude. The Hierarchical Cluster Analysis shows that the relationship among 22 communities during spring were inclusion iv into 21 cluster cycling where in cycle 1 it shows the relation of 2 communities at 1.0928E+03 and last i.e. cycle 21, 22 communities were connected with one another at 1.0144E+05 with 3.29 % chaining. Further more, on the basis of relationship it marked out distinct 4 groups associations by different level, cycling and similarity of communities. The depiction of each one group association is as below:

i. *Prosopis-Fagonia-Saccharum* association

In group 1, 32 species comprising 6 trees, 6 shrubs and 20 herbs and grasses were present. The dominant species of association with highest mean important value were *Prosopis farcta* (IV = 28.4), *Fagonia cretica* (IV = 22.6) and *Saccharum bengalense* (IV = 21.9). Furthermore, it comprises 4 communities i.e. *Prosopis-Saussurea-Saccharum* community (PSS), *Prosopis-Periploca-Aerua* community (PPA), *Fagonia-Prosopis-Saccharum* community (FPS) and *Phoenix-Saussurea-Saccharum* community (PSS) which raised at 4.2195E+04 in cycles 15 (Table 2; Fig. 2).

ii. *Zizyphus-Saccharum-Acacia* association

The group 2 becomes visible at 4.8435E+04 in cycle 16 that contains *Acacia-Saccharum-Citrullus* community (ASC), *Calligonum-Zizyphus-Saussurea* community (CZS), *Zizyphus-Cenchrus-Saccharum* community (ZCS), *Zizyphus-Aerua-Calligonum* community (ZAC), *Zizyphus-Saccharum-Cynodon* community (ZSC) and *Zizyphus-Calligonum-Fagonia* community (ZCF). Moreover, 42 species in which 4 trees, 7 shrubs and 31 herbs were present. Where mean highest important value was represented by *Zizyphus maurtiana* (IV = 54.08), *Saccharum bengalense* (IV = 19.84) and *Acacia nilotica* (IV = 17.26) (Table 2; Fig. 2).

iii. *Fagonia-Zizyphus-Eragrostis* association

In cycle 17 at 5.5773E+04, the *Fagonia-Zizyphus-Eragrostis* association was structured that composed of 47 species of 7 trees, 14 shrubs and 26 herbs in which the mean highest important value 34.5, 28.1 and 19.9 presented by *Fagonia cretica*, *Zizyphus maurtiana* and *Aerua persica* respectively. It consists of 6 communities i.e. *Fagonia-Zizyphus-Saccharum* community (FZS), *Fagonia-Phoenix-Capparis* community (FPC), *Fagonia-Withania-Zizyphus* community (FWZ), *Dichanthium-Withania-Zizyphus* community (DWZ),

Eragrostis-Zizyphus-Capparis community (EYC) and *Salvia-Zizyphus-Rhazya* community (SZR) (Table 2; Fig. 2).

iv. *Aerua-Acacia-Cymbopogon* association

In *Aerua-Acacia-Cymbopogon* association, 34 plant species comprising 5 trees, 11 shrubs and 18 herbs and grasses were present. The dominant species on the basis of important value were *Aerua persica* (IV = 49.4), *Acacia modesta* (IV = 21.2) and *Cymbopogon jwarancusa* (IV=20.9). It was structured at 6.3334E+04 in cycle 18 covering *Cymbopogon-Rhazya-Zizyphus* community (CRZ), *Aerua-Saccharum-Zizyphus* community (ASZ), *Aerua-Rhazya-Acacia* community (ARA), *Aerua-Punica-Acacia* community (APA), *Aerua-Acacia-Capparis* community (AAC) and *Zizyphus-Aerua-Capparis* community (ZAC) (Table 2; Fig. 2).

b) *Detrended Correspondence Analysis (DCA)*

Ordination of the communities by DCA explains that the communities with high weight and structured 4 groups. On Axis 1, the groups 4, 3, 2 & 1 were structured with mean DCA weight 241, 138, 34.6 and 23.8 at Eigen values of axes (0.495) respectively. While on Axis 2, the 1, 2, 3 and 4 groups were produced with mean DCA weight as 145, 74, 135 and 69 at EIG (0.206) respectively. Furthermore, the group 1, 2, 3 and 4 were composed of 4, 5, 3 and 5 communities respectively. Other communities that were not present in groups were ASC, CZS, EYC, FPC and FPS with DCA weight 231, 221, 67, 84, 207 at Axis 1 and 220, 190, 116, 88 and zero at Axis 2 respectively. These groups show different vegetation types during spring seasons (Fig. 3).

V. DISCUSSION

Cluster analysis segregates the communities of similar character into major groups of plant life. In spring, 4 groups were structured. The chaining percentage between communities association was high 3.29 in spring. From this it was noticed that the chaining percentage would be high with high quantity and presence of species in an area. In spring, species were mostly found in all sites in less or high quantity while species presence is restricted to specific area due to diverse factors. Most factors that occur during spring in under investigated area were high grazing, cutting, non availability of water, soil erosion and uprooting of plant species. Ahmed & Yasmin (2011) analyzed natural vegetation of two zones along Hanna Lake, Baluchistan using DECORANA and classify the vegetation into plant communities. Major group is the objective to give structure to plant life. However, cluster analysis is a helpful preliminary position for competent judgment and adjoining neighbors of vegetation. Greater the homogeneity within communities and greater will be the similarity in the clustering. The cluster analysis was used to give clear picture of the plant life in an area in the

form of tree - shape. In hierarchical clustering the principle is to structure a hierarchical chain of communities' groups sorting from groups of community position at the bottom to a comprehensive group at the top. The graphically diagram which represents the hierarchy in the structure of upturned tree expresses a dendrogram that clarifies the arrangement in which position were united (bottom-up outlook) or group were divide (top-down outlook).

Detrended Correspondence Analysis (DCA) was used to give the shape to the communities on the basis of weight. This method is also used to give cleared picture of plant life in specific area in spring season. The present results conclude that the plant species composition was different in spring season in the same area. On axis 1, communities DCA weight was high in plains and low in hilly area. However, DCA has limitations, making it best to remove extreme outliers and discontinuities prior to analysis. DCA consistently gives the most interpretable ordination results, but as always the interpretation of results remains a matter of ecological insight and is improved by field experience and by integration of supplementary environmental data for the plant life sample sites. Ali & Malik (2010) applied the Detrended Correspondence Analysis (DCA) to identify environmental gradients to define vegetation distribution in green belts, gardens and parks of Islamabad city and classified the flora into 4 major association groups. El-Ghanim et al. (2010) studied the vegetation at Hail region north of central Saudi Arabia where multivariate techniques results showed 7 vegetation groups. Ahmad et al. (2010b) analyzed the vegetation along motorway (M-2), Pakistan by using multivariate techniques. In the investigated area, the fore mentioned facts noticeably indicate that slope, edaphic factor, harsh erosion, crushing of herbs and supply of rain water were the key source of plant life discrepancy. These geomorphologic aspects restrict the limitations and composition of plant communities. Distant from the reality that the site changeable are definitely significant for explaining the major plant life nature the association between the results of cluster analysis and DCA planes allow a direct analysis of scores of position data in DCA plane in relation to area up-and-down. The DCA technique provided interpretable and dynamic results than other ordination techniques and the length of first axis was greater than 3.0 and in terms of communities or species turnover. Jongman et al. (1995) recommended that if plants species or communities turnover is larger than 1.9 standard deviation then DCA technique is advanced option of ordination. Detrended Correspondence Analysis (DCA) was carried out to express compositional ascents in the plant life. DCA was presented using a default value for rescaling and detrending. Rare species and divergent communities were downweighted in DCA ordination.

The different association produced by cluster analyses are designed a first two axes as a sprinkled diagram. The DCA ordination axes may signify in same way the main substrate weight that affect the community in these records and have been used by the community and area characteristic of the relationship to argue the dominant characteristics of the location and plant life association. Cluster and DCA analysis are very helpful in communities' and species classification in addition to give structure to plant life. Such type of study was also carried out by Saima et al. (2009) who stated that tree density, pH and soil texture were the major determinant of vegetation pattern. There was thin vegetation in the investigated area and species was present in patches. The ecologists have tried to quantify the division of species beside the ecological gradients. There is an association between plant life sample and resources available (Ahmad et al., 2009b and Jabeen & Ahmad, 2009). The ordination by means of cluster analysis and DCA help us skillfully in evaluating the classification of plants and structure of entire habitat of plant life. Malik & Hussain (2008) conducted a study to work out the relationship between remote sensing data and vegetation communities of ecological importance using multivariate techniques and stated that the ordination methods proved effective in summarizing basic, general structure of the plant community types and to some extent indicated correspondence with their spectral signatures. This study pointed out that the climatic environment of region has restricted enlistment of area and the plant life was changed with the change of seasons and altitude. Our result agrees with Dasti & Malik (1998) who stated that altitude is an environmental factor which affecting plants association. Plant ecologists have commonly been aware that plant life shows an inconsistency over a wide range of particular scales and area that have built up methods for studying the classification of vegetation. The area show less rainfall than 200 mm and consist of thorny trees like *Zizyphus spp*, *A. nilotica*, *A. modesta*. Trees are sprinkled, roots long, leaves thick and small in most plant species therefore, the investigated area fall into tropical thorn forests. The value of altitude as an ecological factor affecting plant species association is not considering, surprising its close correlation with precipitation and interruption of rain (Danin et al., 1975; Evenari et al., 1982).

VI. CONCLUSION

The study demonstrated the potential of different classification and ordination analysis such as HCA and DCA in detecting the main environmental gradients and one could isolate a subset of environmental factors that led to a reasonable (ecologically meaningful) interpretation for important gradients in a few dimensions. It is used as a perfect way to study and

helps skillfully in evaluating the biodiversity and conservation of intact habitat and plant life in specific area. This study pointed out that climatic environment of region has privileged conscription of area and association of plant was changed with the change of altitude. Plant ecologists have commonly been conscious that vegetation shows a discrepancy over a broad variety of particular scales and area. Therefore, it is needed that we apply the multivariate techniques i.e. HEC and DCA methods for studying the degree of plant life differences.

VII. ACKNOWLEDGEMENTS

The paper is a portion of PhD thesis. Authors are grateful to the local people of area who have revealed the valuable information about plant species and assistance. We cannot forget all our class fellows and friends for all support they accorded us during the period we carried out this study.

REFERENCES RÉFÉRENCES REFERENCIAS

1. Ahmad SS (2009). Ordination and classification of herbaceous vegetation in Margalla. Hills National Park Islamabad Pakistan, Biological Diversity and Conservation, Bio. Di. Con., 2(2): 38-44.
2. Ahmad SS, Fazal S, Valeem EE, Zafar I (2009). Evaluation of ecological aspects of road side vegetation around Havalian city using multivariate techniques. Pak. J. Bot., 41(1): 461-466.
3. Ahmad SS, Wahid A Akbar KF (2010). Multivariate classification and data analysis of vegetation along motorway (M-2), Pakistan, Pak. J. Bot., 42(2): 1173-1185.
4. Ali SM, Malik RN (2010). Spatial Patterns Of Vegetation With Underlying Soil Properties Prevailing Along Drain Side Areas In Islamabad City. Pak. J. Bot., 42(4): 2397-2410.
5. Dasti AA, Malik SA (1998). A transect of vegetation and soils on the Indus valley scarp slope, Pakistan. Pak J. Plant Sci., 4(2): 73-84.
6. El-Bana M, Shaltout K, Khalafallah A, Mosallam H (2009). Ecological status of the Mediterranean *Juniperus phoenicea* L., relicts in the desert mountains of North Sinai, Egypt. Flora - Morphology, Distribution, Functional Ecology of Plants.
7. El-Ghanim WM, Hassan LM, Galal TM, Badr A (2010). Floristic composition and vegetation analysis in Hail region north of central Saudi Arabia. Saudi Journal of Biological Sciences, 17: 119-128.
8. He MZ, Zheng JG, Li XR, Qian YL (2007). Environmental factors affecting vegetation composition in the Alxa Plateau, China, Journal of Arid Environments, p. 473-489.
9. Hill MO (1979). TWINSpan - a FORTRAN Programme for Arranging Multivariate Data in an

- Ordered Two-Way Table By Classification of the Individuals and Attributes. Cornell University, Department of Ecology and Systematic, Ithaca, New York.
10. Hussain F (1989). Field and Laboratory Manual of Plant Ecology. UGC. Islamabad.
 11. Jabeen T, Ahmad SS 2009. Multivariate analysis of environmental and vegetation data of Ayub National Park, Rawalpindi. Soil and Environment., 28(2): 106-112.
 12. Khan M (2013). Dimension and Composition of plant life in Tehsil Takht-e-Nasrati, district Karak, Khyber Pakhtun Khawa, Pakistan. Ph.D. thesis, Department of Botany, University of Peshawar, Khyber Pakhtun Khawa, Pakistan.
 13. Khan M (2004). A Fraction of the Angiosperms of Tehsil Banda Daud Shah." M.Sc thesis. Gomal University D. I. Khan, Khyber Pakhtun Khawa, Pakistan.
 14. Khan M. Hussain F (2012). Plant life classification in winter of tehsil Takht-e-Nasrati, district Karak, Khyber Pakhtun Khawa, Pakistan. ARPN Journal of Science and Technology, 2: 113-124.
 15. Khaznadar M, Vogiatzakis IN, Griffiths GH (2009). Land degradation and vegetation distribution in Chott El Beida wetland, Algeria, Journal of Arid Environments, p. 73(3): 369-377.
 16. Malik RN, Husain SZ (2008). Linking remote sensing and ecological vegetation communities: a multivariate approach. Pak. J. Bot., 40(1): 337-349.
 17. McCune B, Mefford MJ (1999). Multivariate analysis of ecological data. Version 4.16. MJM software, Oregon, USA.
 18. Nasir E, Ali SI (eds.) (1972). Flora of West Pakistan. Fakhri Press, Karachi.
 19. Sagers LC, Lyon J (1997). Gradient analysis in a riparian landscape: contrasts among forest layers, Forest Ecology and Management, 96: 13-26.
 20. Saima S, Dasti AA, Hussain F, Wazir SM, Malik SA (2009). Floristic compositions along an 18 - km long transect in ayubia National Park district Abbottabad, Pakistan. Pak. J. Bot., 41(5): 2115-2127.
 21. Stewart RR (1972). An Annotated Catalogue of the Vascular Plants of West Pakistan and Kashmir. Gordon College, Rawalpindi.

Table 2 : Mean relative importance value of species in different associations during spring distinguished through cluster analysis of Tehsil Takht-e-Nasrati, Karak.

S. No	Species Name	Groups			
		1	2	3	4
1	<i>Acacia modesta</i> Wall.	0	0	7.55	21.2
2	<i>Acacia nilotica</i> (L.) Delice.	4.6	17.3	5.56	4.07
3	<i>Dalbergia sissoo</i> Roxb.	2.9	12.4	0.79	2.97
4	<i>Gymnosporia royleana</i> Wall. ex M. A. Lawson.	0	0	0.78	0
5	<i>Monothea buxifolia</i> (Falc.) A.D.	0	0	1.02	0
6	<i>Phoenix dactylifera</i> L.	16.6	0.87	10.7	1.32
7	<i>Prosopis farcta</i> (Banks & Sol.) J.F. Macbr.	28.4	0	0	0
8	<i>Prosopis juliflora</i> (Sw.) DC.	0	0	0	0.86
9	<i>Tamarix aphylla</i> (L.) Karst.	2.03	0	0	0
10	<i>Zizyphus maurtiana</i> Lam.	14.2	54.1	28.1	19.7
11	<i>Astragalus psilocentros</i> Fisch.	0	1.9	2.09	8.88
12	<i>Calligonum polygonoides</i> L.	0	15.3	2.3	0
13	<i>Calotropis procera</i> (Wild.) R. Br.	9.79	10.3	5.59	2.24
14	<i>Capparis decidua</i> (Forssk.) Edge worth.	0	0	7.49	11.9
15	<i>Capparis spinosa</i> L.	0	0	0	8.5
16	<i>Cassia angustifolia</i> Vahl.	0	0	3.19	0
17	<i>Datura metel</i> L.	13	7.99	1.1	0
18	<i>Periploca aphylla</i> Decne.	12.7	5.28	3.26	0.73
19	<i>Punica granatum</i> L.	0	0	0	8.81
20	<i>Rhazya stricta</i> Decne.	0	0	15.7	20.2
21	<i>Ricinus communis</i> L.	6.5	2.83	0.83	0
22	<i>Saccharum bengalense</i> Retz.	21.9	19.8	6.34	9.02

23	<i>Saccharum spontaneum</i> L.	1.38	0	3.03	0.75
24	<i>Withania coagulans</i> (Stocks) Dunal.	0	0	14.2	2.15
25	<i>Zizyphus nummularia</i> (Burm.f.) W. & A.	0	0	4.87	4.93
26	<i>Aerua persica</i> (Burm.f.) Merrill.	16.3	5.28	19.9	49.4
27	<i>Asparagus gracilis</i> Royle.	0	5.98	4.19	9.25
28	<i>Asphodelous tenuifolius</i> Cavan.	0	2.15	2.27	0
29	<i>Cenchrus biflorus</i> Hook. f.	4.17	0	0	0
30	<i>Cenchrus ciliaris</i> L.	0	12.3	15.9	12.8
31	<i>Centaurea iberica</i> Trev.Ex. Spreng	0	0	1.32	1.53
32	<i>Chenopodium album</i> L.	2.7	4.76	0	0
33	<i>Citrullus colocynthis</i> L. Schrad.	1.7	5.57	1.32	0
34	<i>Convolvulus arvensis</i> L.	6.9	2.3	0	0
35	<i>Convolvulus pluricaulis</i> Choisy.	0	0	2.82	7.64
36	<i>Crotalaria medicaginea</i> Lam.	0	1.22	0	0
37	<i>Cymbopogon jwarancusa</i> (Jones) Schult.	0	0	0	20.9
38	<i>Cynodon dactylon</i> (L.) Pers.	5.08	3.4	13.1	8
39	<i>Cyperus rotundus</i> L.	0	3.65	1.41	0
40	<i>Dichanthium annulatum</i> (Forssk) Staph.	0	0	11.5	8.44
41	<i>Echinops echinatus</i> D.C.	0	2.18	9.08	7.16
42	<i>Eragrostis poaoides</i> Beauv.	12.9	11.9	21.7	19
43	<i>Erodium malacoides</i> (L.)L. Her. Ex Ait.	0	0.81	0	0
44	<i>Euphorbia helioscopia</i> L.	5.89	6.44	0	0
45	<i>Euphorbia prostrata</i> Ait.	2.47	4.37	0	0
46	<i>Fagonia cretica</i> L.	22.6	6.68	34.5	8.2
47	<i>Hypocoum pendulum</i> L.	0	3.53	0	0
48	<i>Illoga fontanesii</i> Cass.	12.1	10.7	0	0
49	<i>Ipomoea hederacea</i> (L.)Jacq.	0	0	1.32	0
50	<i>Kickxia ramosissima</i> (Wall) Janchen.	0	1.63	0	3.3
51	<i>Launaea nudicaulis</i> (L.) Hook. f.	0	7.7	8.1	4.25
52	<i>Malcolmia africana</i> (L.) R.Br.	1.8	2.04	0.66	0.44
53	<i>Malva parviflora</i> L.	0	2.75	0.98	0
54	<i>Malva neglecta</i> Wallr.	0	4.58	0.98	1.87
55	<i>Medicago laciniata</i> (L.) Mill.	0	0	0.49	1.66
56	<i>Melilotus indicus</i> (L.) All.	0	3.87	0	0
57	<i>Peganum harmala</i> L.	7.6	0	0	0
58	<i>Plantago ciliata</i> Desf.	9.9	4.34	0	0
59	<i>Plantago ovata</i> Forssk.	11.1	4.3	0	0
60	<i>Solanum nigrum</i> L.	4.99	3.3	0.75	0
61	<i>Salvia moorcroftiana</i> Wallich ex Benth.	0	0	12.4	0
62	<i>Saussurea heteromalla</i> (D.Don) Hand.	20.5	7.61	1.97	0
63	<i>Silene conoidea</i> L.	3.01	2.93	0.66	0
64	<i>Solanum incanum</i> L.	0	0	2.41	3.63
65	<i>Solanum surattense</i> Burm .f.	9.64	4.63	4.17	4.3
66	<i>Vicia sativa</i> L.	4.65	9.03	1.61	0

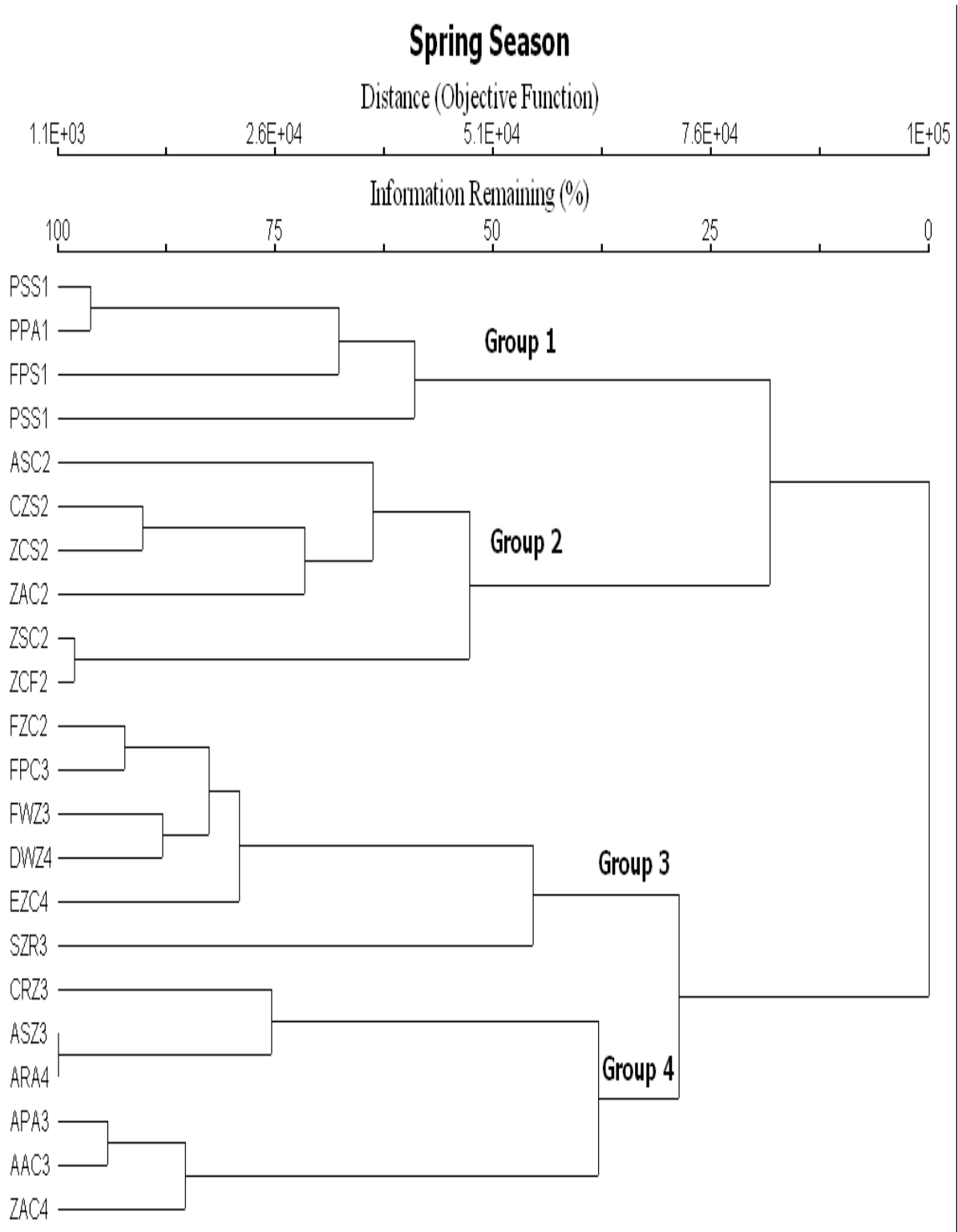


Figure 2 : Two way cluster dendrogram showing grouping of different communities into association during spring, Tehsil Takht-e-Nasrati, District Karak.

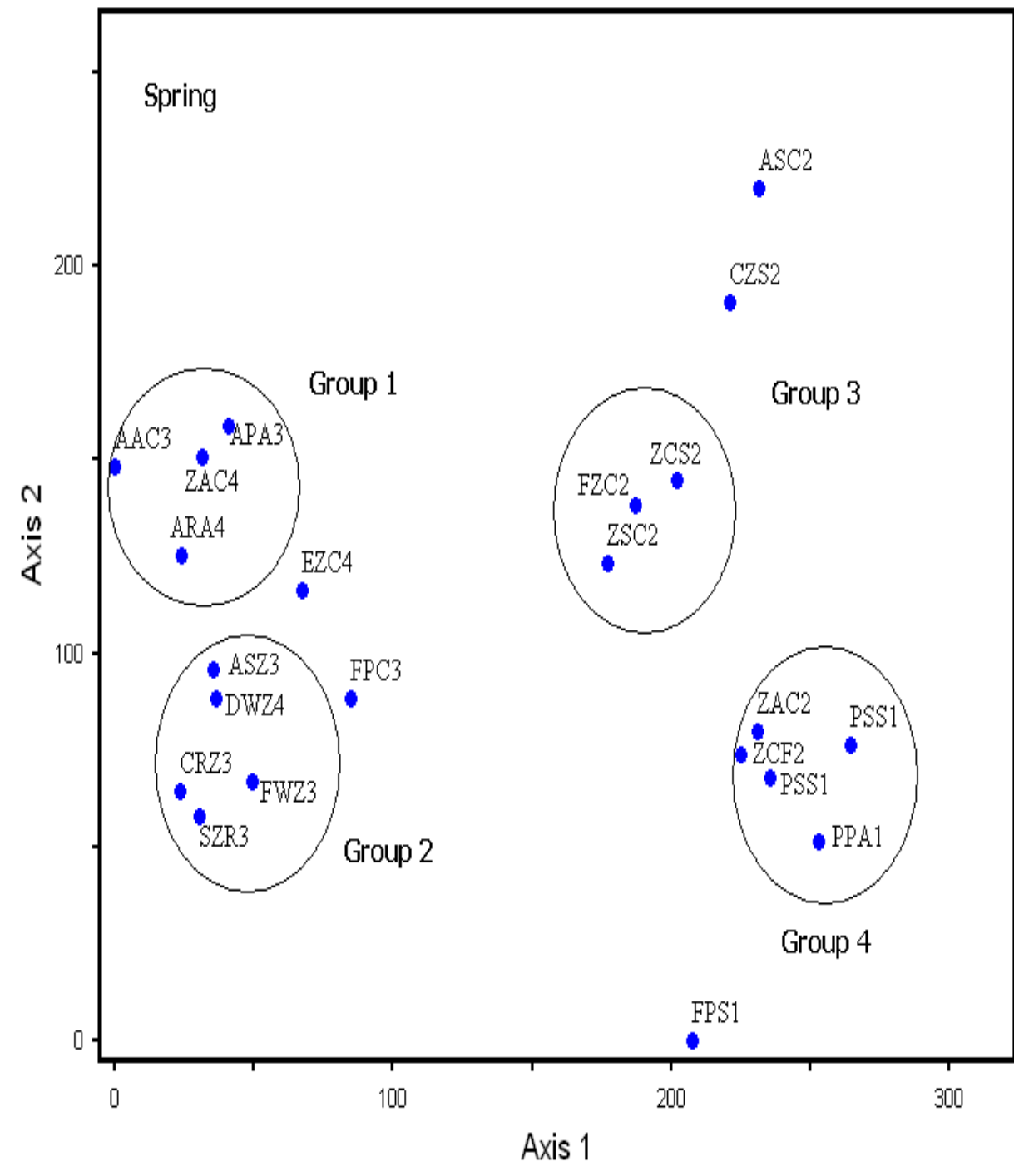


Figure 3 : Detrended Correspondence Analysis (DCA) of communities during spring, Tehsil Takht-e-Nasrati, District Karak.

This page is intentionally left blank



GLOBAL JOURNAL OF SCIENCE FRONTIER RESEARCH: C
BIOLOGICAL SCIENCE

Volume 14 Issue 2 Version 1.0 Year 2014

Type : Double Blind Peer Reviewed International Research Journal

Publisher: Global Journals Inc. (USA)

Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Isolation and Phytochemical Characterization of Bioactive Compounds from the Rhizomes of *Cyperus Rotundus*. L

By Jeyasheela. R, K. Chairman, C. Padmalatha & A. J. A. Ranjit Singh

Sri Paramakalyani College, India

Abstract- Phytochemical constituents of plants with varied phytochemical, physiological and biochemical activity has received attention to use them as food, medicine, cosmetics etc. In fact many plants extracts have been shown to exert biological activity invitro and invivo which justified the healing potential of ethnomedicine. Using phytochemical analysis, UVvisible spectrum and GC-MS studies, the active compound that are rich in rhizomes were tested. From the investigation it was found that phenolic compounds and tannin are rich in rhizomes. An important compound that formed a dominant peak was identified to be 3, 3, 3, trifluoro -N-(-4-fluorophenyl)- bicyclo (4.1.0) heptanes. Hence it is essential to study the traditional health care systems.

Keywords: *cyperus rotundus*, *phytochemical analysis*, *uvanalysis*, *GC-MS analysis*.

GJSFR-C Classification : *FOR Code: 270199p*



Strictly as per the compliance and regulations of :



Isolation and Phytochemical Characterization of Bioactive Compounds from the Rhizomes of *Cyperus Rotundus*. L

Jeyasheela. R^α, K.Chairman^σ, C. Padmalatha^ρ & A. J. A. Ranjit Singh^ω

Abstract- Phytochemical constituents of plants with varied phytochemical, physiological and biochemical activity has received attention to use them as food, medicine, cosmetics etc. In fact many plants extracts have been shown to exert biological activity invitro and invivo which justified the healing potential of ethnomedicine. Using phytochemical analysis, UV-visible spectrum and GC-MS studies, the active compound that are rich in rhizomes were tested. From the investigation it was found that phenolic compounds and tannin are rich in rhizomes. An important compound that formed a dominant peak was identified to be 3, 3, 3, trifluoro -N-(4-fluorophenyl)-bicyclo (4.1.0) heptanes. Hence it is essential to study the traditional health care systems.

Keywords: *cyperus rotundus*, phytochemical analysis, uv-analysis, GC-MS analysis.

I. INTRODUCTION

Cyperus rotundus Linn., (Family -Cyperaceae), is a medicinal plant, also known as purple nut edge or nut grass, is a common perennial weed with slender, scaly creeping rhizomes, bulbous at the base and arising from the tubers which are about 1-3 cm long. The tubers are externally blackish in colour and reddish white inside, with a characteristic odour. The stems grow to about 25 cm tall and the leaves are linear, dark green and grooved on the upper surface. Inflorescences are small, with 2-4 bracts, consisting of tiny flowers with a red-brown husk. The nut is three angled, oblong-ovate, yellow in colour and black when ripe. *Cyperus rotundus* is indigenous to India, but are now found in tropical, subtropical and temperate regions (Pooley et al, 1998). The genus *Cyperus* includes common weeds found in upland and paddy fields in temperate to tropical regions. *C. rotundus*, which are used as traditional folk medicines for treatment of stomach and inflammatory diseases (Gupta et al 1971; Singh et al., 1970). The *Cyperus rotundus* L have been reported to contain oils, alkaloids, glycosides, saponins, flavonoids, tannins. The rhizomes of *C. rotundus* have been used in ancient medicine in

India for fever, dysentery, purities, pain, vomiting and various blood disorders (Kirtikar et al., 1944). In particular, plant extracts offer a rich potential source of novel anti – platelet agents (Ballabeni et al., 2007).

C. rotundus has been reported to contain sesquiterpenes, hydrocarbons, epoxides and ketones and also used as anti-inflammatory estrogenic, antipyretic, antiemetic, diuretic, hypotensive agent (Aslam, 2002). There are some reports on the phytochemical analysis of species belonging to *Cyperus rotundus* found in the literature. These scientific studies on the species of this genus showed the presence of constituents belonging mainly to the groups of sesquiterpenes, flavonoids, tannins sterols, alkaloids, benzoquinones and essential oils (Zargari, 1990 and Lawal and Oyediji, 2009).

A novel norsesquiterpene, named norcyperone, and three known compounds:(-)-clovane-2,9-diol, rosenonolactone, and 5 α ,8 α -epidioxy-(20S,22E,24R)-ergosta-6,22-dien-3 β -ol were isolated from the rhizomes of *Cyperus rotundus* L.(Yan Xu et al.,2008).The rhizome oils of this plant from different countries also showed compositional differences, suggesting the existence of phytochemical varieties. Cyperene (19.2-30.9%) and α -cyperone (4.5-25.2%) were the most abundant constituents of the oils of Nigerian and Tunisian species, but the concentrations of other main components varied (Ekundayo et al., 1991 and Kilani et al., 2005). Root extracts of *C. rotundus* (CR) showed the presence of β -sitosterol, cyperene, cyperol, flavonoids, sesquiterpenoids, ascorbic acid and polyphenols (Sonwa and Konig, 2001).

II. MATERIALS AND METHODS

a) Preparation of the plant extract

Ethyl acetate and methanol extracts were obtained by using soxhlet apparatus. The two extracts, with different polarities were concentrated by evaporating it to dryness under reduced pressure by rotary vacuum evaporator (New Lab, Company) to obtain the respective extracts and each residue was stored at 4 OC. These two extracts were resuspended in Dimethyl sulfoxide. The extracts were then stored at -180c until further analysis.

Author α ρ : Dept. of Zoology, M. V. M. Govt. Arts and Science College for Women, Dindugal, Tamilnadu.

Author σ : Dept. of Zoology, Sri Paramakalyani College, Alwarkurichi, Tirunelveli, Tamilnaudu, India-627 412.

Author ω : Sri Paramakalyani College, Alwarkurichi, Tirunelveli, Tamilnaudu, India-627 412. e-mail: journalpublish2012@gmail.com

b) Column chromatography – Methanol extract

The column was packed with silica gel G for column chromatography (60 – 120) and built the column with n-hexane mesh. The slurry of methanol root extract (3g) was introduced in to the column.

The 50ml of fractions were collected by eluting hexane: ethyl acetate (H: EA) and also followed by ethyl acetate: methanol (EA: M). The order of elution is H:EA(70: 30),H:EA (60: 40), EA100% , EA:M(98:2) ,EA : M (95:5) ,EA : M (90 : 10) ,EA: M (80:20) EA : M (60 ; 40), EA : M (40 : 60), EA : M (20 : 80), 100% Methanol. The collected fractions were then concentrated using rotary vacuum evaporator under reduced pressure was used for further pharmacological and spectral analysis.

c) Column chromatography – Ethyl acetate extract

The column was packed with silica gel G (60 - 120mesh) for column chromatography and built the column with dichloromethane. The slurry of ethyl acetate root extract (6g) was introduced into the column.

The 50ml of fractions were collected by eluting dichloromethane: methanol (DCM: M). The order of elution is DCM : M (80 : 20) ,DCM : M (70 : 30) ,DCM : M (60 : 40) ,DCM : M (50: 50) ,DCM : M (40 : 60) ,DCM : M (30 : 70) ,DCM : M (20 : 80), DCM : M (10 : 90) , 100% Methanol. Finally the collected fractions were evaporated and concentrated using rotary vacuum evaporator under reduced pressure and were used for further pharmacological and spectral analysis.

d) Phytochemical Screening

Phytochemical screening of eluted fractions was tested for the presence of various phytochemical constituents .The analyses were carried out by following techniques.

e) Preliminary screening

The various fractions of methanolic and ethyl acetate root extracts of *Cyperus rotundus* L.were used to screen for the following the phytochemicals like Triterpenoids, reducing sugars, alkaloids, phenolic compounds, Saponin, xanthoprotein, tannins, aromatic acids, flavonoids, phytosterols small quantities of all the fractions were dissolved separated in distilled water and filtered. The filtrate was subjected to further analysis.

f) Detection of Triterpenoids

To the filtrate with one or two pieces of tin and three drops of thionyl chloride was added slowly, a violet or purple colour solution indicates the presence of triterpenoids.

g) Detection of Phenolic Compounds

i. Ferric chloride Test

To the filtrate add few drops of neutral ferric chloride was added and the appearance of an intense blue or violet colour were recorded. This indicated the presence of phenolic compounds.

ii. Detection of saponins

Small portion of the various filtrates were diluted with 20 ml of distilled water and it was agitated in a graduated cylinder for 15 minutes. Formation of foamy layer was record, it indicated the presence of saponin.

iii. Detection of Xanthoproteins

To the filtrates add few drops of concentrated nitric acid was added with excess amount of ammonia .No red orange precipitate indicates the absence of xantho proteins in all fractions.

iv. Detection of Tannins

To the filtrate, 2ml of solution of gelatin was added white precipitate was seen which indicates the presence of tannins.

v. Detection of Aromatic acids

To small quantity of the various filtrates add saturated sodium bicarbonate, no brisk effervescence indicates the absence of Aromatic acids.

vi. Detection of Flavanoids

Small portion of the various filtrates were dissolved in alcohol and treated with magnesium metal followed by concentrated hydrochloric acid. Formation of Magenta colour indicates the presence of flavonoids.

vii. Detection of phytosterols

Small quantity of various filtrates were dissolved in 5ml of chloroform solutions were subjected to salkowski's and Liebermann-Burchard's test for the detection of phytosterols.

viii. Salkowski's Test

To the 1ml of above prepared chloroform solution, few drops of concentrated sulfuric acid was added. It gave red colour which indicates the presence of phytosterols.

ix. Liebermann-Burchard's Test

The above prepared chloroform solution was treated with few drops of concentrated sulfuric acid followed by 1ml of acetic anhydride solution. It gave green colour, which shows the presence of phytosterol.

h) Determination of total phenolics and tannins

The total phenolic content was determined according to the method described by Siddhuraju and Becker (2003).

i) Determination of total flavanoid content

The flavonoid content was determined by the use of a slightly modified colorimetry methoddescribed previously by Zhishen et al. (1999).

j) Phytochemical Separation by using TLC Method

Each fractions of the column eluted sample was subjected to TLC to find out the separation of single compound and confirmation from the fraction. Thin Layer Chromatography was performed on prepared plates with Silica gel F254 grade (Merck, Darmstadt,

Germany) as stationary phase. A one-dimensional ascending development technique was used to detect the constituents of an extract on TLC plate. Visual detection was done in daylight and under UV light at a wave length of 254 and 344 nm depending on the nature of compounds separated.

k) UV-Spectrophotometry analysis

The absorbance spectra of the extracted samples were measured using UV visible spectrophotometer 2203 at wavelength range from 200-1000 nm. The detector used was diode array detector with deionized water.

l) GC - MS Analysis

The Clarus 500 GC-MS used in the analysis employed a fused silica column packed with Elite-1 (100% dimethyl poly siloxane, 30nm X 0.25mm ID X 1 m df) and the components were separated using Helium as carrier gas at a constant flow rate of 1 ml/min. The 2 sample extract injected into the instrument was detected by the Turbo gold mass detector (Perkin Elmer) with the

aid of the Turbo mass 5.1 software. During the 36th minute GC-MS extraction process, the oven was maintained at a temperature of 1100C with 2 minutes holding. The injector temperature was set at 2500C (mass analyzer).

The different parameters involved in the operation of the clarus 500 GC-MS were also standardized (Inlet temperature: 2000C; Source temperature: 2000C). Mass spectra were taken at 70 eV; a scan interval of 0.5 s and fragments from 45 to 450 Da. The MS detection was completed in 36 minutes. The detection employed the NIST Ver. 2.0 - year 2012 library.

III. RESULTS AND DISCUSSION

Phytochemical screening of various fractions of methanol extract of *Cyperus rotundus* rhizomes reveals the presence of aromatic acids, triterpenoids, reducing sugars, alkaloids, phenolic compounds, saponins, tannins, flavonoids, phytosterols and absence of xanthoproteins (Table 1).

Table 1 : Phytochemical screening of Methanol extract fractions of *Cyperus rotundus* L. rhizomes.

S. NO	Phytoconstituents	Methanol extract fractions of <i>Cyperus rotundus</i> L. rhizomes										
		Hexane(H) :Ethyl acetate (EA) ; Ethyl acetate (EA) : Methanol (M)										
		H:EA 70:30	H:EA 60:40	EA 100%	EA: M 98:02	EA: M 95:5	EA: M 90:10	EA: M 80:20	EA: M 60:40	EA: M 40:60	EA: M 20:80	M 100%
1	Triterpenoids	+	+	+	-	+	-	+	-	-	-	-
2	Reducing sugar	+	+	+	+	-	+	-	-	-	-	+
3	Alkaloids	+	+	-	+	+	+	+	+	+	+	+
4	Phenolic compounds	+	-	+	+	+	-	+	-	-	-	-
5	Saponins	-	+	-	-	+	+	-	+	+	+	+
6	Xanthoprotein	-	-	-	-	-	-	-	-	-	-	-
7	Tannins	+	-	-	+	-	-	-	+	-	-	-
8	Aromatic acid	-	-	-	-	-	+	+	-	-	-	-
9	Flavonoids	+	+	+	-	-	+	-	+	+	-	-
10	Phytosterols	+	+	+	+	-	-	-	-	+	-	+

(+) Presence (-) Absence

Table 2 : Phytochemical screening of ethyl acetate extract fractions of *Cyperus rotundus* L. rhizomes.

S.NO	Phyto constituents	Ethyl acetate extract fractions of <i>Cyperus rotundus</i> L. rhizomes								
		Dichloro Methane (DCM) : Methanol (M)								
		DCM:M 80:20	DCM:M 70:30	DCM:M 60:40	DCM:M 50:50	DCM:M 40:60	DCM:M 30:70	DCM:M 20:80	DCM:M 10:90	M 100%
1	Triterpenoids	-	+	-	-	-	+	-	-	-
2	Reducing sugar	+	+	+	+	+	-	+	+	+
3	Alkaloids	+	+	+	+	-	-	+	+	+
4	Phenolic compounds	+	-	+	-	-	+	-	-	-
5	Saponins	+	-	+	+	+	-	+	+	+
6	Xanthoprotein	-	-	-	-	-	-	-	-	-
7	Tannins	-	-	+	-	-	+	-	+	-
8	Aromatic acid	-	-	-	-	-	-	-	-	-
9	Flavanoids	+	-	-	-	-	+	+	-	-
10	Phytosterols	+	+	+	+	+	-	-	+	+

(+) Presence (-) Absence

Phytochemical screening of various fractions of methanol extract of *Cyperus rotundus* rhizomes reveals the presence of Triterpenoids, reducing sugars, alkaloids, phenolic compounds, Saponins, tannins, flavanoids, phytosterols and absence of xanthoprotein and aromatic acids. (Table -2)

The total phenolics in methanol extract, ethyl acetate extract and fraction DCM: Methanol (30:70) of ethyl acetate extracts are 57.46 ± 0.84 , 31.50 ± 0.51 and

22.63 ± 0.88 respectively. The total flavanoid in methanol extract, ethyl acetate extract and fraction DCM: Methanol (30:70) of ethyl acetate extracts are 1.10 ± 0.07 , 0.29 ± 0.030 and 22 ± 0.05 respectively. The total tannin in methanol extract, ethyl acetate extract and fraction DCM: Methanol (30:70) of ethyl acetate extracts are 12.76 ± 0.83 , 12.87 ± 0.19 and 5.32 ± 1.00 respectively (Table 3)

Table 3 : Estimation of Total phenolics, Total Flavanoids and total Tannins present in the Methanolic extract, Ethyl acetate extract and Ethyl acetate extract fraction DCM: Methanol (30:70) of *Cyperus rotundus* L. rhizomes.

S.No	Sample	Total Phenolics mg TAE/g extract	Total Flavanoid Mg RE/g extract	Total Tannin mg TAE/g extract
1.	Methanol crude	57.46 ± 0.84	1.10 ± 0.07	12.76 ± 0.83
2.	Ethyl acetate crude	31.50 ± 0.51	0.29 ± 0.03	12.87 ± 0.19
3.	Fraction DCM:M (30:70)	22.63 ± 0.88	0.22 ± 0.05	5.32 ± 1.00

Values are means of three independent analyses of the extract + standard deviation (n=3)

TAE – Tannic acid equivalent

RE – Rutin equivalent

a) UV-SPECTRAL ANALYSIS

UV- spectrum of the test fraction EA: Methanol (80:20) of Ethyl acetate extract gives prominent peak of 241.6, 208.0, 248.0, 257.6, 979. 2 with 3. 025 ,3.064, 3.020, 3.013, 0.053 absorbance which supports the bioactive compound in the root extract. (Fig-1)

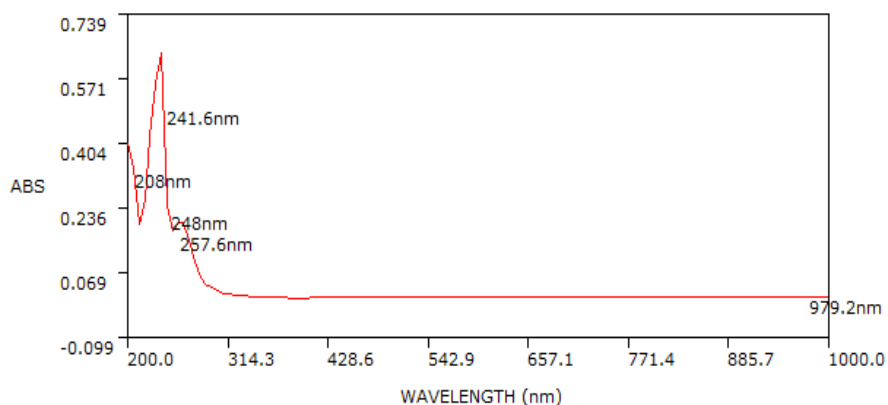


Fig. 1 : EA: M (80:20)

UV spectrum of the test fraction DCM: Methanol (30:70) of ethyl acetate extract gives prominent peak of 646.4 with 0.034 absorbance which supports the bioactive compound in the root extract. (Fig-2)

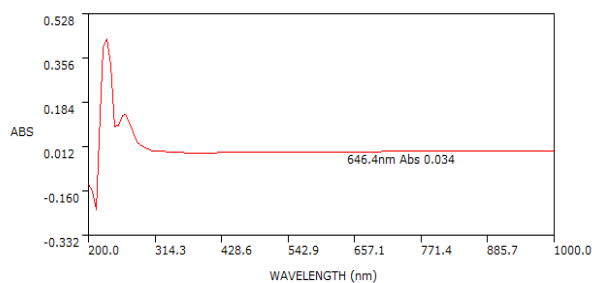


Fig. 2 : DCM: M (30:70)

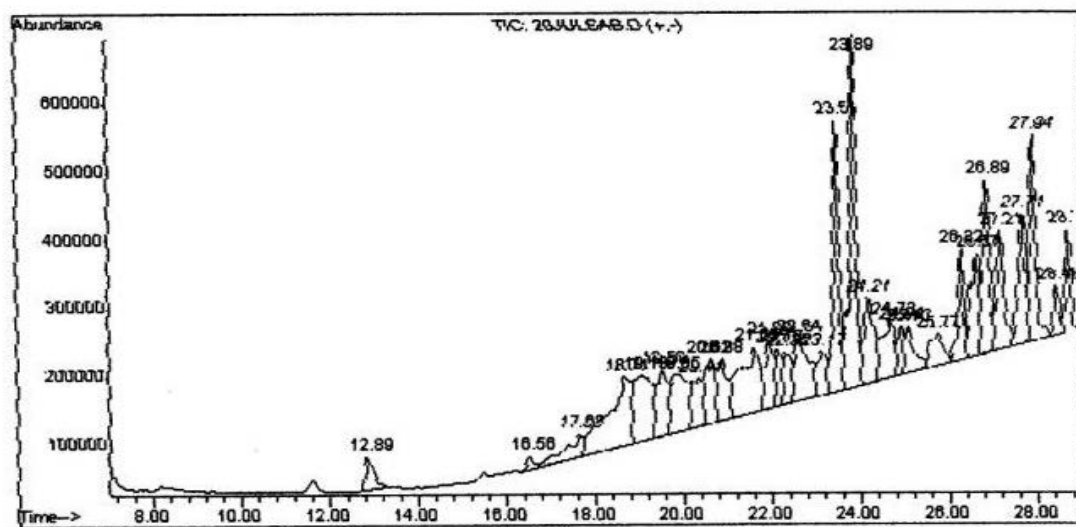


Fig. 6 : In GC analysis of the test fraction DCM: Methanol (30:70) of ethyl acetate extract of C. rotundus

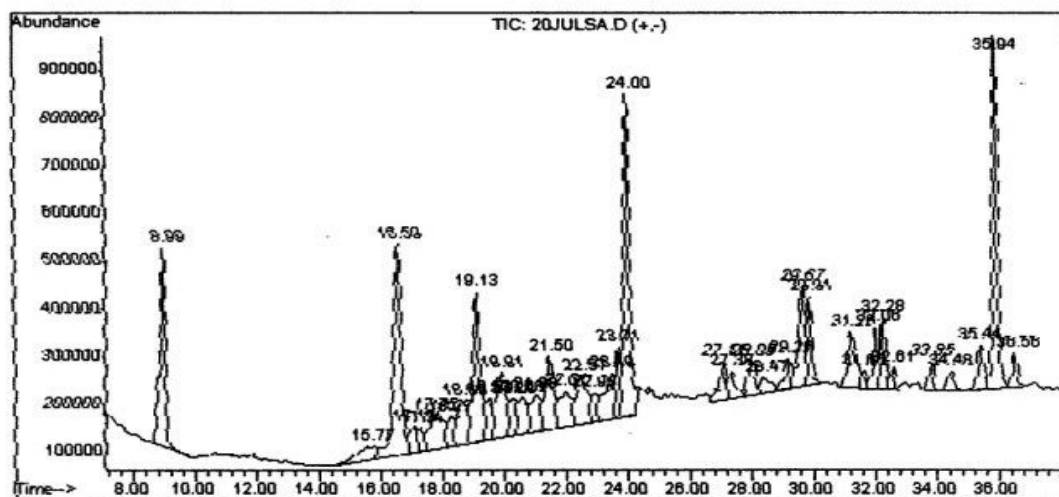
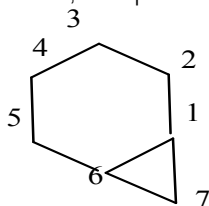


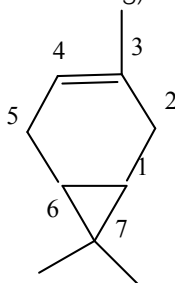
Fig.7 : In GC analysis of the test fraction ethyl acetate: Methanol (80:20) of methanol extract of C.rotundus

In GC analysis of the test fraction EA: Methanol (80:20) of methanol extract of C.rotundus gives prominent peak. The most abundant peaks with retention time 8.98, 16.59, 19.13, 24.00, 29.68 and 35.94 were observed along with other peaks with smaller abundant out of the six more abundant peaks, the peak at 24.00 and 35.94 show the response for aromatic carboxylic acid and esters. Others are showing the response for aliphatic esters, acids and amides (Fig 6,7).

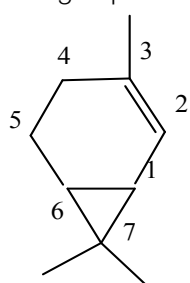
In GC analysis of the test fraction DCM: Methanol (30:70) of Ethyl acetate extract of C.rotundus gives prominent peak. The most abundant peaks with retention time 12.89, 23.50, 23.90, 26.90 and 27.94 were observed along with other with little abundant. Out of five peaks the most abundant peaks with RT 23.5 and 23.90 were quite interesting. The peak at 23.50 is due to Bicyclo (4.1.0)heptanes, a terpene compound



It belongs to bicyclic monoterpene class I (6+3 membered ring). It belongs to carane group.



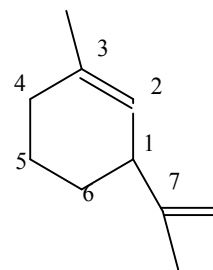
Car-3-ene



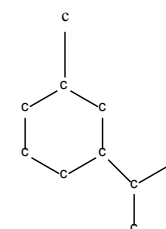
car-2-ene

The car-3-ene and car-2-ene are found to be present in natural source is essential oils. Finar, (1973). p-cymene, p-cymenene has been reported earlier in Cyperus rotundus (El-Gohary 2004).

The carenes are obtained from m-cymene skeleton is.



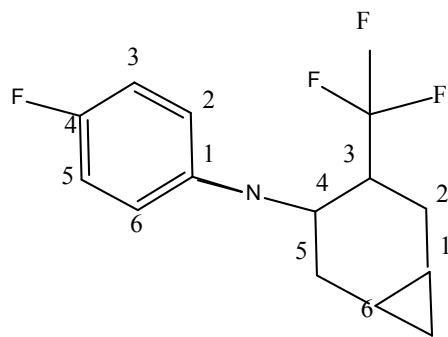
p-cymene



m-cymene

Sylvestrene are also reported in natural source as essential oil. The most probable compound belonging to the peak at 23.50 is justified by the above evidences.

The DCM: Methanol (30:70) fraction of ethyl acetate extract of Cyperus rotundus rhizomes is found to contain.



3,3,3, trifluoro -N-(4-fluorophenyl)- bicyclo (4.1.0)heptane

This fraction shows excellent antimicrobial activities and antioxidant activities. Further phytochemical studies may lead to the exact bioactive compound principle. This most probable compound seems to be the first report in the rhizome extracts of *Cyperus rotundus*

Recent literature survey in this plant indicates the bioactive potential of this plant *Cyperus rotundus* L. The plant root extract is found to contain various phytochemicals. The selected phytochemicals such as phenolic compound, flavanoid and tannin, have been estimated. The GC-MS pattern of ethyl acetate extract fraction dichloromethane: methanol (30:70) indicates the presence of 3,3,3, trifluoro -N-(4-fluorophenyl)- bicyclo (4.1.0) heptane.

IV. ACKNOWLEDGEMENT

Authors are thankful to Management, Principal, Sri Paramakalyani College, Alwarkurichi, Tirunelveli, Tamilnadu, lab facilities and encouragement. We thankful for supporting agency of Department of Science and Technology, Govt. of India, New Delhi.

REFERENCES RÉFÉRENCES REFERENCIAS

- Pooley E, (1998). A Field Guide to Wild Flowers in KwaZulu-Natal and Eastern Region; Natal Flora Publications Trust: Durban, South Africa, p. 562.
- Gupta MB, Palik TK, Sing N, Bhargava KP, (1971). Pharmacological studies to isolate the active constituents from *Cyperus rotundus* possessing anti-inflammatory, antipyretic and analgesic activities. Indian J Med Res; 59, pp:76-82.
- Singh N, Kulshretha V K, Gupta MB, Bhargava KP. 1970. A Pharmacological study of *Cyperus rotundus*. Indian journal of medical Research; 58:103-109
- Kirtikar KR, Basu, BD, 1944. Indian Med. Plants 4: 4:2628 Liu F and Ng TB, Life Sci. 66, pp :725.
- Ballabeni V, Tognolone M, Bertoni S, Bruni R, Gwerrini A, Rueda GM, Baroceli E, (2007). Antiplatelet and antithrombotic activities of essential oil from wild ocotea quijos kosteom calies from amazonean Ecuador. Pharmacological Research. 55, pp: 23-30.
- Aslam M, (2002). Aspects of Asian Medicine and its Practice in the West. In: Trease and Evans Pharmacognosy by W.C. Evans, fifteenth Edn., W.B. Saunder Company Ltd., Edinburgh, UK., pp: 467-481.
- Zargari A, (1990). Medicinal Plants. Tehran University Publications, Tehran, Edition 4, Vol. 4, pp: 679-682.
- Lawal OA, Oyediji AO, (2009). Chemical composition of the essential oils of *Cyperus rotundus* L. from South Africa. Mole., 14(8), pp: 2909-2917.
- Yan Xu , Hong-Wu Zhang , Chang-Yuan Yu , Yang Lu , Ying Chang , and Zhong-Mei Zou, (2008). Norcyperone, a Novel Skeleton Norsesquiterpene from *Cyperus rotundus* L. Molecules, 13, pp: 2474-2481.
- Ekundayo O. Oderinde R. Ogundeyin M. Biskup ES, (1991). Essential oil constituents of *Cyperus tuberosus* Rottb. Rhizomes. Flav. Fragr. J, 6, pp: 261-264.
- Kilani S, Abdelwahed A, Chraief I, Ben Ammar, R, Hayder N, Hammami M, Ghedira K, Chekir-Ghedira L, (2005). Chemical composition, antibacterial and antimutagenic activities of essential oil from (Tunisian) *Cyperus rotundus*. J. Essent. Oil Res. 17, pp:695-700.
- Sonwa MM, Koning WA,(2001). Chemical study of the essential oil of cyperus roundus. Phyto chemistryNov, 58(5), pp: 799-810.
- Siddhuraju P and Becker K, (2003). Antioxidant properties of various solvent extracts of total phenolic constituents from three different agroclimatic origins of Drumstick tree (*Moringa oleifera* Lam.) leaves. Journal of Agricultural and Food Chemistry, 51, pp: 2144–2155.

This page is intentionally left blank



GLOBAL JOURNAL OF SCIENCE FRONTIER RESEARCH: C
BIOLOGICAL SCIENCE

Volume 14 Issue 2 Version 1.0 Year 2014

Type : Double Blind Peer Reviewed International Research Journal

Publisher: Global Journals Inc. (USA)

Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Evaluation of Ovicidal and Larvicidal Activities of Methylene Chloride-Methanol Extract of *Annona Senegalensis* (Annonaceae) Stem Bark on *Heligmosomoides Bakeri* (Nematoda, Heligmosomatidae)

By Francesco D'Angelo, Wabo Poné J, Yondo Jeannette,
Komtangi Marie Claire, Sauro Vittori & Mpoame Mbida

University of Dschang, Cameroon

Abstract- Infections of animals with gastrointestinal nematodes constitute a world wide health problem. The aim of this study was to assess the effectiveness in vitro anthelmintic of Methylene Chloride/Methanol (1:1 volume mixture) extract of *Annona senegalensis* (Annonaceae) the barks of the stem on *Heligmosomoides bakeri* eggs and larvae (for ovicidal and larvicidal activities, respectively). *Annona senegalensis* is included in the list of the plants that have anthelmintic activity in the traditional medicine, just as with other plants like *Albizia anthelmintica* (Mimosaceae), *Canthium mannii* (Rubiaceae), *Nauclea latifolia* (Rubiaceae) and *Carica papaya* (Caricaceae). The plant material was collected from the peripheral savanas of Foumban, Noun Division, West Region of Cameroon. The final concentrations of plant extract tested were: 5 000, 3 750, 2 500, 1 250 and 625 $\mu\text{g/mL}$; 4 % Tween 80 aqueous solution was used as negative control. Ovicidal and larvicidal activities were assessed thru egg embryonation and hatching rates and thru mortality rate of L1 and L2 larvae, respectively.

Keywords: *heligmosomoides bakeri*; *annona senegalensis*; ovicidal; larvicidal; anthelmintic.

GJSFR-C Classification : FOR Code: 820303



Strictly as per the compliance and regulations of :



© 2014. Francesco D'Angelo, Wabo Poné J, Yondo Jeannette, Komtangi Marie Claire, Sauro Vittori & Mpoame Mbida. This is a research/review paper, distributed under the terms of the Creative Commons Attribution-Noncommercial 3.0 Unported License <http://creativecommons.org/licenses/by-nc/3.0/>), permitting all non commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

Evaluation of Ovicidal and Larvicidal Activities of Methylene Chloride-Methanol Extract of *Annona Senegalensis* (Annonaceae) Stem Bark on *Heligmosomoides Bakeri* (Nematoda, Heligmosomatidae)

Francesco D'Angelo ^α, Wabo Poné J ^σ, Yondo Jeannette ^ρ, Komtangi Marie Claire ^ω, Sauro Vittori [¥] & Mpoame Mbida[§]

Abstract- Infections of animals with gastrointestinal nematodes constitute a world wide health problem. The aim of this study was to assess the effectiveness in vitro anthelmintic of Methylene Chloride/Methanol (1:1 volume mixture) extract of *Annona senegalensis* (Annonaceae) the barks of the stem on *Heligmosomoides bakeri* eggs and larvae (for ovicidal and larvicidal activities, respectively). *Annona senegalensis* is included in the list of the plants that have anthelmintic activity in the traditional medicine, just as with other plants like *Albizia anthelmintica* (Mimosaceae), *Canthium mannii* (Rubiaceae), *Naucllea latifolia* (Rubiaceae) and *Carica papaya* (Caricaceae). The plant material was collected from the peripheral savanas of Fouban, Noun Division, West Region of Cameroon. The final concentrations of plant extract tested were: 5 000, 3 750, 2 500, 1 250 and 625 µg/mL; 4 % Tween 80 aqueous solution was used as negative control. Ovicidal and larvicidal activities were assessed through egg embryonation and hatching rates and through mortality rate of L1 and L2 larvae, respectively. The extract produced low but dependant concentration on egg embryonation and hatching rates. With the highest extract concentration (5 000 µg/mL) embryonation and hatching rates of 20.8 % and 16.1 % were obtained respectively. On the contrary, a strong larvicidal activity was observed. L1 mortality rates of 100 % and 96.7 % were recorded respectively, in the two most concentrated extract (5 000 and 3 750 µg/mL) just after six hours of exposition. L2 larvae appeared more resistant as the two most concentrated extracts (5000 and 3 750 µg/mL) produced larvicidal mortality rates of 96.1 % and 90.0 % respectively, just twenty four hours after the administration of the treatment. These results suggest that the extract of *A. Senegalensis* bark stem used, possess high larvicidal properties. Further more in vivo, studies assess the effects on adult worms and toxicity on mice hosts are still needed.

Keywords: *heligmosomoides bakeri*; *Annona senegalensis*; ovicidal; larvicidal; anthelmintic.

I. INTRODUCTION

Infections of animals with gastrointestinal nematodes constitute a world wide health problem. These parasites frequently cause death in heavily infected host, resulting in important economic losses. Chronic infections are dangerous and can cause a reduction of milk and meat production, fertility and growth in animals. The anthelmintics discovered in the '60s, and which were largely used in the last 50 years, limited the problem until resistance, and multi-resistance, appeared in nematode populations (Holmes, 1985; Zajac et Gipson, 2000). Actually, in certain regions of the world, mostly among the developing countries, the situation is very serious (Van wyk et al. 1999). In fact, in tropical and sub-tropical zones, the spread of gastro-intestinal parasitic infections is strongly increased by climatic factors, such as temperature and humidity, and poor hygiene (Satrija et al. 1995). In Cameroon, the Permanent Secretary of the National Programme for the control of Schistosomiasis and Gastrointestinal Helminthiasis reported in January 2006 that, over 10 millions natives are infected with various intestinal parasites and that 2 millions suffer from schistosomiasis. These infections affect children of school age especially, influencing strongly their growth, intellectual development and vulnerability to other diseases (Ngangout et al., 2012). The control measures used today depend on vaccination (Newton & Mun, 1999), breeding of sheep resistance races (Gray, 1997), improving food quality (Wallace et al. 1998) and breeding dairy farming methods (Bargers, 1999; Niezen et al. 1999). In addition, some biological measures are being developed such as the optimization for the use of anthelmintics already available on the market (Larsen, 1999; Van Wyk & Bath, 2002).

In this context, the search for new nematocidal agents is still a priority for humans and for livestock (Witty, 1999). Synthetic anthelmintics still dominate the

Author ^α [¥]: School of pharmacy, University of Camerino, 62032 Camerino (MC), Italy.

Author ^σ ^ρ ^ω [§]: Department of Animal Biology, Laboratory of Applied Biology and Ecology (LABEA), Faculty of Science, University of Dschang, PO Box 067 Dschang, Cameroon

animal pharmaceutical industry and they are widely sold at high prices (see International Federation for Animal Health website: <http://www.ifahsec.org>). The massive and strategic use of modern anthelmintic drugs is widely spread to control worm infections. Unfortunately, the high cost of these medicines, the increasing development of resistant strains of gastro-intestinal parasites and the shortage of veterinarians, especially in poor countries, push livestock breeders and herdsman towards traditional medicine using therapeutic plants (Kaboré et al., 2005).

For a long time, humans have developed throughout the world a traditional pharmacopea based on the knowledge of medicinal plants. This knowledge became highly enriched over time through the observation of animal behaviour and through experimental tests. In many cases, the information thus acquired is only orally transmitted and it is therefore dangerously being put out in favour of modern medicine. In fact, traditional medicine still represents the cheap possible and readily available treatment for the natives. It is also an important potential source for the development of new pharmacological agents. Thus it is clear that modern ethnobotanical research is both important and urgent (Schillhorn Van Veen, 1997; Hammond et al., 1997). Various studies, and some of these studies have shown that many plants contain several molecules with antiparasitic activity, such as quinine and artemisin, that are presently widely used (Kayser et al., 2003), while some other plants show promising anthelmintic activity (Al-qarawi et al., 2001; Onyeyilli et al. 2001). However, studies that scientifically evaluate the effectiveness of traditional medicine are very few (Lans & Brown, 1998; Veira et al., 1999), and publications related to Africa are even fewer (Aké Assi & Guinko, 1991; Nfi et al., 2001). Besides, the need for stringent regulation mechanisms and secrecy over the use of traditional medicine remains the major stumbling block (Gqaleni et al., 2007). Furthermore, the inadequate toxicological evidences about the safety of these medicinal plants is still an unsolved problem (Fennel et al., 2004).

The resistance against medically active substances is particularly pronounced in the case of gastrointestinal nematodes of sheep and goats (Sangster, 1999), and especially in the cases of *Haemonchus contortus* and *Heligmosomoides polygyrus* (now known as *H. bakeri*) (Diehl et al., 2004; Githiori et al. 2003).

Annona senegalensis (also known as African custard apple), is one of the medicinal plants that are commonly used in Central Africa against gastrointestinal parasite infections. This is a flowering plant of the custard apple family that takes the form of either a shrub or a small tree, growing up to, between two and six meters tall. Its bark has a smooth or a coarse texture, and may be gray-silver or gray-brown. It is leaf-scared,

with nearly round flaking, showing lighter-hued spaces under the bark. Branches have thick, gray, brown or yellow tomentum when they are still new. Leaves are from green to blue-green and flowering white creamy. The fruits are made up of numerous fused, fleshy, bumpy, ovoidal or globular carpels. *Annona senegalensis* is origin to east and northeast, west and central, and southern tropical Africa, and to islands in the western Indian Ocean. In South Africa, it is found in KwaZulu-Natal, Limpopo and Mpumalanga (Anonymous, 2010). In vitro studies on aqueous and ethanolic extracts of the bark of stem, of this plant, have already confirmed their ovicidal and larvicidal activity on nematodes (Ngangout et al., 2012). In fact, the bark of this plant was used in early history to prepare tisanes and tea herbs for treating a wide array of ailments such as: intestinal and tissue parasitic worms, diarrhea, gastroenteritis, lung infections, toothaches and even snakebites (Anonymous, 2010). The aim of this study was to assess the in vitro ovicidal and larvicidal activity of Methylene Chloride/Methanol 1:1 volume mixture of extract from bark of the stem of *A. senegalensis* on *H. bakeri* eggs and larvae obtained from the faeces of experimentally infected mice.

II. MATERIALS AND METHODS

a) Plant materials

The bark of stem of *A. senegalensis* used in this experiment was collected from the peripheral savanas of Fouban, Noun Division, West Region of Cameroon. It was then air dried while protected from sunlight and dust. Finally, the bark was well cut in small pieces (3 cm x 4 cm), ground and kept in the laboratory for further use.

b) Preparation of plant extract

The procedure used was according to Wabo Poné et al. (2006, 2010). Briefly, 200 grams of stored powder were macerated in 1.5 L of methanol (purity > 95%) and 1.5 L of Methylene Chloride (purity > 95%). The Methylene Chloride-methanol mixture was used for its greater capacity to extract some specific compound materials of the plant. The mixture was placed in an airtight glass jar and kept in a dark place. It was stirred daily to accelerate extraction. Seventy two (72) hours later, it was filtered through two metallic sieves (mesh sizes: 500 µm and 150 µm), then through a cotton layer and finally through filter paper of pore size of 2.5 µm. The solution obtained was then concentrated in a rotavapor at ~80 °C for 2 hours (rotation rate: ~150 rounds/min). The extract obtained, was poured in two large glass containers, covered with paper, and kept in the oven at 40-45 °C for 24 hours to allow it for a complete evaporation of the solvents. Two hundred (200) mg of the obtained extract were dissolved in 0,8 mL of Tween 80 (to facilitate the mixture with water). Warm water was finally added to bring the solution to a

volume and prepare 20 mL of stock solution at 10 000 µg/mL. Through a series of dilutions were made to obtain the following concentrations: 7 500, 5 000, 2 500 and 1 250 µg/mL.

0.8 mL of Tween 80 were added to 19.2 ml of distilled water to obtain a solution at 4 % V/V, used for negative control.

c) Recovery of nematode eggs

Mice (*Mus musculus*) were infected by oral gavage with their natural nematode, *Heligmosomoides bakeri* (previously known as *Nematospiroides dubius*, *H. polygyrus* and *H. p. bakeri*). The eggs of *H. bakeri* were obtained from the faeces of mice as follows. Each day, ~100 mg of faeces were collected from the animal cages, homogenized in a mortar adding a small volume of water, suspended in saturated salt solution (NaCl 40 % W/V). Then the solution was cleared of organic debris by filtration through a 250 µm mesh-size sieve into a beaker and finally poured into three glasses of U-vials until the formation of a meniscus at the top. A cover slide was thus deposited on each vial, in direct contact with the solution. Three (3) minutes later, the cover slides were removed and put on a slide and soon

analysed under an optical microscope Olympus-CH under the 4x objective to look for eggs. Slides and cover slides containing the eggs were finally rinsed with tap water into a 50 mL vial. The vial was allowed to stand for 30 minutes for the sedimentation of the eggs at the bottom. Then, to completely remove the salt solution, 40 mL of solution were accurately siphoned out using a syringe and replaced with the same amount of tap water. This operation was repeated each 30 minutes three times. Finally the supernatant was removed and the remaining solution was distributed into 24 Petri dishes (Ø = 35 mm) each with 1 mL.

Figs 1 and 2 show *H. bakeri* fresh and embryonated eggs seen through the optical microscope, respectively. Here it is easy to recognize the L1 stage larvae still within the shell of the eggs.

d) Evaluation of ovicidal activity

The ovicidal activity was determined using two different parameters: the effect on the embryonation rate and the hatching rate. To evaluate the effect on the embryonation rate, a percentage of embryonation inhibition (EI) was calculated using the following formula:

$$EI \% = 100 - \left[\left(\frac{\text{Number of } L_1 \text{ larvae}}{\text{Number of fresh eggs in culture}} \right) \times 100 \right]$$

The eggs in 6 Petri dishes were counted immediately after their introduction (20-40 eggs/Petri dish) and soon each, Petri dish received 1 mL from each one five different extract concentrations or 1 mL of Tween 80 solution (4 % V/V) for the negative control. After 48 hours, the larvae in each Petri dish were

counted. It is assumed that the embryonated eggs contain the 1st larval stage.

To evaluate the hatching rate, a percentage of hatching inhibition (HI) was calculated by the formula below:

$$HI \% = 100 - \left[\left(\frac{\text{umber of } L_1 \text{ larvae}}{\text{Number of embryonated eggs in culture}} \right) \times 100 \right]$$

In this case, 1 mL of each one of five different concentration extracts or Tween 80 solution (4 % V/V) was introduced into 6 different Petri dishes 24 hours after the collection of eggs, just when these start to hatch. The counting of the larvae was done 6 hours later, when 90 % of eggs are hatched in the negative control.

In all Petri dishes, the final tested concentrations were behalved from the initial ones due to the addition of egg suspension (1mL) resulting as follows: 5 000, 3 750, 2 500, 1 250 and 625 µg/mL for the plant extract, and 2 % V/V Tween 80 aqueous solution for the negative control. Each treatment was repeated 4 times.

e) Recovery of nematode L1 and L2 larvae

To obtain larvae of the parasite, some eggs, kept inside the vials, were maintained in culture at room temperature (24-25 °C) for fixed periods of time.

L1 larvae were soon identified after hatching from eggs. The larvae were incubated in the extract and

tween around 30 hours after the collection of the eggs from faeces. This is when the number of larvae in the negative control reaches 90 % of the number of eggs present in a Petri dish.

To obtain L2 larvae, a solution of faeces collected from the mice free of parasite was added to the egg suspension and kept in a temperature room (24-25 °C) for about 48 hours. The addition of the extract was made only after the identification of L2 larvae. In fact, there are some morphological and specific characteristics that can be exploited, during the qualitative analysis under the microscope, to distinguish between the first and second stage of larvae (L1 larvae are smaller than L2 larvae and do not present the internal eskeleton that is characteristic of adult larvae. Further more, L1 larvae movements are limited while L2 larvae agitate so fast in "S-shaped" movements like a snake. Figs 3 and 4 show these evident differences between L1 (Fig. 3) and L2 (Fig. 4) larvae.

f) Evaluation of larvicidal activity

To assess the effect of larval extract on the survival, 1 mL of solution containing each 15-25 larvae, previously poured into 6 Petri dishes, was mixed with the same volume of extract at the following final concentration (5 000, 3 750, 2 500, 1 250 and 625 µg/mL). The negative control thus reached at the ratio of

$$MR \% = 100x\left(\frac{\text{Number of dead larvae}}{\text{Number of larvae in culture}}\right)$$

Immobile and straight shaped larvae were stimulated with a light-heating ray for about 20-30 seconds to confirm death (Fig. 5). Furthermore, their external layer is not uniform and presents holes and irregularities. In all the cases, the number of dead or immobile larvae was counted 2, 4, 6, and 24 hours after incubation in the extract.

g) Statistical analysis

The inhibitory 50 % concentrations (IC₅₀) for embryonation and hatching rates were calculated using the regressive line of the data obtained from the tests, using the high value of the coefficient of determination (R²). The lethal 50 % concentrations (LC₅₀) for L1 and L2 larvae mortality rates were determined using the regressive line of the probit as a fonction of the natural logarithm of the concentrations (also in this case the coefficient of determination R² was taken into account). The mean percentages of inhibition and larval mortality were compared using Chi-square test and the differences were considered significant at P < 0.05.

III. RESULTS

The yield of the extraction process with the mixture of Methanol and Methylene Chloride (1:1 V/V) was of 8.95 %, thus resulting in 17.9 g of dried extract (starting from 200 grams of dried powder).

The effect of various concentrations of plant extracts on embryonation rate are shown in Figure 6a. The negative control (Tween 80 aqueous solution at 2 % V/V) hardly affected embryonation rate (4.50% inhibition rate). Embryonation inhibition rate was concentration dependant. The highest concentration of extract (5000 µg/mL), yielding the highest embryonation inhibition rate (20.80%). The calculated IC₅₀ value for the embryonation rate is 15 930 µg/mL (R² = 0,92).

The percent inhibition of *H. bakeri* eggs hatching, in various concentration of Methylene Chloride-Methanol extract of *A. senegalensis* barks of the stem, is shown in Figure 6b. In the negative control the mean hatching inhibition rate of the eggs is very low (only the 3 % of eggs affected). Forty eight (48) h post-treatments hatching inhibition rate was clearly concentration dependant (9.00%. at 625 µg/mL to 16.10% at 5 000 µg/mL). The calculated IC₅₀ value for the hatching rate is 23 910 µg/mL (R² = 0, 97).

2 % V/V of Tween 80 in water. All the treatments were repeated 4 times.

To evaluate larval mortality, the number of dead or immobile larvae was accurately counted under the microscope with the 4x objective. Then, the percentage of mortality rate (MR) was calculated using the following formula:

The effect of *A. senegalensis* extract on the survival of *H. bakeri* L1 larvae is reported in Figure 7a which presents the mean mortality rate obtained two, four, six and twenty four hours post-treatment. The negative control didn't cause any larval mortality. Larval mortality was concentration and time dependant. The highest value (100 %) being recorded in 5 000 µg/mL extract concentration in only 6 hrs. The calculated LC₅₀ values for the L1 larvae mortality rate are as follows: 5 000 µg/mL (R² = 0.97), 426 µg/mL (R² = 0.76), 167 µg/mL (R² = 0.92), 25 µg/mL (R² = 0.93) for 2, 4, 6 and 24 h, respectively. Figure 7b shows the activity of *A. senegalensis* barks stem extract on *H. bakeri* L2 larvae survival. The absence of activity in the negative control demonstrates the safety of 2 % Tween 80 aqueous solution for *H. bakeri* larvae. The concentration and time dependence recorded for L1 larvae was also observed in this case. The calculated LC₅₀ values for the mortality rate are as follows: 21 320 µg/mL (R² = 0.92); 2 407 µg/mL (R² = 0.96); 1 849 µg/mL (R² = 0.98); 236 µg/mL (R² = 0.84) after 2, 4, 6 and 24 h respectively.

IV. DISCUSSION

Taking into account the data presented, it is thus easy to understand that the Methylene Chloride-Methanol extract of *A. senegalensis* barks stem, possesses some anthelmintic properties against *H. bakeri* eggs. These findings could be due to the polarity of the solvents used for the extraction and consequently to the secondary metabolites extracted from the plant material. Thus methanol (a highly polar solvent; dielectric constant 32.6) will extract tannins, catechins, terpenoids, polyphenols and alkaloids while Chloride (apolar solvent; dielectric constant 9.1) will extract semi-polar and apolar compounds, such as heterosides, terpenes, sterols, coumarins and carotenoids (Marie-Magdeleine et al. 2010a). Many studies have revealed the saponins among the most active compounds in terms of nematotoxic activity because of their specific interactions with the cell membranes and with the collagen proteins present on the cuticles of the parasite larvae, causing changes in cell wall permeability and cellular death (Heng et al., 2004; Argentieri et al., 2008; Eguale & Giday, 2011). In this work, saponins were not present in the *A. senegalensis* Methylene Chloride and Methanol extracts. Our hypothesis is that, the compounds extracted by the two solvents are not capable of passing through the

parasite fresh egg shell, and therefore cannot affect mean embryonation and hatching rates of *H. bakeri* eggs.

On the other hand, the effect of the extracts against L1 and L2 *H. bakeri* larvae is very high. Mortality rate, reaching 100 % in some cases, as described in the previous session. In each assay, the data obtained in the negative controls demonstrates that the used excipient (Tween 80 2 % V/V) can be considered totally ineffective and thus any activity observed in assays can be completely ascribed to plant extracts. The results show that *A. senegalensis* Methylene Chloride/Methanol extracts are much more active on L1 larvae than on L2 ones. These findings could be related to the presence of flavonoids and alkaloids, known to possess strong larvicidal properties. In fact, the activity of flavonoids is attributed to their anti-oxidative and free-radical scavenging capacity (Middleton et al., 2000). As for alkaloids, they create alkaline conditions which are deleterious to the survival of parasitic larvae that normally prefer acidic conditions (Wabo Poné et al. 2011). Thus the larvicidal activity observed, may be related to two different mechanisms of action, the first, creating unsuitable environmental conditions for the survival of larvae and the second, affecting the internal organs of the larvae either through interference with the neuromuscular physiology or blockage of energy

metabolism (Nchu et al., 2011). To this purpose, it is necessary that the active compounds are found within the larval body and spread in the intestinal cells (Marie-Magdeleine et al. 2010b). The active molecules may either enter the larvae through the cuticle or through ingestion, during feeding. It is possible that the Methylene Chloride-Methanol extract of *A. senegalensis* could contain a large spectrum of active compounds, characterized by different modes of actions. In fact, the bark of plant stems represents the site of the biosynthesis and storage of secondary metabolites that probably are responsible for the biological properties of medicinal plant extracts.

The Methylene Chloride/Methanol extract of *A. senegalensis*, compared to the aqueous and ethanolic extracts of the same plant, [6] show a lower effect on the eggs of *H. bakeri* but, at the same time, a surprisingly higher activity on the parasite larvae.

In conclusion, the observations brought out in this work, reveal that the Methylene Chloride/Methanol extract of *A. senegalensis* shows an ovicidal and larvicidal activity. The activity of the plant, very high against *H. bakeri* L1 and L2 larvae, is probably related to the combined interaction of the extracted compounds as described above. However, in vivo further studies are needed to confirm its efficacy and mostly, to investigate the potential presence of toxic effects.

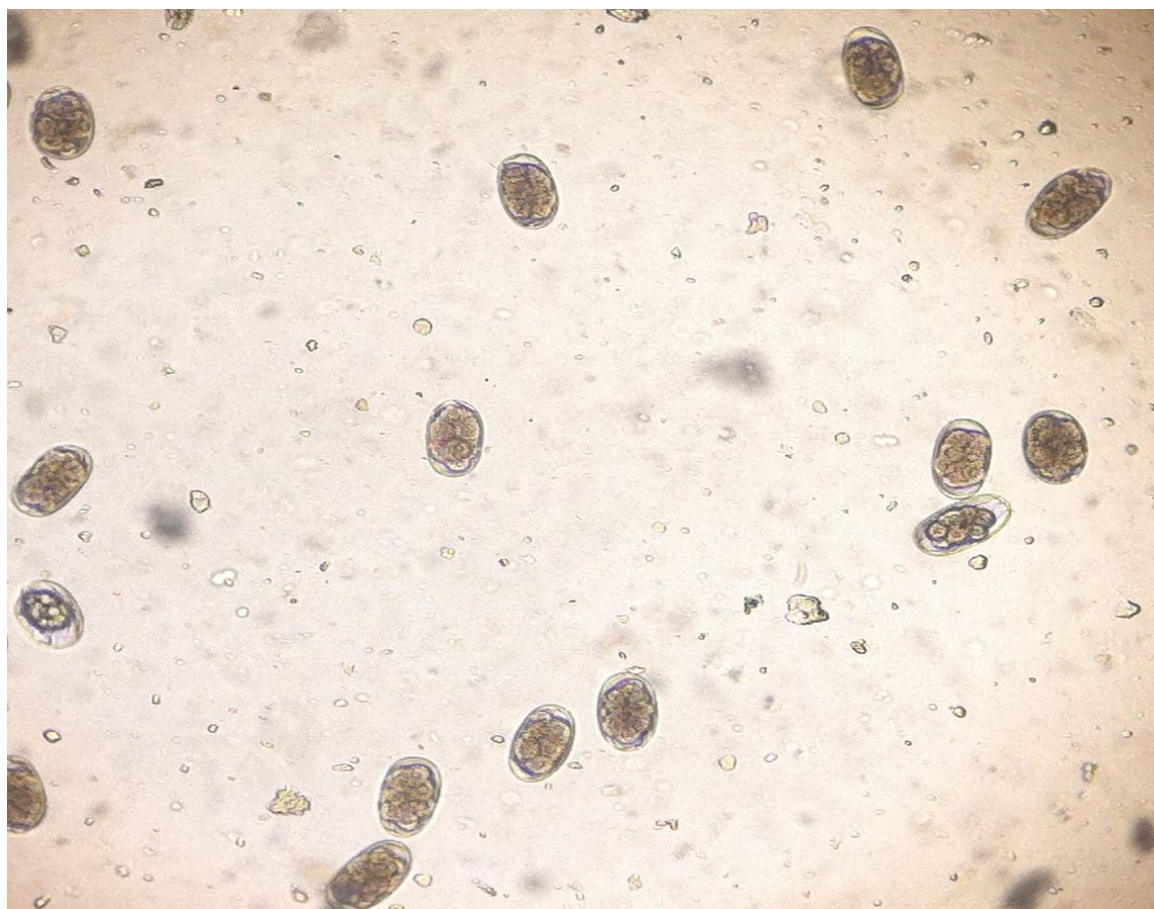


Figure 1 : Fresh eggs of *Heligmosomoides bakeri* (x100)



Figure 2 : Embryonated eggs of *Heligmosomoides bakeri* (24 hrs-old). X 100



Figure 3 : L1 larvae of *Heligmosomoides bakeri* (x100)



Figure 4 : L2 larvae of *Heligmosomoides bakeri* (x 100)

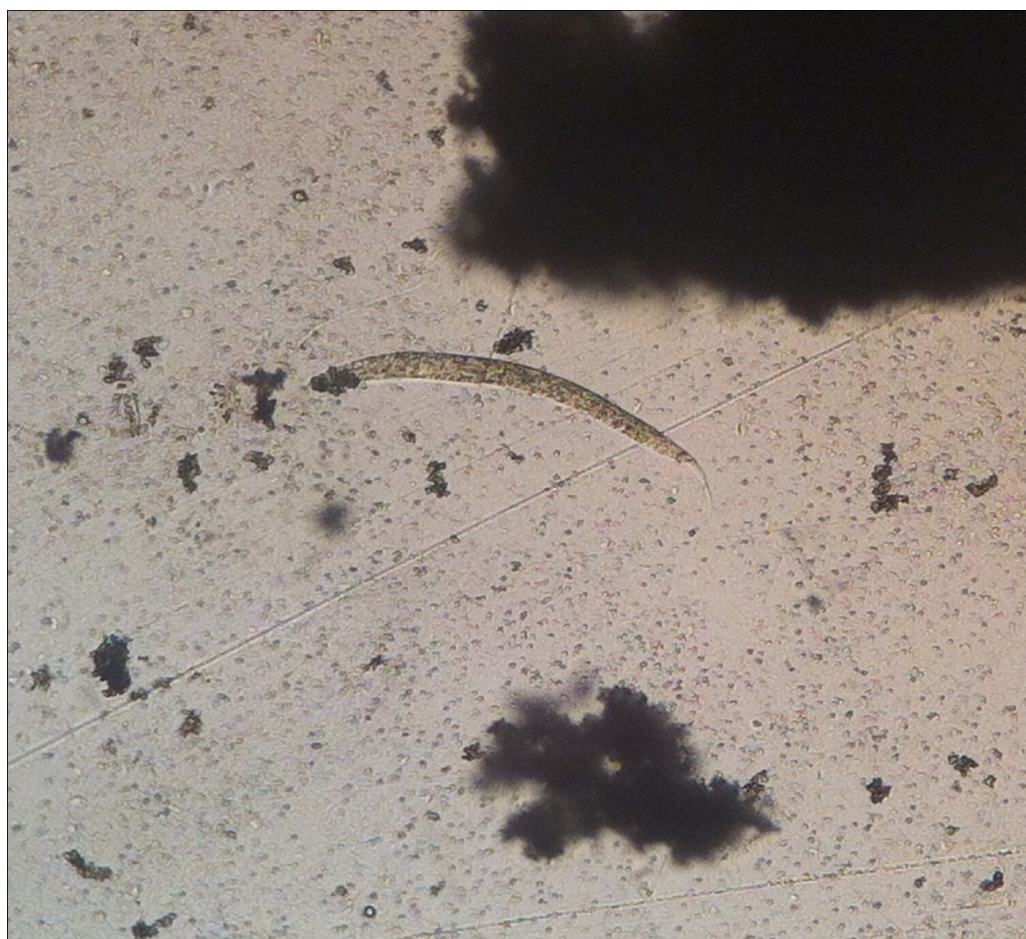


Figure 5 : *Heligmosomoides bakeri* dead larva (x100)

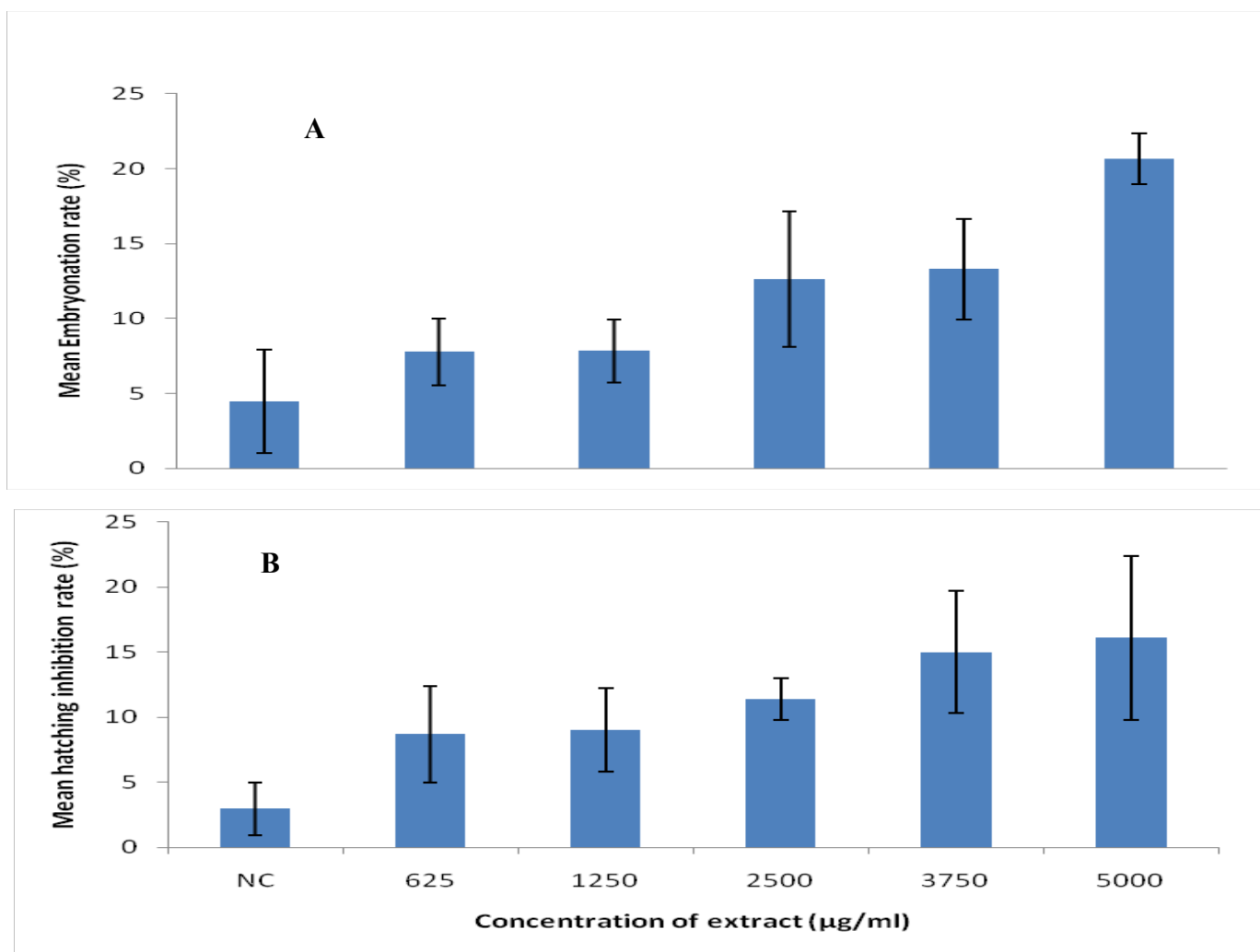


Figure 6 : Effect of *Annona senegalensis* extract on mean embryonation inhibition rate (A) and on mean hatching inhibition rate (B) of *Heligmosomoides bakeri* eggs. Legend: NC= Negative control

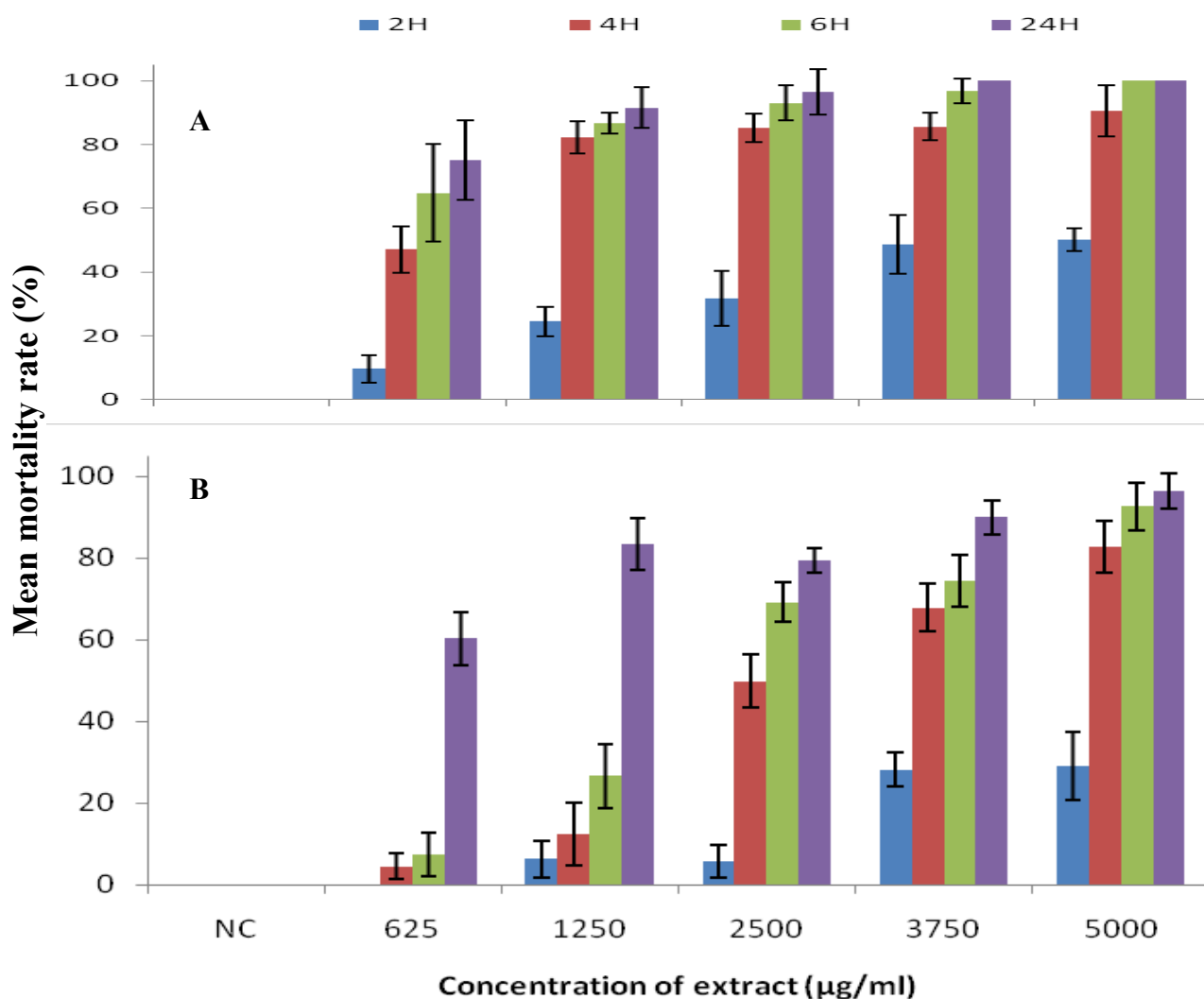


Figure 7 : Effect of *Annona senegalensis* extract on mean mortality rate of L1 larvae (A) and L2 larvae (B) of *Heligmosomoides bakeri*. Legend: NC= Negative control

V. ACKNOWLEDGEMENTS

The authors wish to express their sincere thanks to Professors KUIATE Jules-Roger and NGUELEFACK Télesphore Benoît for their advice and to the Department of Biomedical Sciences of the Faculty of Science, University of Dschang for the technical support.

REFERENCES RÉFÉRENCES REFERENCIAS

1. Anonymous 2010. "Annona senegalensis". AgroForestryTree Database (World Agroforestry Centre). Retrieved August 3, 2010.
2. Aké Assi, L., Guinko, S., 1991. Plantes utilisées dans la médecine traditionnelle en Afrique de l'Ouest. Editions Roche, Switzerland, p. 152.
3. Al-Qarawi, A.A., Mahmoud, O.M., Sobaih, M.A., Haroun, E.M., Adam, S.E., 2001. A preliminary study on the anthelmintic activity of *Calotropis procera* latex against *Haemonchus contortus* infestation in Najd sheep. Veterinary Research Communications 25, 61-70.
4. Argentieri PM., D'Addabbo T., Tava A., Agostinelli A., Jurzysta M., Avato P., 2008. Evaluation of nematicidal properties of saponins from *Medicago sativa* spp. Eur J Plant Pathol; 120, 189-197.
5. Bargere, I.A., 1999. The role of epidemiological knowledge and grazing management for helminth control in small ruminants. International Journal for Parasitology 29, 41-47.
6. Diehl, M.S., Kamanzi Atindehou, K., Téré, H., Betschart, B., 2004. Prospect for anthelmintic plants in the Ivory Coast using ethnobotanical criteria. Journal of Ethnopharmacology 95, 277-284.
7. Eguale T., Giday M. 2011. In vitro anthelmintic activity of crude extracts of five medicinal plants against egg hatching and larval development of

- Haemonchus contortus. J Ethnopharmacol; 137, 108-113.
8. Fennel, C.W., Lindsey, K.L., McGaw, L.J., Sparg, S.G., Stafford, G.I., Elgorashi, E.E., Grace, O.M., Van Staden, J., 2004. Assessing African medicinal plants for efficacy and safety: pharmacological screening and toxicology. Journal of Ethnopharmacology 94, 205-217.
9. Githiori, J.B., Hoglund, J., Waller, P.J., Leyden Baker, R., 2003. The anthelmintic efficacy of the plant, Albizia anthelmintica, against the nematode parasites Haemonchus contortus of sheep and Heligmosomoides polygyrus of mice. Veterinary Parasitology 116, 23-34.
10. Gqaleni, N., Moodley, I., Kruger, H., Ntuli, A., McLeod, H., 2007. Traditional and complementary medicine. In: Harrison, S., Bhana, R., Ntuli, A. (Eds.), South African Health Review. Health Systems Trust, Pretoria, South Africa.
11. Gray, G.D., 1997. The use of genetically resistant sheep to control nematode parasitism. Veterinary Parasitology 72, 345-357.
12. Hammond, J.A., Fielding, D., Bishop, S.C., 1997. Prospect for plant anthelmintics in tropical veterinary medicine. Veterinary Research Communications 21, 213-228.
13. Heng L., Koningsveld van JP., Roozen JP., 2004. Protein-flavour interactions in relation to development of novel protein foods. Trends Food Sci Technol; 15, 217-224.
14. Holmes, P.H., 1985. Pathogenesis of trichostrongylosis. Veterinary Parasitology 18, 89-101.
15. Kaboré A., Belem A.M.G., Tamboura H.H., Traore A., Sawadogo L., 2005. In vitro anthelmintic effects of two medicinal plants (Anogeissus leiocarpus and Daniellia oliveri) on Haemonchus contortus, on abomasal nematode of sheep in Burkina Faso. Afr. Journal Biotech. 8 (18), 4690-4695.
16. Kayser, O., Kiderlen, A.F., Croft, S.L., 2003. Natural products as antiparasitic drugs. Parasitological Research 90, S55-S62.
17. Lans, C., Brown, G., 1998. Observations on ethnoveterinary medicines in Trinidad and Tobago. Preventive Veterinary Medicine 35, 125-142.
18. Larsen, M., 1999. Biological control of helminths. International Journal for Parasitology 29, 139-146.
19. Marie-Magdeleine C., Mathieu M., D'Alexis L., Philibert L., Archimede H., 2010a. In vitro effects of Tabernaemontana citrifolia extracts on Haemonchus contortus. Res Vet Sci; 89, 88-92.
20. Marie Magdeleine C., Udino L., Philibert L., Bocay B., Archimede H., 2010b. In vitro effect of cassava (Manihot esculenta) leaf extracts on four development stages of Haemonchus contortus. Vet Parasitol; 173, 85-92.
21. Middleton E., Kandaswami C., Theoharides T.C., 2000. The effects of plant flavonoids on mammalian cells: implications for inflammation, heart disease and cancer. Pharmacol Rev; 52, 673-651.
22. Nchu F., Githiori JB., McGaw LJ., Eloff JN., 2011. Anthelmintic and cytotoxic activities of extract of Markhamia obtusifolia Spague (Bignoniaceae). Vet Parasitol; 183, 184-188.
23. Newton, S.E., Mun, E.A., 1999. The development of vaccines against gastrointestinal nematode parasite, particularly Haemonchus contortus [Review]. Parasitology Today 15, 116-122.
24. Nfi, A.N., Mbanya, J.N., Ndi, C., Kameni, A., Vabi, M., Pingpoh, D., Yonkeu, S., Mouss, C., 2001. Ethnoveterinary medicine in the northern province of Cameroon. Veterinary Research Communications 25, 71-76.
25. Ngangout Alidou M., Wabo Poné J., Khna Payne V., Komtangi Marie Claire, Yondo Jeannette, Mbogning Tayo Gertrude, Mpoame Mbida, Bilong Bilong C.F., 2012. Ovicidal and larvicidal activities of aqueous and ethanolic extract of stem bark of Annona senegalensis (Annonaceae) on Heligmosomoides bakeri (Nematoda, Heligmosomatidae). Asian Pacific Journal of Tropical Biomedicine, 1-5.
26. Niezen, L.H., Robertson, H.A. Waghorn, G.C., Charlestone.G., 1999. Production, fecal egg counts and worms burdens of ewe lambs which grazed six contrasting forages. Veterinary Parasitology 80, 15-27.
27. Onyeyili, P.A., Nwosu, C.O., Amin, J.D., Jibike, J.I., 2001. Anthelmintic activity of crude aqueous extract of Nauclea latifolia stem bark against ovine nematodes. Fitoterapia 72, 12-21.
28. Sangster, N.C., 1999. Anthelmintic resistance: past, present and future. International journal for Parasitology 29, 115-124
29. Satrija, F., Nansen, P., Murtini, S., He, S., 1995. Anthelmintic activity of papaya latex against Heligmosomoides polygyrus infections in mice. J. Ethnopharmacol. 48 (3), 161-164.
30. Schillhorn van Veen, T.W., 1997. Sense or nonsense? Traditional methods of animal parasitic disease control. Veterinary Parasitology 71, 177-194.
31. Van Wyk, J.A., Bath, G.F., 2002. The FAMACHA system for managing haemonchosis in sheep and goats by clinically identifying individual animals for treatment. Veterinary Research 33, 509-529.
32. Van Wyk, J.A., Stenson, M.Mo., Van der Merwe, J.S., Vorster, R.J., Viljoen, P.G., 1999. Anthelmintic resistance in South Africa: Surveys indicate an extremely serious situation in sheep and goat farming. Onderstepoort Journal of Veterinary Research 66, 273-284.
33. Vieira, L.S., Cvalcante, A.R., Pereira, M.F., Dantas, L.B., Ximenes, L.F., 1999. Evaluation of anthelmintic efficacy of plants available in Ceara State, North-East Brazil, for the control of goat

- gastrointestinal nematodes. *Revue de Medicine Veterinaire* 150, 447-452.
34. Wabo Poné J., Bilong Bilong C.F., Mpoame M., 2010. In vitro nematicidal activity of extracts of *Canthium mannii* (Rubiaceae), on different life-cycle stages of *Heligmosomoides polygyrus* (Nematoda, Heligmosomatidae). *Journal of Helminthol.* 84, 156-165.
 35. Wabo Poné J., Bilong Bilong C.F., Mpoame M., Fusi Ngwa C., Coles C.G., 2006. In vitro activity of ethanol, cold and hot water extracts of the stem bark of *Canthium mannii* (Rubiaceae) on *Ancylostoma caninum* eggs. *East & Central Afr. Journal Pharm. Sci.* 9 (1), 14-18
 36. Wabo Poné J., Olivia FT., Jeannette Y., Komtangi MC., Mbida M., Bilong Bilong CF., 2011. The in vitro effects of aqueous and ethanolic extracts of the leaves of *Ageratum conyzoides* (Asteraceae) on three life cycle stages of the parasitic nematode *Heligmosomoides bakeri* (Nematoda, Heligmosomatidae). *Vet Med Inter*; 104061/ 2011 140293.
 37. Wallace, D.S., Bairden, K., Duncan, J.L., Eckersall, P.D., Fishwick, G., Gill, M., Holmes, P.H., McKellar, Q.A., Murray, M., Parkins, J.J., Stear, M.J., 1998. The influence of dietary supplementation with urea on resilience and resistance to infection with *Haemonchus contortus*. *Parasitology* 116, 67-72.
 38. Witty, M., 1999. Current strategies in the search for novel antiparasitic agents. *International Journey for Parasitology* 29, 95-103.
 39. Zajac, A.M., Gipson, T.A., 2000. Multiple anthelmintic resistance in a goat herd. *Veterinary Parasitology* 87, 163-172

This page is intentionally left blank



GLOBAL JOURNAL OF SCIENCE FRONTIER RESEARCH: C
BIOLOGICAL SCIENCE

Volume 14 Issue 2 Version 1.0 Year 2014

Type : Double Blind Peer Reviewed International Research Journal

Publisher: Global Journals Inc. (USA)

Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Strategies of Rodent Control Methods at Airports

By Abd El-Aleem Saad Soliman Desoky

Sohag University, Egypt

Abstract- Rodent populations at airports can cause human safety issues by attracting raptors ... be, expended to reduce of rodent populations at an airport may decrease birds population in the area and therefore, reduce the risk that raptors pose to aircraft. Rodent populations can be reduced by population management (i.e., use of rodenticides) or by habitat management (i.e., vegetation management, barriers, and land uses) that reduces the area's carrying capacity for rodents. We discuss potential approaches to reduce rodent populations at airports within the context of an integrated pest management strategy.

Keywords: aircraft, habitat management, integrated pest, management strategy, raptors, rodent, rodenticides, vole, wildlife damage.

GJSFR-C Classification : FOR Code: 779904p



Strictly as per the compliance and regulations of :



Strategies of Rodent Control Methods at Airports

Abd El-Aleem Saad Soliman Desoky

Abstract- Rodent populations at airports can cause human safety issues by attracting raptors ... be, expended to reduce of rodent populations at an airport may decrease birds population in the area and therefore, reduce the risk that raptors pose to aircraft. Rodent populations can be reduced by population management (i.e., use of rodenticides) or by habitat management (i.e., vegetation management, barriers, and land uses) that reduces the area's carrying capacity for rodents. We discuss potential approaches to reduce rodent populations at airports within the context of an integrated pest management strategy.

Keywords: aircraft, habitat management, integrated pest, management strategy, raptors, rodent, rodenticides, vole, wildlife damage.

1. INTRODUCTION

Worldwide, rodents have been, and continue to be, the major vertebrate pest group. Much effort has been, and continues to be, expended to reduce their numbers and damage (Witmer *et al.*, 1995). Rodents are implicated in many types of damage, including crop and tree damage, structural property and cable damage, disease transmission, and significant predation on native species of animals and plants on islands to which rodents have been accidentally introduced (Witmer *et al.*, 1998). Numerous books have appeared in the last decade from all continents or regions of the world, addressing rodent damage and its management (e.g., Corrigan 2001, Singleton *et al.*, 1999). At the same time, rodents have many important ecological roles and most species are not major pests. Some of the roles include soil mixing and aeration, seed and spore dispersal, influences on plant species composition and abundance, and a prey base for many predatory vertebrates.

Birds and other wildlife are a serious problem at U.S. airports. Certain species are more hazardous to aviation safety than others, most often due to the size and behavior of the species. Raptors, including hawks, vultures, and eagles, were the fourth most common bird group reported in bird strikes to the Federal Aviation Administration from 1991 - 1997, and hawks specifically were the fifth most common bird species group reported in bird strikes in Canada during the same time period.

Red-tailed hawks were the fifth most common bird species reported in U.S. Air Force bird strikes from

1985 - 1999, resulting in over \$12 million in damage costs. Since raptors are protected under the Migratory Bird Treaty Act, the ability to directly manage raptor populations is limited. Management of their habitat, however, is often more easily accomplished. Raptors are attracted to airport habitats that provide their basic necessities: food, water, and cover. Small mammals, such as mice and voles, are attractive prey for raptors.

Reduction of small mammal populations at an airport may decrease raptor populations in the area and therefore, reduce the risk that raptors pose to aircraft. Reduction of small rodent populations can be achieved through a variety of methods, including habitat manipulation and the use of rodenticides. Habitat management can be accomplished through a grass height management regime or through the introduction of an endophyte-infected grass which may support fewer herbivores, both of which are currently being studied. Zinc phosphide, a rodenticide, was tested for efficacy at Kansas City International Airport. This presentation will discuss these options and the implications of the studies (Witmer and Fantinato, 2003).

Airports often provide good year round habitat for rodent populations. Rodents at airports can cause damage directly by gnawing and burrowing activities. Larger rodents (e.g., beaver, porcupine, woodchucks) can pose a direct collision hazard to aircraft moving on the ground. It should be noted, however, that larger mammals such as deer and coyotes are considered a much more serious direct strike hazard than are rodents or other mammals (e.g., Dolbeer *et al.*, 2000). Perhaps the most serious hazard posed by a sizeable rodent population at airports, however, is the indirect hazard of attracting foraging raptors with an associated raptor aircraft strike hazard (e.g., Barras and Seamans 2002). Raptors pose one of the most hazardous groups of birds at the airport setting (Cleary *et al.*, 2002). Unfortunately, many of our activities at airports result in good habitat for rodents (e.g., allowing tall grass in an effort to reduce loafing habitat for flocking birds) or reduced predation of rodents (e.g., perch removal, bird hazing, carnivore-proof perimeter fencing, and raptor and carnivore capture and relocation; see discussion by Barras and Seamans [2002]).

In this paper, we provide background information on the biology and ecology of rodents and the habitats available to rodents at airports. We also discuss human activities and land uses at or near

Author: Plant Protection Department (Zoology) Faculty of Agriculture Sohag University, Egypt. e-mail: abdelaleem2011@yahoo.com

airports that can benefit or adversely affect rodents and, hence, influence the potential for raptor aircraft collisions. The recommendations are not meant to contravene, in any way, the existing authorities, rules, and regulations of federal, state, and local governmental agencies regarding wildlife, land management activities, and airport management.

II. THE NATURE OF RODENTS

Over a third of all mammalian species in the world are rodents. They occur on most, if not all, continents. Species have adapted to all life-styles: terrestrial, aquatic, arboreal, and fossorial. Most rodent species are small, secretive, nocturnal, adaptable, and have keen senses of touch, taste, and smell. For most species, the incisors grow throughout the animal's life, requiring them to be constantly gnawing to keep the incisors at an appropriate length and position. Rodents are known for their high reproductive potential; however, there is much variability among species as to the age at first reproduction, size of litters, and the number of litters per year. Under favorable conditions, populations of some species such as the microtines (e.g., voles) can irrupt, going from less than 100 per ha to several thousand per ha in the period of a few months (e.g., O'Brien 1994). As part of this life strategy, individuals of most rodent species have short life-spans and the annual mortality rates in a population may be as high as 70%. Although rodents are good dispersers, unless conditions are very favorable, mortality rates during dispersal are quite high.

There are many interesting dynamics to various rodent populations that should be understood to better facilitate their management and to reduce damage. The population goes through an annual cycle that may include high and low densities, active and inactive periods, reproductive and non-reproductive periods, and dispersal periods. To avoid inclement periods, some species exhibit a winter dormancy (hibernation), and some species have a summer dormancy (estivation) during hot, dry periods. Some species exhibit multi-year cycles; for example, the microtines often reach population peaks (irruptions) every 3-5 years. Raptors may be attracted to areas such as airports during the "highs" of these population cycles (Baker and Brooks 1981). Even when vole populations "crash", those that survive in grassy "refugia" are able to quickly reproduce and re-invade formerly occupied areas (e.g., Edge *et al.*, 1995, Wolff *et al.*, 1997).

Clearly, it is important to know which rodent species occur at the airport and to have a good understanding of their biology, population dynamics, and ecology along with their relationships to damage, land uses, and human activities.

III. MONITORING RODENT POPULATIONS

It is important to monitor rodent populations at airports. Monitoring allows you to identify the problem species and to conduct pro-active actions, not just retroactive actions. Several to numerous rodent species may occur in any given area, but in many situations only one (or a few) species is causing damage or a problem situation (e.g., high numbers of foraging raptors). Knowing what species are present allows the development of control strategies which account for non-target species and minimize non-target losses. Monitoring rodent populations is also very important because densities can fluctuate dramatically within a year and between years. Monitoring also provides additional information on the rodent population: do they breed throughout the year, how rapid is reinvasion, and how far and quickly are animals dispersing.

Obtaining accurate estimates of population density is difficult and costly, in terms of labor, time, and resource requirements. Often, an index that efficiently tracks the population is adequate. A wide array of methods exist for monitoring rodent populations, including trap grids or transects, plot occupancy, open and closed hole indices for burrowing species, bait station or chew card activity and food removal, and runway or burrow opening counts (Engeman and Witmer 2000, Witmer and VerCauteren 2001).

Airport personnel or a contractor should develop and implement a rodent monitoring protocol. This may require some trials with trap placement and potential, palatable baits. Once an effective protocol is developed, it should be implemented in certain areas both inside and outside the perimeter fence. Care must be taken to insure that traps, wire flags, and other materials used in the field for rodent management do not contribute to foreign object damage.

IV. DEVELOPING AN INTEGRATED PEST MANAGEMENT STRATEGY

While vertebrate Integrated Pest Management (IPM) has not been as fully explored and implemented as has IPM for invertebrate, weed, and plant disease pests, there has been considerable progress in recent decades. Rodenticide application, causing rapid and large-scale population reduction, continues to be an important tool in rodent damage management. These reductions, however, are short-term and there is a growing concern with the environmental hazards and safety issues associated with rodenticide use. Great strides have been made to better understand the nature of rodent populations, why damage occurs, how damage can be predicted and reduced by non-lethal approaches (physical, chemical, behavioral, and cultural), and how to apply ecologically based rodent management strategies (e.g., Singleton *et al.*, 1999).

The general equipment, methods, and strategies used to manage rodents, including rodenticides, have been presented in detail by **Buckle and Smith (1994)** and **Hygnstrom *et al.*, (1994)**. Many new approaches (use of disease agents and fertility control) have proven ineffective or ill-conceived for vertebrates in the preliminary testing phases.

The strategies adopted for Managing Rodent Pests (MRP) varies from agro ecosystems to the other such as desert and semi-desert ecosystems. However, the present work was initiated to through a beam of light on the Management Strategies of Rodents (MSR) within different Ecosystems. The conclusion that has been achieved from the conducted experiments could be summarized in the following points: (1)survey and population density of rodent species in the area (2) The differences in species composition of rodents depending on locality, habitat type and preferred food.(3-)The rodent species preferred the vegetable

baits in the traps. This can be useful to prepare rodent baits to capture rodents.(4) The control of rodents depends upon the locality, neighboring and available food.(5)-Mechanical, biological and chemical control methods can be used effectively in an Integrated Pest Management Approach (IPMA) for the regulation of the rodents population density (**Desokey, 2007**).

We can develop an effective IPM strategy for rodent population and damage management that involves rodent population management, habitat management, and people management (Table 1). Although we seek a relatively easy and long-term solution to the problem, these often do not exist. Therefore, continual, diligent efforts using multiple methods are required. Once an IPM strategy is applied, it is important to monitor the results and to adjust activities as necessary (i.e., incorporate a feedback loop and practice adaptive management).

Table 1: Potential approaches to the management of lower populations of rodents at airports

Habitat Management	Population Management
Burrowing destroying	Trapping
Sanitation (food and debris removal)	
Remove wetlands, riparian habitats, standing water	Rodenticides use
Manage substrates, soil Compaction	Enhance natural predation (counter-productive; attracts predators) Manage substrates, soil
The differences in species composition of rodents depending on locality, habitat type and preferred food.	
Plant monoculture of endophytic grasses or unpalatable plants	Fertility control (future?)
Manage vegetation height and amount with mowing, herbicides, burning, or plowing; remove plant residues	Introduce rodent disease or parasite (future?)
Use artificial turf or other surface cover which prevents burrowing (not practical?)	Mechanical, biological and chemical control methods can be used effectively in an Integrated Pest Management Approach (IPMA) for the regulation of the rodents population density.
The control of rodents depends upon the locality, neighboring and available food	
Establish rodent-proof barriers (at the perimeter fence), extending above and below the ground surface (needs testing)	
Use crops (soybeans, corn) or livestock grazing outside perimeter fence that do not support high populations of rodents	
Remove animal travel and dispersal corridors leading into airport property	

Several manuals have been developed for guidance on managing wildlife populations and habitats at airports (e.g., **Cleary and Dolbeer 1999**, **Transport Canada 2002**). These manuals stress the need to reduce the attractiveness of airports to wildlife through habitat manipulation.

V. HABITAT MANAGEMENT

All rodents require food, shelter, and water. The shelter provides protection from predators, inclement weather, and a favorable place to bear and rear their young. Although rodents require water, those water requirements vary greatly by species. Because rodent food and cover (i.e., vegetation) can be influenced by

human activities, there has been considerable development of strategies to reduce populations and damage by manipulating vegetation (Table 1). We will discuss some of these habitat management approaches, but caution that many of them have not been thoroughly investigated or tested on a large scale (e.g., **Barras and Seamans 2002**).

Good sanitation should be practiced on all areas of the airport. It is especially true around food processing facilities, dumpsters, and employee outdoor eating areas (**Barras and Seamans 2002**). Commensal rodents, in particular, are prone to exploit these areas. Debris piles (rocks, metal, boards, branches and plant clippings) should not be created as they provide protective cover that most rodents will utilize as burrows, dens, and nest sites. Additionally, airport personnel should anticipate a potential influx of rodents when major airport construction or demolition occurs. Wet lands, surface water, and riparian areas all provide very good habitat for rodents and other wildlife because of the close proximity of food, cover, and water. These habitats should be removed, or minimized in area, within the perimeter fence and out to 5,000-10,000 feet of aircraft movement areas (**Cleary and Dolbeer 1999**).

Vegetation height and plant residues can be managed by a number of physical and chemical means--burning, plowing, herbicide application (e.g., **Tracy 1999**), and mowing (**Cornely et al., 1983, Witmer and VerCauteren 2001**). It has been well documented that rodent population densities are generally lower when vegetation height is maintained at 20 cm (8 inches) or less (**Allen 1998 and Barras et al., 2000**). Mowing is the most commonly used practice to achieve this goal, but it should be recognized that plant residues (i.e., cuttings or thatch) should not be allowed to build up as these provide good overhead cover as well as insulating nest materials for rodents (e.g., **Peles and Barrett 1996**). Tall grass may dampen the cycles observed with microtines (**Getz and Hoffman 1999**), with relatively high numbers being maintained year-round. Tall grass can also allow small, resident populations to build up rapidly (**Birney et al., 1976**). In some situations, even with mowing, vole populations have quickly increased to pre-mowing levels (**Edge et al., 1995**). Another consideration is that mowing outside the perimeter may result in an influx of rodents to airport property if better cover exists there.

Grass or vegetation type is also an important consideration. Certain types of grass (bluegrass, creeping fescue) appear to be less supportive of rodents than other types such as tall fescue (**Sullivan and Vandenberg 2000**). Some varieties of grass, called endophytic grasses, contain an alkaloid-producing fungus that can improve the hardiness of the grass and reduce herbivory. Some preliminary studies suggest that endophytic grass fields support lower rodent densities (**Pelton et al., 1991**).

Other species of plants may be unpalatable to rodents. Trials are currently underway with a plant called meadowfoam to assess its natural repellency of wildlife (Sharon Gordon, personal communication). With any of these approaches, it would be important to maintain essentially a monoculture of the plant type to prevent the availability of an alternative food source. Grasslands at airports are typically neglected, except for mowing, so extra effort and expense would be required to maintain monocultures. Artificial turf has even been suggested as a way to restrict rodent habitat, but in most situations, the approach may be prohibitively expensive.

Barriers to rodent movement or burrowing should be considered. The ability of rodents to construct and maintain burrow systems could be reduced by heavy compaction of the site's soil where vegetation occurs over it. Alternatively, a substrate (e.g., gravel, very fine sand) less supportive of intact burrows could be used. Another possibility would be a layer of mesh or woven material placed over the surface that would allow grass to grow through, but would not allow rodents to move between the surface and the subsurface. Finally, a barrier (e.g., cement or metal flashing) could be established at the perimeter fence, extending at least 25 cm (10 inches) above and below the soil surface to restrict rodent dispersal on to the airport proper. An alternative to this type of barrier would be a shallow, horizontal trench extending out from the perimeter fence about 5 meters (16.4 feet) filled with gravel or other material that would make above and below ground movement difficult for rodents. Of course, these barriers would only be effective if the existing rodent population within the perimeter could be successfully eliminated, or greatly reduced, by the use of rodenticides within the perimeter fence. Also, tall vegetation or deep snow cover, may allow rodents to gain access over vertical barriers. While repellents may have some potential to exclude voles from areas, more research and field trials are needed before effective, commercial products become available (**Witmer et al., 2000**).

Land uses outside the perimeter fence should not be supportive of rodent populations, especially if a rodent-proof barrier cannot be established. Of course, any of the above vegetation management approaches could be implemented on lands managed by the airport outside the perimeter fence. Additionally, cereal grains should not be grown as these crops support rodents as well as grain-eating birds (**Barras and Seamans 2002**). Certain crops, such as soybeans and corn, are much less supportive of rodent populations. On the other hand, corn fields may attract other mammals and birds. Also, intensive livestock grazing is less supportive of rodent populations (**Moser and Witmer 2000**). Travel ways or dispersal corridors that could be used by wildlife (tree and shrub cover along streams flowing to or from the airport) should also be eliminated (e.g., **Barras and Seamans 2002**).

VI. RODENT POPULATION MANAGEMENT

Populations of rodents can be reduced by a variety of means. Although methods such as trapping, burning, flooding, and drives have been---and are still being---used in developing countries, many parts of the world have come to rely on rodenticide baits for rodent control (Singleton *et al.*, 1999; Witmer *et al.*, 1995). Considerable development has gone into making rodenticides effective, efficient, and relatively safe for use in buildings or the environment. The use of rodenticides is closely regulated by federal and/or state and provincial governments. In many cases, they can only be applied by a certified pesticide applicator.

Trapping is not very practical for rodent population management, except with some of the larger rodents such as beaver, woodchucks, and porcupines. Trapping can also be used to help control commensal rodents within buildings. Perhaps the most important use of traps in rodent management, however, is as a tool for monitoring rodent populations as discussed earlier.

Rodenticides, in many situations, are the most practical and effective way to reduce a large, widespread rodent population. There are two general classes of oral rodenticides. Acute rodenticides (including zinc phosphide and strychnine) usually kill with a single feeding. In contrast, chronic or multiple-feeding rodenticides (including warfarin, diphacinone, and chlorophacinone) usually require a period (days) of feeding before killing. The distinction has become somewhat blurred because the anticoagulant group includes first generation (examples given) and second generation (bromadiolone, brodifacoum, difethialone) anticoagulants. Second generation anticoagulants are very toxic and can usually kill within several days of a single feeding. These materials are generally not available for field application. Use patterns generally allow rodents to feed continuously at bait stations or on bait blocks, however, so that second generation materials offer no practical advantage in many situations. An additional group of rodent toxicants includes the fumigants (e.g., gas cartridges, aluminum phosphide, methyl bromide) which are used in building fumigation or in burrow systems that are closed after application.

Broadcast baiting with zinc phosphide (ZP; 2% active ingredient) on oats or wheat has worked well for vole (and other small rodent) control at some airports (e.g., Witmer 1999). The bait should be applied early in the year, during a dry period, and pre-baiting with "clean" oats (or wheat) should be done to get good bait acceptance and to avoid the development of "bait shyness" (whereby rodents don't consume a lethal dose, become sick, and won't touch the bait again). ZP does pose a primary hazard to any animal that consumes it so it should be used carefully. On the other

hand, ZP is considered to pose very low secondary hazards (to scavengers or predators) because it disperses quickly as phosphide gas and does not bio-accumulate (Johnson and Fagerstone 1994). Rodents do not become bait shy when anticoagulants (chlorophacinone, diphacinone) are used, but there may be greater secondary hazards because the compounds do bio-accumulate. In some situations, the use of bait stations is required for anticoagulant use. If one rodenticide is not working, it is often recommended that a different one be tried. It is preferable to apply rodenticides during more vulnerable times in the rodent's life cycle---often early or late in the year when succulent vegetation for foraging is less abundant.

On the other hand, found that bait consumption acceptance of rodents with the addition of natural Materials, seeds powder of coriander (*Coriander sativum*); anise (*Pimpinella anisum*) and yeast, vanillia unnatural Materials as attractants. Also, The active burrows of rodent were decreased when used Aluminum phosphate fumigation (Dsokey,2011)

Airport personnel or contractors should establish an effective rodenticide program to control rodent populations. An effective program would provide a ready tool for a pro-active response to an irrupting rodent population, as determined by the population monitoring protocol.

Other methods of rodent population reduction are not practical or may be counter-productive in an airport setting (e.g., enhancing natural predation) or are not yet registered for field application (introduction of rodent disease agents or parasites, use of fertility control materials).

VII. CONCLUSIONS

Dealing with rodent problems, especially in complex settings with many constraints such as airports, may be difficult. Multiple approaches are available and possible, however, and should be woven into a rodent IPM strategy (Table 1). In some cases, it will be necessary to experiment with approaches on a small scale to see which will be most effective and practical in a specific setting. In general, vegetation, overall setting, and land uses of the airport and adjacent properties should be managed so as to be less supportive of rodents, hence attracting less activity by raptors. The rodent population should be carefully monitored with a standardized protocol so that direct population control can be quickly implemented, if necessary. Hopefully, research will continue to provide a better understanding of rodent populations and access to new or improved methods of population and damage reduction.

REFERENCES RÉFÉRENCES REFERENCIAS

1. Allen, J. K. (1998). Small mammal abundance and raptor presence on John F. Kennedy International

- Airport. M. S. Thesis. Montclair State University, Montclair, NJ, USA
2. Baker, J. A., and R. J. Brooks (1981). Raptor and vole populations at an airport. *Journal of Wildlife Management* 45:390-396.
3. Barras, S. C.; R. A. Dolbeer; R. B. Chipman, and G.E. Bernhardt (2000). Bird and small mammal use of mowed and unmowed vegetation at John F. Kennedy International Airport, 1998-1999. *Proceedings of the Vertebrate Pest Conference* 19:31-36.
4. Barras, S. C. and T. W. Seamans (2002). Habitat management approaches for reducing wildlife use of airfields. *Proceedings of the Vertebrate Pest Conference* 20:309-315.
5. Birney, E. C.; W. E. Grant and D.D. Baird (1976). Importance of vegetative cover to cycles of *Microtus* populations. *Ecology* 57:1043-1051.
6. Buckle, A. P. and R.H. Smith (1994). *Rodent pests and their control*. CAB International, Wallingford, U.K.
7. Cleary, E. C. and R. A. Dolbeer (1999). *Wildlife Hazard management at airports*. U.S. Department of Transportation, Federal Aviation Administration, Washington, D.C., USA.
8. Cleary, E.C.; S.E. Wright and R. A. Dolbeer (2002). *Wildlife strikes to civil aircraft in the United States 1990-2000*. U.S. Department of Transportation, Federal Aviation
9. Cornely, J. E.; C. M. Britton and F. A. Sneva (1983). Manipulation of flood meadow vegetation and observations on small mammal populations. *Prairie Naturalist* 15:16-22.
10. Corrigan, R. M (2001). *Rodent Control*. GIE Media, Cleveland, OH, USA.
11. Desoky, A. S. S. (2007). Management strategies for rodents within different ecosystems. M. Sc. Thesis, Fac. Agric. Assiut Univ. 124.
12. Desoky A. S. S. (2011) *Studies on Certain Ectoparasites Associated with Some Farm Animals and their Control*, Ph.D. Thesis, Fac Agric Assiut Univ, Assiut, Egypt, 179 pp.
13. Dolbeer, R. A.; S. E. Wright and E.C. Cleary (2000). Ranking the hazard level of wildlife species to aviation. *Wildlife Society Bulletin* 28:372-378.
14. Edge, W. D.; J. O. Wolff and R.L. Carey (1995). Density-dependent responses of gray-tailed voles to mowing. *Journal of Wildlife Management* 59:245-251.
15. Engeman, R. M. and G. W. Witmer (2000). IPM strategies: indexing difficult to monitor populations of pest species. *Proceedings of the Vertebrate Pest Conference* 19:183-189.
16. Getz, L. L. and J. E. Hofmann (1999). Diversity and stability of small mammals in tallgrass prairie habitat in central Illinois, USA. *Oikos* 85:356-363
17. Hygnstrom, S. E.; R. M. Timm, and G.E. Larson (1994). *Prevention and Control of Wildlife Damage*. University of Nebraska Cooperative Extension, Lincoln, NE, USA.
18. Johnson, G. D., and K.A. Fagerstone (1994). Primary and secondary hazards of zinc phosphide to non-target wildlife a review of the literature. USDA, Animal and Plant Health Inspection Service, Denver (National) Wildlife Research Center. Research Report Number11-55-005. Fort Collins, CO, USA.
19. Moser, B. W. and G. W. Witmer (2000). The effects of elk and cattle foraging on the vegetation, birds, and small mammals of the Bridge Creek Wildlife Area, Oregon. *International Biodeterioration and Biodegradation* 45:151-157.
20. O'brien, J. M. (1994). Voles. Pages B177 – B182 in S. Hygnstrom, R. Timm, and G. Larson, editors. *Prevention and control of wildlife damage*. Cooperative Extension Service, University of Nebraska, Lincoln, NE, USA.
21. Peles, J. D. and G. W. Barrett (1996). Effects of vegetative cover on the population dynamics of meadow voles. *Journal of Mammalogy* 77:857-869.
22. Pelton, M.R.; H. Fribourgh; J. Landre; and T. Reynolds (1991). Preliminary assessment of small wild mammal populations in tall fescue habitats. *Tennessee Farm and Home Sciences* 160:68-71.
23. Singleton, G. R.; L. A. Hinds; H. Herwig and Z. Zhang (1999). Ecologically-based management of rodent pests. Australian Centre for International Agricultural Research, Canberra, Australia.
24. Sullivan, W.T., and J. G. Vandenbergh (2000). A comparison of grass covers and meadow vole populations in North Carolina. 358 *Proceedings of the Wildlife Damage Management Conference* 9:300-306.
25. Tracy, E. (1999). PBI/Gordon's Stronghold Plus BK 800 Broadleaf Weed Control reduces mowing, and eliminates grass and weed seed heads. Pages 159-160 in *Proceedings of Bird Strike '99*. Transport Canada, Ottawa, Canada.
26. Transport Canada. (2002). *Wildlife control procedures*. Third Edition. Transport Canada, Ottawa, Canada
27. Witmer, G. (1999). Field efficacy of "Zinc Phosphide Concentrate" (EPA Reg. No. 56228-6) on rolled oats for controlling deer mice (*Peromyscus* spp.) infields around structures. Unpublished Report to U.S. Environmental Protection Agency, Washington, D.C. USDA, Animal and Plant Health Inspection Service, Wildlife Services, National Wildlife Research Center, Fort Collins, CO, USA.
28. Witmer, G. ; E. W. Campbell, and F. Boyd (1998). Rat management for endangered species protection in the U.S. Virgin Islands. *Proceedings of the Vertebrate Pest Conference* 18:281-286.

29. Witmer, G. and J. W. Fantinato (2003). Management of rodent populations at airports, USDA National Wildlife Research Center - Staff Publications. Paper 291.
30. Witmer, G ; M.W. Fall and L. A. Fiedler (1995). Rodent control, research, and technology transfer. Pages 693-697 in J. Bissonette and P. Krausman, editors. Integrating people and wildlife for a sustainable future. Proceedings of the First International Wildlife Management Congress. The Wildlife Society, Bethesda, MD, USA.
31. Witmer, G ; A. Hakim and B. Moser (2000). Investigations of methods to reduce damage by voles. Proceedings of the Wildlife Damage Management Conference 9:357-365.
32. Witmer, G and K. Vercauteren (2001). Understanding vole problems in direct seeding---strategies for management. Pages 104-110 in R. Veseth, editor. Proceeding of the Northwest Direct Seed Cropping Systems Conference, PO Box 2002, Pasco, WA, USA.
33. Wolff, J.O.; E. M. Schaubert; and W. D. edge (1997). Effects of habitat loss and fragmentation on the behavior and demography of gray-tailed voles. Conservation Biology 11:945-956.

This page is intentionally left blank



GLOBAL JOURNAL OF SCIENCE FRONTIER RESEARCH: C
BIOLOGICAL SCIENCE

Volume 14 Issue 2 Version 1.0 Year 2014

Type : Double Blind Peer Reviewed International Research Journal

Publisher: Global Journals Inc. (USA)

Online ISSN: 2249-4626 & Print ISSN: 0975-5896

“Plantain of Guinea”. The Atlantic Adventure of Banana

By Manuel De Paz-Sánchez

Universidad de La Laguna, Spain

Abstract- “Plantain of Guinea”. The Atlantic Adventure of Banana. It is studied the historical process of the first move of Musaceae to the West Indies, along with sugarcane, in the context of a transatlantic network. Historical texts are critically analysed; evidence about cultivations and species in Europe, Africa and the archipelagos in Macaronesia is shown; longterm historical mistakes are discussed and some hypotheses about the Atlantic transport of biotypes or hybrids during the sixteenth century are suggested.

Keywords: *musa spp., bananas and plantains, history of the musaceae, history of culture.*

GJSFR-C Classification : *FOR Code: 210106*



Strictly as per the compliance and regulations of :



“Plantain of Guinea”. The Atlantic Adventure of Banana

Manuel De Paz-Sánchez

Abstract- “Plantain of Guinea”. The Atlantic Adventure of Banana. It is studied the historical process of the first move of Musaceae to the West Indies, along with sugarcane, in the context of a transatlantic network. Historical texts are critically analysed; evidence about cultivations and species in Europe, Africa and the archipelagos in Macaronesia is shown; long-term historical mistakes are discussed and some hypotheses about the Atlantic transport of biotypes or hybrids during the sixteenth century are suggested.

Keywords: *musa spp.*, bananas and plantains, history of the musaceae, history of culture.

Resumen- “Plátano de Guinea”. La aventura atlántica del plátano. Se estudia el proceso histórico del primer traslado de musáceas [*Musaceae*] a las Antillas, junto con la caña de azúcar, en el contexto de una red trasatlántica. Se analizan críticamente textos históricos; se muestran evidencias sobre cultivos y especies en Europa, África y archipiélagos de la Macaronesia; se comentan errores históricos de larga duración y se plantean algunas hipótesis sobre el transporte atlántico de biotipos o híbridos durante el siglo XVI.

Palabras clave: *musa spp.*, bananas y plátanos, historia de las musáceas, historia cultural.

I. INTROUCTION

In 1736 Linnaeus dedicated a monograph to the *Musa cliffortiana* and, in the epilogue, in order to praise its beauty and eulogise the global diffusion of its cultivation, he included an elegant composition (Linnaeus, 1736: 50) by the neo-Latin poet Hendrik Snakenburg:

Salve; hospitali sede beator,
Quam si vel Indus vel Tropicus tuo
Pinguescat e fructu, et saporis,
Musa, satur nihil optet ultra.

This monograph, as Mark Griffiths has highlighted, allowed Linnaeus to refine his method and taxonomic system (Griffiths, 2007: 23, 25). Half a century ago, the Colombian botanist and historian Víctor Manuel Patiño (1912-2001) held that the division which is usually made between plantains (*Musa paradisiaca*, *Musa spp.*) as vegetable or starchy vegetable substitute for bread, and bananas (*Musa sapientum*, *M. Cavendishi*, etc.) as fruit of consumption like a dessert or sweet, was a arbitrary regarding a large part of equin octial America, since both plantains and bananas were used green, as a vegetable or because of its starch, and

when mature both were consumed as fruit (Patiño, 1969: 297-298).

With few exceptions, the familiar eating bananas are naturally occurring hybrids among the various subspecies of *Musa acuminata* and interspecific hybrids between *M. acuminata* and *M. balbisiana* (Ploetz *et al.*, 2007). These same authors highlight that

Musa taxonomy is confused by several factors including the sterility, ancient domestication, and hybrid origins of the cultivated varieties (cultivars), and the unwillingness of many to adopt newer, correct names. For example, Linnaean binomials such as *M. paradisiaca* (French plantain) and *M. sapientum* (Silk) are still used decades after the cultivars to which these names refer were recognized as *M. acuminata* x *M. balbisiana* hybrids (Ploetz *et al.*, 2007).

The relevance of the *Musaceae* could be appraised according to four essential concepts, as Nelson, Ploetz and Kepler emphasise. Firstly, its “extraordinary significance to human societies, produces the fourth most important food in the world today (after rice, wheat, and maize), bananas and plantains”. Secondly, the fact that “*Musa* species grow in a wide range of environments and have varied human uses, ranging from the edible bananas and plantains of the tropics to cold-hardy fiber and ornamental plants”. Thirdly, its evolution and genetic diversity: “These large, perennial herbs, 2-9 m (6.6-30 ft) in height, evolved in Southeast Asia, New Guinea, and the Indian subcontinent, developing in modern times secondary loci of genetic diversity in Africa, Latin America, and the Pacific”. And, in short, despite it is not regarded as “invasive, *Musa* nonetheless is a persistent plant that competes relatively well with other species within managed agro-forestry settings” (Nelson *et al.*, 2006).

II. TEMPUS ADVENTUS

When did the *Musaceae* arrive in the Canary Islands before moving to the New World? “Thomas Nichols, who enumerated several introduced crops he saw on his visit to Madeira and the Canary Islands in 1526 [sic], used the Spanish word *plátano* to describe his first encounter with the plantain”, and he stated about the fruit of the *plátano* [sic] that “when it is ripe it is blacke, and in eating more delicate then any conserve” (Carney & Rosomoff, 2009: 41-42). However, this must have occurred around 1556, when Nichols

Author: Departamento de Geografía e Historia, Universidad de La Laguna, Spain. e-mail: mdepaz@ull.es

visited the Canary Islands for the first time, since "according to his own words, it seems that he was born in the city of Gloucester by the year 1532" (Castillo, 1992: 66).

The first edition of his book, *A Pleasant Description of the Fortunate Ilandes, called the Ilands of Canaria, with their straunge fruits and commodities*, was published in London (1583), and later on the work was spread by Richard Hakluyt in *The Principal Navigations, Voyages and Discoveries of the English Nation* (London, 1589-1600). This contributed to forge the image of the Canary Islands in England, at least until late in the eighteenth century (Castillo, 2000: 75-76; Castillo, 2009: 31).

The text by Nichols about bananas, as reproduced by Hakluyt, reads:

but especially the PLANTANO which groweth neere brooke sides, it is a tree that hath no timber in it, but groweth directly upward with the body, having marvelous thicke leaves, and every leafe at the toppe of two yards long and almost halfe a yard broad. The tree never yeeldeth fruit but once, and then is cut downe; in whose place springeth another, and so still continueth. The fruit groweth on a branch, and every tree yeeldeth two or three of those branches, which beare some more and some lesse, as some forty and some thirty, the fruit is like a Cucumber, and when it is ripe it is blacke, and in eating more delicate then any conserve (Hakluyt, 1599, II (2): 316).

The error which sets Nichols' visit to the Canaries in 1526 is very old since it stems from the travels' compilation by Hakluyt, who placed a brief "note concerning an ancient trade of the English Marchants to the *Canarie-lands*", in which it is alluded to the year of Lord 1526 (Hakluyt, 1599, II (2): 315). Some years after this edition, in 1629, the French Pierre Bergeron (c.1580-c.1637) collected it in his *Traité de la Navigation* (Bergeron, 1629: 220; Bergeron, 1735, I: col.116), from whom must have took it, in turn, José Viera y Clavijo (Viera y Clavijo, 1772, I: 47; Viera y Clavijo, 1950, I: 55). Bergeron (1629: 225-226) also reproduced the description about bananas made by Nichols.

Much later authors followed the trail of the anachronism. Bonnet translated the text and published it in Castilian in 1933, based on the cited edition (1599) of the collection by Hakluyt. This earned him the applause of the Canary Islanders historians of the period, who indicated that "Mr. Bonnet has rendered a great service to the history of the Archipelago by translating into Spanish such an interesting account". The article was entitled "Description of the Canaries in the Year 1526, Made by Thomas Nicols [sic], English Factor". He included, annotated, the description of the *plántano*: "estando muy maduro, la cáscara se ennegrece; es por demás delicioso al gusto que la más regalada conserva

que se pueda hacer" (Bonnet, 1933: 209; Benítez-Padilla, 1959: 144).

Nichols had also written about sugar production in Tenerife, where he said "there are 12 sugar houses called *Ingenios*", and drew attention to the extraordinary fertility of the Valle de La Orotava, "there is also one league of ground which [...], it is thought that the like plot of ground is not in all the World" (Hakluyt, 1599, II (2): 317; Bonnet, 1933: 210-211), centuries before Humboldt did it.

The cultivation of sugarcane in the Canaries was initiated, in the last quarter of the fifteenth century, with plants from Madeira. In 1502 the conqueror of La Palma and Tenerife, Alonso Fernández de Lugo, transferred to Catalan merchants some of his lands in Los Sauces (La Palma), a "very rich in sugarcane plantations" zone, where other settlers from Catalonia also invested (Pérez-Vidal, 1983, II: 309; Fabrellas, 1952: 457-459). Slavery was inserted in this plantation economy. The trade between the Canaries and Africa was already common at this time since the routes had been opened a long time ago by the Portuguese (Aznar *et al.*, 2012: 55-63).

Unfortunately there is no complete evidence, apart from what Gonzalo Fernández de Oviedo says, on early dates, about the presence of *Musaceae* in the Canaries. The poet Vasco Díaz Tanco could see bananas in the Islands around 1525, since he sang to them in his *Triumphos*, which were published in Valencia around 1530 approximately. In the stanzas by this poet from Extremadura local and foreign plants were mixed: "vi plátanos, cedros y linaloeles [aloe]", assuming, of course, that he refers to *Musaceae* and not to *Platanaceae*. He also praised the dragon trees (*Dracaena Draco* L.): "vi dragos perfectos muy medicinales" in the same stanza (Rodríguez-Moñino, 1934: 14, 21; García-Arranz, 1989: 30).

Another poet, Bartolomé Cairasco de Figueroa (1538-1610), born in Gran Canaria, mentions the voice *plátano* on several occasions. It seems clear that in the first part of its monumental *Templo Militante*, the reverent allusion is to the Virgin Mary, according to the biblical quote *et quasi Platanus exaltata sum iuxta aquas*; so there can be no doubt that he refers to *Platanus × hispanica* or London planetree. Probably, also comment on this tree the verses dedicated to Doramas, islander hero against conquest, born to freedom in the jungle of his name:

Plátano, Fuente, amomo inusitado:
En cuyo gremio estuvo nueve meses,
El divino Doramas retirado
(Cairasco, 1615, IV: 282).

It is of great interest the testimony of the nobleman-soldier-priest Juan Ceverio de Vera (Las Palmas [Gran Canaria], 1550-Lisbon, 1600), who travelled through America (Hispaniola, Panama,

Colombia, Peru, Quito) between 1567 and, approximately, the late 1580s (Borges, 1980: 354, 358). In 1595 he went on a journey to the Holy Land, and in Tripoli (Lebanon) he not only saw bananas, but he also related them to the Canaries, to the Iberian Peninsula and to the New World. The first edition of his book, printed in Rome, is of 1596:

I also saw bananas brought from Egypt, which is healthy and exquisite fruit; and although the trees have come from Canaria [Gran Canaria] to Spain, they are destroyed by the cold, because they want a temperate land and being in the streams of water; they give a single fruit, and being mature, the tree dries and leaves in place many sprouts. And in the Indies [West Indies] there are so many, that in the mountains they are raised without profit or owner (Ceverio de Vera, 1598: 93-94; Martínez-Figueroa & Serra-Rafols, 1964: 112).

In 1645, a group of Spanish Capuchins received bananas in Gran Canaria, during a layover of the missionary journey they went on to Congo. In Las Palmas, where they were feted, they were offered food in abundance, but they "only took a few lemons and fruits from India [sic], which in Canaria is called plátano; of which there are much abundance in the Congo, called *nicefos* in the language of that kingdom" (Pellicer de Tovar, 1649: 5).

These friars were very interested in the acclimatisation of trees in the Congo region. "There are not pears, apples or other similar to these, or born, although they sow them, as the religious have confirmed by experience"; but "three genus" of plants grew well there; in the first place the *niceffo* or *nicefo*, and then the ananas and the coconut palm. The *nicefo*, fairly extended, was grown throughout the year,

Its trunk is not wood like the other trees, but made of the same leaves multiplied one upon another, which then spread on top and make a beautiful crown [...]. This plant or tree produces a very large cluster, full of *nicefos* (Pellicer de Tovar, 1649: 52-53).

Giovanni-Antonio Cavazzi da Montecuccolo (1621–1678) also referred to the *niceffo*, of which he reproduced some pictures, and he talked about its cultivation in Angola: "Il Niceffo, che gli Ambondi chiamano Maongio-à-Camburi, e pianta utilissima, [...] e produce una pigna capace di cento, sino a ducento frutti somigliantissimi a cetrioli". In addition, he recommended it for dysentery sufferers: "cibarli con frutti acerbi del Niceffo" (Cavazzi da Montecuccolo, 1687: 35-36, 143), so it could be a variety of cooking.

In 1678 Friar José de Sosa, talking about Las Palmas, described the "platanales which guard its shores and often serve as hedges". He also pointed out that the monastery of San Francisco had been founded in the most cheerful part of the town, and that in its

magnificent vegetable gardens there were grown "sour fruit trees, plantanales [sic] and other fruits" (Sosa, 1849: 24-25; Sosa, 1941: 34 y 36).

Tomás Arias-Marín de Cubas (1643-1704) claimed in turn that in the late fifteenth century two vessels were chartered in Gran Canaria in order to defend the island from pirate attacks. The ships arrived in Guinea, where they took "blacks to service in the sugar mills", and brought "potatoes, maize, banana roots, yams, and other seeds" (Arias-Marín de Cubas, 1986: 220-221; Bonnet, 1933: 209-note 5). But this information raises doubts because of its inaccuracy and because it incorporates, at that time, maize and potatoes to the credible import of other plants and seeds.

The cultivation of vegetable gardens of platanales continued, however, during the seventeenth and eighteenth centuries (Rodríguez & Macías, 2012: 144). In La Gomera the banana was incorporated into the feast of proclamation of Luis I de Borbón (1725), in the town of San Sebastián, where "the church was seen the next day adorned with bananas and its clusters, and the procession accompanied by the confraternities", although in a certain way its uniqueness was stressed. But it is described in Hermigua where, "in olden days, there was *hazas* of sugar plantations and two sugar mills, today there are only vestiges", and in the *Valle de la Negra* [Valley of the Black], "covered by platanales and *iñames*" (*Dioscoreaceae*). In Los Sauces (La Palma) still existed the "sugar mill", the water flowed clear and there were "bananas, dates, lemons" (Viera y Clavijo, 1776, III: 66-67, 91, 93, 498; Viera y Clavijo, 1951, II-III: 450, 466, 467, 763).

The same could be said of Igueste de San Andrés (Santa Cruz de Tenerife), where throughout the eighteenth century small vegetable gardens of bananas and yams were sold. Not far away, the powerful *ingenio* of Taganana had operated with Portuguese technicians, free employees and slaves since the early sixteenth century, and the same could be said about the fertile lands of the Valle de La Orotava (Viña-Brito, 2006a: 363-364; Rivero-Suárez, 1990: 19-33).

There is something undeniable about all this. *Dioscoreaceae* and *Musaceae* subsisted in the Canaries, especially in areas which had stood out because of their sugar mills during the sixteenth century, since around the end of this century sugar production decreased. It was about irrigated regions where slaves had resided. In these strongholds, where it should have been cultivated at the same time as the sugarcane plantation, bananas survived as a mute witness of a special agrarian, food and, obviously, cultural past.

III. SUGAR, BANANAS AND SLAVES

But when, exactly, did the first *Musaceae* arrive in the Canaries? At different times several authors from distinct scientific fields have echoed the "old tradition" of the arrival of the banana in the Canaries sometime in the fifteenth century, coming from Guinea and brought by Portuguese (López-Gómez, 1972: 16; Pérez-Marrero, 2000: 23; Ramírez *et al.*, 2013: 53; Lassoudière, 2010: 117-118; Hall, 2009: 26; Crane & Balerdi, 2012, etc.).

On this subject, Langdon writes, "as far as Simmonds is concerned, the banana was carried by the Portuguese from Africa to the Canary Islands some time after 1402" (Langdon, 1993: 16; Simmonds, 1966: 313; Marin *et al.*, 1998: 968). It has even been suggested that bananas "seem to have been brought from Guinea by two Franciscan friars" (Martínez-Figueroa & Serra-Rafols, 1964: 192), but the source is not indicated.

Viera y Clavijo also includes this ancient tradition in his *Dictionary of Natural History* when he states that the French gave to the banana the name of "*bananier*, taken from that of the *banano*, which is the one given to it by the natives of Guinea, from whose coast is tradition, the *plátano* was brought to our Islands" (Viera y Clavijo, 1869, II: 200-201). Nevertheless, a tradition is not evidence, and therefore this issue should be further specified.

The occupation of the eastern islands of Lanzarote and Fuerteventura by Jean de Béthencourt and Gadifer de La Salle, in 1402-1404, could not cause the cultivation of any type of *Musaceae*, as the plant does not occur on any of these islands. They have always produced cereals and, partially, grapevine, but the two islands are very poor in water resources, thus making it impossible to plant bananas or sugarcane. They were the granary (cereal producers) of the Canaries when it rained. With absolute certainty the amusing *Figure 9.7* (Camel transporting bananas with donkey in background, Canary Islands, n. d.), included by Carney & Rosomoff (2009: 165), and taken from Simmonds, does not refer to the Canaries: neither the child nor the clothing or the landscape is characteristic of the Archipelago. It is probably somewhere in the NW continental Africa.

The island of El Hierro, which joined as well the lordly conquest, also lacked sufficient water; in fact, the water used to drink was that distilled by the *Garóe*, a mythical tree, probably a variety of *Ocotea foetens*, by a phenomenon of horizontal rain. Nowadays, El Hierro has bananas and tropical fruits such as ananas, but these cultivations began in the last third of the twentieth century.

The great development of the banana in the Canaries came from the mid-nineteenth century, when the Englishman Alfred Diston introduced, from greenhouses in the UK (Paz-Sánchez, 2008: 69-70), the *Musa Cavendishi* that revolutionised the agricultural

economy of the Archipelago thanks to the high European demand (Nuez-Yáñez, 2005: 154; Macías-Hernández, 2011: 241).

The Crown of Castile dealt directly with the organisation of the conquest of the three islands which, in the last third of the fifteenth century, were still unoccupied. Thus, Gran Canaria was conquered between 1478 and 1483, La Palma between 1492 and 1493, and finally, Tenerife between 1494 and 1496. On these three islands (and to a lesser extent in La Gomera, which had a lordly jurisdiction) occurred, after the conquest, a remarkable development of the sugar plantation, whose works demanded importing slave labour: Blacks, Moors and baptised Moors. The first sugar mill began its work in Gran Canaria immediately after the conquest (Fernández-Armesto, 2002: 519).

Canary Islander planters acquired black slaves mainly in three ways: a) by means of exchanging captured Muslims in the Barbary area, which "was made in exchange for blacks from Guinea"; b) by purchasing to slave ships or Portuguese merchants who "travelled through the islands offering their human merchandise" (Rumeu de Armas, 1947: 84) to sugar mills and workplaces; and c) by expeditions led by the Canary Islander settlers themselves (against the international treaties) to the ports of Senegal, Guinea, Cape Verde or Magarabomba [Sierra Leone] (Lobo-Cabrera, 1983: 102-104; Aznar, 1983: 212-214; Fuentes-Rebollo, 2002: 238, 274; Rosa-Olivera, 1978: 184, 227, 236-237; Viña-Brito, 2006a: 376; Cortés-López, 1989: 44, 107-108; Green, 2012: 69, 81, 90, 133, 183).

Cape Verde became a usual market for the black slaves supply to the Canaries. In 1494, a Portuguese neighbour of Gran Canaria, along with two Spanish, armed caravels, went to Guinea and "caught, stole and captured many souls of blacks from Guinea and so brought them captives" (Lobo-Cabrera, 1983: 104; Pérez-Embid, 1948: 227). The monarchs were forced to ban Canary Islanders and Castilian settlers' raids into Guinea by several royal orders between 1477 and 1516 (Viña-Brito & Macías, 2012: 57, 226, 376).

In April 1503, the Catholic Monarchs ordered Juan de Silva, senior lieutenant of Seville, to arrest the guilty and to return to the king of Portugal

certain blacks, melegueta, and other things that some neighbors of Lepe, Palos, Triana and Alcalá del Río took in Guinea where it was said Manicongo, in Santo Tomé, Príncipe island, Fernando Poo and Melegueta Coast, which was the land belonging to the king of Portugal and where they continually used to go to rescatar [swap] their vassals (Lobo-Cabrera, 1983: 104; Cortés-López, 1989: 156).

The gathering of melegueta pepper or Guinea grains (*Aframomum melegueta*), in Grain Coast [Liberia], came to demonstrate the ease with which slave trader could be involved in the introduction of spices and

possibly of plants that they could market in their places of origin.

To the Canaries, essential link in the chain connecting the Old and the New World, some *Musaceae* should be moved in the late fifteenth century by Castilian, Catalan, Valencian, Portuguese or Genoese colonists who actually were going to look for slaves and spices. This move could occur between 1483 and early 1500, and would include taxa from Guinea-Congo and perhaps from the Senegambia region and Cape Verde.

IV. IN TRANSITU AD NOVUM ORBEM

When did the plantain or banana come to the New World? The testimony of Fernández de Oviedo, who, provisionally is the closest to the facts, clearly expresses that it happened in 1516, from Gran Canaria to Hispaniola, and that it was the Dominican Friar Tomás de Berlanga who carried it out. This is an accurate testimony which has been accepted by hundreds of scholars throughout time.

The first reference to banana can be read in the *Summary*, i.e., in the work *Oviedo de la natural hystoria de las Indias*, which was printed in Toledo on February 15, 1526:

from Spain were brought the first, and they have multiplied so much that it is a thing of wonder to see the abundance that there is of them on the islands and in Mainland, where there are villages of Christians, and they are bigger than better and of better flavour in those parts than in these (Fernández de Oviedo, 1526: XLIIJ).

In *La historia general de las Indias*, published in Seville (Juan Cromberger, September 30, 1535), we read (book VIII, chap. I, § X):

These were not in these Indias, and were brought to them [...] (Fernández de Oviedo, 1535: LXXIX).

They were brought from the island of Gran Canaria in the year MDXVI [1516] by the Reverend Father Friar Tomás de Berlanga of the Order of Preachers to this city of Santo Domingo and from here they have extended [...]. The first were brought as I said from Gran Canaria, and I saw them there in the same city at the monastery of San Francisco in the year MDXX [1520], and so there are some of them in other Fortunate islands or Canary Islands. And I have also heard that there are some in the city of Almería in the kingdom of Granada: but to the true [...]: this fruit is from the Levant and the East India according to Genoese, and Italians and Greeks merchants [...] (Fernández de Oviedo, 1535: LXXIX v-LXXX).

And these came here owing to that Reverend Father Friar Tomás de Berlanga, to whom meritoriously the Imperial Majesty has made the mercy of the Bishopric of Castilla del Oro in Tierra Firme (Fernández de Oviedo, 1535: LXXX v).

The edition of Salamanca, in the office of Juan de Junta, was completed on May 2, 1547 and is entitled *Coronica de las Indias: la hystoria general de las Indias*, "corrected and amended". It does not offer significant differences on this point.

Now then, book VIII, chapter I, § 10 of the scholarly edition of 1851, by José Amador de los Ríos, shows striking changes in the paragraph referring to Almería:

As to the truth they cannot be called plátanos (nor they are so); but that which is, *según he oído a muchos*, was brought this lineage plant from the island of Gran Canaria, the year one thousand five hundred and sixteen, by the Reverend Father Friar Tomás de Berlanga [...]. And I have also heard that there are some in the city of Almería in the kingdom of Granada, *y dicese que de allí pasó esta planta a las Indias, y que a Almería vino del Levante y de Alejandria, y de la India oriental*. I have heard Genoese and Italian and Greek merchants [...] (Fernández de Oviedo, 1851, I: 291-292).

Does Fernández de Oviedo want to indicate that the plant could also be moved from Almería to the New World? So it seems, by judging the preceding text, which would be based on the manuscripts recovered in the nineteenth century and which, according to the "Warning" of the publisher, had suffered "great additions and amendments" by the hands of the author himself (Fernández de Oviedo, 1851, I: v-vi). The same text, with minor spelling changes, in the edition by Juan Pérez de Tudela (Fernández de Oviedo, 1959, I: 248).

V. AL-ANDALUS GARDENS

Did bananas continue to be cultivated in Andalusia during the sixteenth century, as had happened in the Muslim period? Of course to a much lesser extent, but it seems that it was so. There is a testimony that even documents the eventual consumption of the fruit among certain courtiers. The doctor of Felipe II, Juan Fragoso, stated it; he was a man of a "balanced critical spirit" (Calbet, 1988: 7). Fragoso wrote *Discursos de las cosas aromáticas* (1572), and said about the "fruit called Musa" that

This plant is known today in Almería, from where the fruit has been sent to some gentlemen of this Court, being a great gift and with good reason, being of such an exquisite and rare tree. These figs at first to be tasted, give discontent; but if one continues using them the person who eats them is not sick of them (Fragoso, 1572: 168).

Fragoso was an influential man. It was pointed out that he was one of the first Spanish doctors to quote Paracelsus; that he was fellow countryman, friend and classmate of Francisco Hernandez; and that his *Discourses* were not only about Asian plants, but also about many American plants, copying García da Orta

and Nicolás Monardes (López-Piñero & Pardo-Tomás, 1996: 28, 52, 112; Fresquet-Febrer, 1995: 76-77).

Actually, Fragoso was inspired by the commented edition that Carolus Clusius had made about the celebrated *Coloquios dos simples, e drogas he cousas medicinais da Índia* (1563) by the Jewish-Portuguese physician and botanist García da Orta (c. 1499-1568). Wisely, Clusius had decided to comment and publish this work in Latin, and his work is not a simple translation, but a scholarly study which preserved the authorship of Orta under the title *Aromatum et simplicium aliquot medicamentorum apud Indos nascentium historia* (1567).

Accompanied by Jakob Fugger, Clusius had visited Spain and Portugal in 1564. As a result of that journey he discovered the *Coloquios dos simples* by the Lusitanian and, impressed by his newness, he decided to translate the work immediately (Barona-Villar & Gómez-Font, 1998: 30-31). During his stay in Lisbon Clusius saw some bananas, which had a low fruition, but which were there, as if to prove they existed. The plant was known as *Figuera Banana*:

Vlysipone, ubi aliquot plantas vidi, minime tamen fructiferas, nomen hoc retinet; vocant enim etiamnum *Figuera Banana*, id est, ficum *Bananas ferentem* (Orta & Clusius, 1567: 222; Clusius, 1605: 230).

José de Acosta, author of the influential *Natural and Moral History of the Indies* (1590), which Humboldt did not cease to praise, however had pointed out that the *plátano de Indias* did not grow in Spain or Italy, where grew the *Platanus* (Acosta, 1590: 248-249). But Juan de Guzmán, the first translator into Castilian (1586) of the *Georgics* by Virgil (Herreros, 1998: 192, 395, 419; Morreale, 2002: 597, 601, 615), was more prudent when he wrote the hemistich *et steriles platani malos gessere valentes* (Georg. 2, 70), saying that these *Platanus* were

different from those of the Indies [West Indies], because in Seville there are those of the Indies, although they do not bear fruit here like they do there, and are small in comparison, it can thus be inferred that they were those brought from Asia (Guzmán, 1795, II: 189-190).

The cultivation of banana varieties among Spanish Muslims is a fact known and debated in the context of discussions on irrigation in Al-Andalus and its socio-political implications (Glick, Thomas F., 1994: 974; Retamero, 2009: 276; Essa & Ali, 2010: 61). Crops of *Musaceae* and other species, which required enough water and special care, were successfully introduced by means of specific hydraulic techniques. In the *Calendar of Cordoba* (attributed to Ibn Sa'id, tenth century), in the *Compendium of Medicine* (Abd al-Malik Ibn Habib, 790-c. 853) and in the *Anonymous Andalusian Calendar* (thirteenth century) there are mentioned the sugarcane (qasab al-sukkar), the cotton (al qutun), and the banana

(al-mawz). According to the chronicle by Ibn Hayyan (eleventh century) during the first half of the ninth century, in the Cordoba court of Abd al-Rahman II it was discussed "the characteristics of the banana (al-mawz)" (Trillo-San José, 2004: 46-47, 50).

In the process of receiving and diffusing these vegetables in the West, it has to be taken into account, together with the commercial tradition of the Arabs, the "extensive kindred networks and the obligation of hospitality with friends and pilgrims". It has also been studied the introduction in Al-Andalus of the main varieties of *Musaceae* (Watson, 1983: 51; Watson, 1998: 117; Trillo-San José, 2004: 46-50).

The agronomist Abu Zacaria Iahia [Ibn al-Áwwam, Yahyà b. Muhammad], who flourished in Seville during the twelfth century, dedicated an interesting epigraph to the *Musaceae* in his *Book of Agriculture*, where he counseled a number of practical care for the cultivation and conservation of the fruits (Boutelou, 1878, I: 228-229).

VI. FERNÁNDEZ DE OVIEDO, ANGHIERA Y VARTHEMA

Patiño (in several adaptations of his manual on *Cultivated Plants and Domestic Animals in Equinoctial America*, 1963-1969) considered that, if the banana had been moved from Andalusia to America and not from the Canaries, it would also be "clones adaptable to high latitudes". Moreover, he drew attention to the doubts raised by the text by Fernández de Oviedo (editions of 1851 and 1959) because he introduces certain inaccuracies ("as I have heard from many" or "it is said that from there moved"); because he indicates that he first saw bananas in 1520 in the Franciscan monastery of Las Palmas; and, as well, because he quotes the works by Anghiera and Varthema in order to describe the plant (Patiño, 1969: 300).

However, Fernández de Oviedo had ratified all the time the famous move and, besides, he had praised the merits of Berlanga when he was appointed Bishop of Castilla del Oro (Colombia-Isthmus), as already mentioned (Fernández de Oviedo, 1535: LXXX v; Fernández de Oviedo, 1851, I: 293; Fernández de Oviedo, 1959, I: 249-250).

On the other hand, it seems that he simply turned to the cited authors in order to get the necessary information and to provide a correct classification of a crop that he considered very useful. The surly though sharp Pietro Martire d'Anghiera had written about this unique biotype:

De arbore, quam potius caulem appellauerim, quod sit vti carduus, medullosa non solida, quamuis ad lauri celsitudinem surgat, multa sunt repetenda, facta est mentio brevis de hac in primis decadibus (Anghiera, 1530: c).

Text which Torres-Asensio had no difficulty in translating as follows:

About the tree, which I better call cabbage because it is like a fluffy thistle, not solid but as high as the laurel, many things have to be repeated: in the first Decades it had been mentioned (Torres-Asensio, 1892, IV: 205).

Thus, what Fernández de Oviedo makes is to confirm that, apart from what he had heard from certain travellers, Anghiera had eaten this fruit, "called *musas*", in Alexandria, and it was clear that it was very different from *Platanus*. This author, besides, did not feel very attracted by the plant since, as he said, it "grows so much" that it renders the land useless for other crops (Torres-Asensio, 1892, IV: 207-208) more typical of Western European agriculture.

Fernández de Oviedo believed, on the contrary, that the *Musaceae*'s capacity to reproduce was one of its advantages. For this reason he confessed to own at least *cuatro mil pies de ellos* in his own farm,

[...] and they have been moved to Tierra Firme and where they have been planted they have grown very well: *y no hay hombre de cuantos en esta tierra tenemos heredades en el campo que esté sin muchos de ellos. Bien creo que hay en mi hacienda iiii [cuatro] mil pies de ellos, y en otras muchas haciendas que hay, mayores que la mía, hay muchos más*, because they are very advantageous and the many there are of them are used by folk, and it is even a good income for their owners, for any expense is put into growing them (Fernández de Oviedo, 1535: LXXX; Fernández de Oviedo, 1547: id.).

The peculiar thing of this revealing passage, for it shows that our chronicler grew bananas on his farm and that he had direct knowledge of the plant, is that it does not appear in the editions of 1851 and 1959, to which scholars usually refer. The equivalent paragraph reads:

[...] and they have been moved to Mainland and where they have been planted they have grown very well; and in the heredities which neighbours have on the island, there are countless numbers of these bananas, because they are very advantageous and they are used, the many there are of them, by folk, and it is even a very good income for their owners, for any expense is put into growing them (Fernández de Oviedo, 1851, I: 292; Fernández de Oviedo, 1959, I: 248).

It may be thought that, definitively, the author himself decided to delete that little paragraph; but other alternatives should not be dismissed, such as the loss of part of the material or the use (in 1851 and 1959) of defective copies of the original manuscript. Cuesta-Domingo had pointed out that Fernández de Oviedo "had lived for a quarter of a century" in America and, for

that reason, his experiences and the information obtained allowed him to write a "great work in which the physical and human geography are combined" (Cuesta-Domingo, 2007: 118), despite its imperfections.

The second of the mentioned books is the *Itinerary* by the Bolognese Lodovico di Varthema (c. 1470-1517), who indeed had referred to the *plantain-tree* under the name of *malapolanda*, corruption, as it seems, of the Tamil *valei pullum*. Perhaps the most interesting thing is that this Italian traveller described three species: "The third sort are bitter. The two kinds above mentioned are good like our figs, but superior" (Badger, 1863: 162-163). Fernández de Oviedo, who mistakenly writes Ludovico de Vartenia [sic], an error that has endured throughout centuries (1851, I: 292, 1959, I: 249), points out that in Santo Domingo [Hispaniola], the plant also showed differences in the quality of the fruit, which could be an indication of the existence of species or perhaps different hybrids,

And I also say that on this island this fruit is not all of a goodness, because there are some better fruits of these and tastier than others of the same fruit; but this may happen because of the soil or the disposition of the land as it happens with all other fruits in Spain and elsewhere (Fernández de Oviedo, 1535: LXXX).

It is possible, on the other hand, that he had first seen the plant in Las Palmas in 1520, for he was a long time linked to his destinations in Mainland, involved in political and administrative conflicts and travelling quite frequently between America and Spain. Simply, he knew that they had been moved to Santo Domingo in 1516 and, when he wrote his chronicle, he confessed he had seen them during a layover made in the Canaries. At the same time, he discovered that they held great attraction for ants,

Ants are very keen on these bananas, and it is always seen on bananas great masses of them [...]; and in some parts there have been so many ants that [...] they have uprooted many of these bananas and thrown them out of the villages (Fernández de Oviedo, 1526: XLIIJ).

This is not a simple anecdote, which furthermore he repeats in all his works. Bartolomé de Las Casas, in Chapter cxxviii of the Book III of his *History of the Indies*, talked, in almost marvellous terms, about the dreadful epidemic of ants that invaded, among other places, the city of Santo Domingo "for this time of year 18 and 19". This new biblical plague destroyed several vegetable gardens, and among them "one of the monastery of the Dominicans, a principal one with pomegranates and orange trees", and in the Vega, another famous vegetable garden of the Franciscans. At the end of the chapter Las Casas writes:

The cause that originated this anthill, some said and believed, was the brought and position of the bananas (Casas, 1876, V: 27; Casas, 1956, III: 472).

VII. FRIAR TOMÁS DE BERLANGA

The move by Friar Tomás de Berlanga, from Gran Canaria to Santo Domingo, not of a single and stunted specimen of *Musaceae*, but probably of several taxa or hybrids of the plant, around 1516, is credible, despite the fact that up to now no evidence has been found documenting his trip to America in this particular year.

The possibility that this move had taken place after 1526 is dismissed because of the publication, on the same date, of the said *Summary* [*Oviedo de la natural hystoria de las Indias*], where the writer already describes the importance of bananas in Hispaniola. There is, however, documentary evidence of Berlanga's first trip to the New World, as part of a group of Dominicans who set out from Seville "in mid-November 1510" for a voyage of "about a month and a half". New expeditions were chartered in 1515 (Figueras-Vallés, 2010: 48, 76, 85-89; Rubio y Moreno, c. 1930: 301, 330).

In 1517 Friar Tomás de Berlanga sent Friar Bartolomé de Las Casas "to the Peninsula in order to recruit peasants who wanted to go to the Indias [West Indies] to settle". Among the two hundred farmers who accepted the proposal there were seventy neighbours of Berlanga, since Friar Tomás had insisted that Las Casas had to go to his hometown "and not elsewhere" because, as Figueres-Vallés has pointed out,

he knew his people would do an excellent job in the Indias, as did a fellow countryman of him, who was in Hispaniola, the bachelor surgeon Velloso [or Velosa], who developed a system for whitening much better the sugar cane (Figueres-Vallés, 2010: 86-87).

Everyone had had "their eyes closed", wrote Fernández de Oviedo, until the "bachelor Gonzalo de Velosa, at his own expense of great and excessive spending", brought sugar masters to this island "and made a *trapiche* [rustic sugar mill] with horses and he was the first who succeeded in making sugar on this island". However, he clarified that, since some time ago, they had taken the first sugarcanes to Hispaniola, and also molasses had been produced; but it is obvious that Velosa had been characterised by a higher professional thoroughness. For this reason he had built a *trapiche* drawn by an animal on the banks of the Nigua River and, very soon, as we will immediately say, associated with Cristóbal and Francisco de Tapia brothers. "He brought the officers to do so from the islands of Canaria (Canary Islands), and ground and made sugar before anyone made it" (Fernández de Oviedo, 1535: XLII v; Fernández de Oviedo, 1851, I: 118).

Fernández de Oviedo was probably informed about the move of bananas to Santo Domingo, led by

Friar Tomás de Berlanga, by the bachelor of Gonzalo de Velosa or, where appropriate, by someone from his old surrounding such as, for example, Cristóbal and Francisco de Tapia brothers. We know that the latter had been governor of the fortress of Santo Domingo, a position in which he was replaced in 1533 by Fernández de Oviedo himself (Pérez de Tudela, 1959, I: cxix-cxx), so he put on recorded his new employment in the colophon of his *History* (1535): "governor of the fortress and castle of the city of Santo Domingo in Española island".

Thus, Fernández de Oviedo, given the quality and closeness of his informants, had not the slightest doubt when it comes to include the fact in his *History* as an indubitable truth, despite his corrector obsession of the advanced age. Velosa had invested heavily in the incipient sugar sector, and therefore he moved the technicians, tools, slaves and, naturally, some of the Canary Islands-African food traditions that, thereafter, would mark with an indelible stamp the cultural and food and agriculture history of the New World.

VIII. INVESTING IN HISPANIOLA

In 1515-1516 occurred in Santo Domingo and indeed, in the Americas, a very special coincidence. The start-up of the first *ingenio* [sugar mill] worthy of such name came to coincide, technically, with the arrival of bananas in Hispaniola. The date of the inauguration of Velosa's *trapiche* is in Father Las Casas (chap. cxxxix):

Later, a neighbour of the city of Santo Domingo came to understand how to do it [sugar]; he was called bachelor Velloso because he was surgeon, native of the town of Berlanga, about the year of 516; he was the first who made sugar in that city, after making some more suitable instruments, and thus it was better and whiter than the first of the Vega, and the first was that from which he made *alfeñique* [cooked sugar-paste] and I saw it [...] he managed to make one that is called *trapiche*, which is a mill or *ingenio* [sugar mill] that is drawn by horses (Casas, 1876, V: 28; Casas, 1956, III: 473).

Velosa was appointed surgeon of the city in 1511; but "between 1514 or 1515 the salary stopped to be paid to the physicist, apparently because he used the office negligently" (Mira-Caballeros, 2010: 512), which, at first, would contradict his entrepreneurship; but the change in his financial stability may induced him to invest their savings in the *trapiche*. It was, in any case, an important investment with a high initial cost to make it profitable: sufficient sugarcane plantations, technology, workforce, commercial organisation to output products, etc. As Pérez-Vidal suggested "that development is not reached, apparently, in Hispaniola until 1515", since until that moment "sugar could only be obtained in small quantities and with inappropriate means" (Pérez-Vidal, 1983, II: 309; Phillips, 1985: 196).

However, the overlap of the two dates, that of the arrival of the banana and the one of the start of the not handmade production of sugar, is surprising even in its imprecision. As Ortiz stressed in his brief chronological proposal: "1515 (or earlier): The first sugar harvest of the first rustic sugar mill. By *Gonzalo de Velosa*", and next, "1516: The introduction of the first *ingenio* (sugar mill). By *Gonzalo de Velosa* and *Francisco and Cristóbal Tapia* brothers" (Ortiz, 1987: 295).

Basically, it is a logical coincidence within the frame of reference of a temporal sequence that should be placed in the mid-1510s, when the enhancement of the Caribbean led to the New World resources that had already been experimented in the Mediterranean and, above all, in the Atlantic archipelagos of *Macaronesia*, where it is introduced the novelty of slave labour in the plantation (Viña-Brito, 2006b: 22-23). It is a phenomenon that is repeated: settlers, landowners, traders, slaves and industrial technicians, and also certain patterns of sugar technical and cultural tradition. The first initiative for the sugar exploitation, although using rudimentary methods, was that of the Catalan Miguel Ballester, though the first who cultivated the cane was Pedro de Atienza (Ortiz, 1987: 295-296; Pérez-Vidal, 1983, II: 305, 311; Cuevas, 1999: 7; Cantero *et al.*, 2005: 112).

There was a transatlantic network between the archipelagos of *Macaronesia* and the Caribbean, which of course also includes Brazil in competition for new technological developments (Sánchez-Valerón & Martín-Santiago, 2003: 72, 88-89; Daniels & Daniels, 1988: 494, 496, 510). This historical reality was highlighted, already since 1773, by Viera y Clavijo:

Our Islands were not secretive of their excellent *sweet canes*, or of the manner of making sugar in their *Ingenios*, since sugarcanes, ingenios, trapiches and officials, all came to America from the Canaries. What a colony so useful for that continent! (Viera y Clavijo, 1773, II: 476-477; Viera y Clavijo, 1951, II-III: 250).

The investment required to start an *ingenio* of those called "powerful" was not less than ten or twelve thousand gold ducats in order to have it "run-of-the-mill". The figure, undoubtedly raised, should not be surprising because it was needed to have,

At least, continuously, eighty or one hundred blacks and even one hundred and twenty and some more, in order to have better all they need; and near a good herd or two of cows of one thousand or two thousand or three thousand of them, *que coma el ingenio* [which eat the *ingenio*]; apart from the great expense of officers and masters who make the sugar, and of carts to carry the cane to the mill and to bring wood, and people who continually cultivate the wheat and take care of and water the canes, and other necessary and of constant expense things (Fernández

de Oviedo, 1535: XLIIJ; Fernández de Oviedo, 1547: id.; Fernández de Oviedo, 1851, I: 119).

The growing decrease in indigenous population, along with the decline in gold production, turned the sugarcane into the last hope of salvation; at the same time black slaves were the "indispensable means of production" in the change of the production model. Various subterfuges were resorted to, such as the demand that slaves who travelled to America had to be Christianized, which strategically could benefit the Canaries' intervention as a previous layover in the process of slave trade. But in the end, the interests of individuals triumphed and especially those of the Crown because, as the academic Joaquín Maldonado-Macanaz wrote,

More certain is that the Catholic King Fernando had *situados* 500,000 gold escudos per year on the income of the Island, which came not only from the working of the mines, but also from the sugar industry transplanted there from the Canaries by Gonzalo Velosa, who founded the first *ingenio*, as well as from other sectors of agriculture to which Spanish population was dedicated (Maldonado-Macanaz, 1870: 9).

From 1518, by virtue of the *asiento* [slaving monopoly] or royal privilege that was granted by Charles V to Laurent de Gouvenot, Governor of Breza, it was intended to introduce in America some 4,000 blacks in the course of eight years (Ngou-Mve, 1994: 40; Friedman, 2000: 49; Phillips, 1985: 185) in order to guarantee the workforce in a plantation economy that was beginning to be efficient.

The situation had actually changed from 1516, with the arrival in Spain of Carlos V. The new governor of Santo Domingo, Rodrigo de Figueroa, had the support of the Crown for the promotion of sugar production, and as Phillips indicates, "the king also encouraged sending experts from the Canaries to the Caribbean, exempted technological equipment from taxation, and allowed on-the-spot production of the copper", necessary for manufacturing works of sugar. "Progress was rapid" (Phillips, 1985: 197).

In short, around 1516 all the factors were given for *Musaceae* to pass to America, as a traditional food of Africans that had also a great identity value. Benítez-Rojo and other authors have stressed that, along with various products of vegetal origin, banana "was an essential element of the African diet, so much so that in many places in the Caribbean it is still called *guineo*, that is, native to Guinea" (Benítez-Rojo, 1996: 96-97; Vesa-Figueras, 2003: 75). Yam constituted, in turn, a staple food in tropical areas of Africa such as, for example, Benin (Fernández-Armesto, 2002: 211).

It was also pointed out that, "as with sugar, the history of the banana plant in Spain's New World colonies begins at the gateway of the Canary Islands".

The problem that arises is to know the type of *Musaceae* officially moved to the Americas, since "the European palate's attraction to the sweet banana would imply that Berlanga's clone was in fact the fruit type", which Fernández de Oviedo neither helps clarify (Carney & Rosomoff, 2009: 40, 113, 114). As Lassoudière suggests: "Des doutes subsistent sur les espèces : s'agit-il seulement de bananiers dessert? De bananiers plantains? Des deux?" (Lassoudière, 2010: 117).

IX. IN THE FOOTSTEPS OF THE CHOSEN SPECIES

Was it a single biotype or were they several? It has been noted that, probably, it would be cultivars "Silk fig" or "French plantain", which are not "edible in raw, but after cooking" (Galán-Saúco & Cabrera, 1992: 4; Robinson & Galán-Saúco, 2011: 2-3). In the Caribbean, it was seen that the old term *Musa sapientum* would correspond to the hybrid "Silk fig" in Trinidad; to the "Figue pomme" in Haiti, Guadeloupe and Martinique; and to the "Cambur manzano" in Venezuela. The term *M. paradisiaca* would refer to the "French plantain" or *Dominico* of Venezuela (Cheesman, 1948: 293-296; Cheesman, 1950: 29-31; Haddad & Borges, 1971: 227-228).

García-Álvarez suggests that different varieties were introduced at different times and from different territories, which would give rise to names associated "with the geographical origin of the clones", and hence the "generic name *guineo* used in Eastern Cuba for banana" (García-Álvarez, 2001: 150). This is interesting, since bananas were grown in Santiago de Cuba around 1538, when it was described by "hum fidalgo Delvas" who accompanied Hernando de Soto, before moving to Florida. "Chamam se naquella terra *Plantanos* [sic], e sam de bom sabor e amaduram depois de colhidos", and he also highlighted the *batatas*, which "mantem muita gente, e principalmente os escrauos" (Burgos, 1557: XI v, XII; Costa de Macedo, 1844, I: 11-12).

The added *guineo* is therefore a form of cultural identification and, of course, a reference to the African origin of the plant, which had already been pointed out by Anghiera:

Ab ea Aethiopiae parte, quam vulgo Guinea dicitur, vbi est familiaris & sua sponte nascitur, primum aduentam ferunt (Anghiera, 1530: C v).

It is told that they first took it from that part of Ethiopia which is commonly said Guinea, where it is common and grows spontaneously (Torres-Asensio, 1892, IV: 208).

Acosta distinguished at least two types of bananas or *plantains*; some small, delicate and white, which in Hispaniola are called *dominicos*, and others "thicker and tough and red". He also stated that it was the most commonly used "fruit" in the Indies, "although it is said that its origin was Ethiopia and that from there

came, and in fact blacks use it a lot" (Acosta, 1590: 247, 250).

The Inca Garcilaso de la Vega maintained that the *dominicos*, smaller but more rarer and tastier, received this name because the skin, when the fruit was ripe, "was black and white with patches" (Garcilaso de la Vega, 1609: 211; Garcilaso de la Vega, 1723: 282), imitating therefore the habit of the Dominican friars.

In the New Kingdom of Granada, Friar Pedro Simón takes the tradition that states that the *plantains* or bananas had been brought to America by "the Spanish from the Canaries", and maintained that they were of "good taste when raw if they are well seasoned; and they are also cooked". He also said that he had seen bunches of those that are "called of Guinea" with more than three hundred fruits, "though small" (Simón, 1626: 725).

The *Historical Relation* by Jorge Juan and Antonio de Ulloa talks about dominico and guineo bananas (Juan & Ulloa, 1748, I (2): 391); and in 1769 the botanist Gómez de Ortega distinguished, in a note to the voice "bananas" of the book by Commodore Byron *A Voyage Round the World*, the three species of *Musaceae* that were best known in his time. The big ones (bananas), the small ones (plantains guineos) and the medium ones (dominicos); "to the second species it is likely that its name come from Guinea, where it is produced a special abundance of them" (Byron, 1769: 11-12).

In his *Saggio di Storia Americana* the Jesuit Filippo Salvatore Gilij (1721-1789), who developed his missionary work in the Middle Orinoco, also drew attention to the varieties *guinèo* or *cambùre*, *artòni* and *dominico*, of which he says that "ed è un frutto di mezzo tra l'Artòne, e l'Guinèo se non che il Dominico è di figura quasi triangolare" (Gilij, 1780, I: 212, 310-311).

Humboldt, who described fascinated the Valley of La Orotava (Tenerife), "the greatest sight, the richest of the universe", mentioned groups of bananas being part of such an idyllic landscape (Puig-Samper & Rebok, 2007: 289). In New Spain, when he defended his thesis on the existence of a type of pre-Columbian *Musa*, as had defended the Inca Garcilaso de la Vega, he suggested that Friar Tomás de Berlanga "could not transport from the Canary Islands to St. Domingo any other species but the one which is there cultivated, the *camburi*", and not "the *plátano* [*h*]artón or *zapalote* of the Mexicans". The first of these species, wrote, "only grows in temperate climates, in the Canary Islands, at Tunis, Algiers, and the coast of Malaga". He also stated that "the *guineo*, a variety of the *camburi*, as its name proves, came from the coast of Africa" (Humboldt, 1822a. II: 369, 371; Humboldt, 1822b, II: 233-234).

The fact is that while "in Peninsular Spain both plantains and bananas were called *plátano*", in Spanish America "sweet fruit banana was linguistically

differentiated from the plantain (*plátano*) as *plátano guineo*" o *guineo* (Carney & Rosomoff, 2009: 103).

One possible explanation is that this linguistic phenomenon occurs for two principal reasons. In peninsular Spain crops of bananas, from the fall of Granada, were further reduced to marginal areas, and the fruit became, already from the sixteenth century, a courtly delicacy.

In the Canary Islands, with more suitable temperatures, *Musaceae* survived as I already said, but also marginally because of the change in the production model to vine and wine exports (seventeenth and eighteenth centuries). Despite everything, lexical coincidences have been detected in the traditional glossary of the banana between the two shores of the Atlantic, and it has been suggested that, already since the sixteenth century, the plant was known in the Canaries as *plátano guineo*. "In this way the banana as well as sugarcane, yam and maybe the vine were known in America from the Canaries" (Leal-Cruz, 1996: 209-210). But surely it was called *plátano de Guinea* in the Canaries and it was in America where it was known later as *guineo*, because slavery, the culture of black Africa and also the biodiversity of the *Musaceae* carried much more weight there.

Thus, in the Americas, the lexical richness would be related to the process of introducing the plant, to the species and territories diversity (from Florida to Ecuador), and especially to the weight that in some of these countries had slavery, cultural resistance and miscegenation. The *guineo* is a culturally mestizo hybrid vegetable.

X. "COME OUT THE GUINEO TO DANCE" [CALDERÓN DE LA BARCA]

Hermann Schacht (1814-1864), who visited Madeira and the Canary Islands in the mid-1850s, detected among others, species of *Musa sapientum*, *M. paradisiaca* and *M. Cavendishi*. He assured that they thrived in low areas; that they rarely grew to 600-700 feet; that in Tenerife they spread everywhere and formed "large plantations"; he offered some interesting data on the size of the *cepa* or trunk, on the type of cluster, on the bloom, etc. "The fruit of *M. sapientum* has the shape of a cylinder, elongated and flattened at both ends", when it is ripe it "has yellow colour with black spots that also appear on the trunk of the plant". The fruits of *M. paradisiaca* and *M. Cavendishi*, which are smaller, "are not cylindrical as the previous ones, but angular, and some people will prefer these ones". They could be eaten ripe or well roasted and cooked "as a vegetable". The *M. sapientum*, which was the one that had a higher stem (ten to twelve feet), opened its large leaves out on either side of a central rib, "and it soon splits due to the action of the wind" (Sarmiento-Pérez *et al.*, 2012: 94-98).

It is striking that, in addition to food uses, Fernández de Oviedo also emphasised, from the *Summary* of 1526, morphological aspects that Schacht repeats accurately, for example, size and appearance of the leaves after the action of the wind; clusters with forty and fifty fruits more or less, which measure "a hand and a half", and are the bulk of the "wrist of an arm" (Fernández de Oviedo, 1526: XLIII v-XLIII). Without forgetting the differences in the quality of the fruits, which the chronicler attributed to the fertility of the soil.

In Cuba, the term *guineo*, alone or accompanied by the voice *plátano*, was clearly identified with a particular species of *Musaceae*, which according to Pichardo would be *M. sapientum*:

The GUINEO (*Musa sapientum*) is the smallest of all; its length does not exceed one-third of a foot, straight, cylindrical; when mature softest flesh (Pichardo, 1836: 212-213).

In later editions he insisted on that the "*plátano guineo* or *de Guinea* (*M. sapientum*)" was the smallest of them, although "near the bulk of the *macho*" [*M. paradisiaca*], and described it in similar terms. He added that its clusters were laden with excess of fruits, and that the vegetable could not be from the Caribbean region, since even the *dominico* or *hembra*, or *Congo*, a variety, he states, of *M. regia* (small, delicately curved, soft and delicate when ripe), was from Nigricia [Negroland], as well as the *guineo*, while those of the *Otaheiti* and of *Orinoco* clearly expressed their origin. How could Columbus and the others talk about *ñame*, *yuca*, etc., and mute the interesting *plátano*?, he asks himself (Pichardo, 1849: 187; Pichardo, 1861: 213-214).

Thus, when a certain species of bananas left the Canaries in 1516 it is possible that it already bore the appellation *plátano* or *plátano de Guinea*, and that, with the passage time, it would be transformed, especially in the Caribbean islands (Santo Domingo and Cuba), into *plátano* or *plátano guineo*, since in both cases meant the same: bananas coming from the Gulf of Guinea, the banana of the black slaves. Indeed, from 1510 it becomes "legal the sending of black Guineans" to the Caribbean (Viña-Brito, 2006b: 21-22).

In the Canary Islands there has always been the *yerba* [grass] from Guinea [*Panicum maximum*], as well as in Cuba where, in addition, there is the "guinea fowl"; but Canary Islanders have also the "guinea pumpkin", long, curved and of very yellow flesh, perhaps like those grown in the nascent town of *Ingenio* (Gran Canaria), from the sixteenth century (Sánchez-Valerón & Martín-Santiago, 2003: 432; Morera, 2006: 642-643; Corrales & Corbella, 2009, I: 1074-1075).

Also, the *guineo* is a dance similar to the primitive *canario* (ancient dance that apparently came from the natives of the Canaries), and which came into fashion in Europe during the Modern Age. That is why the footman Rodrigo says, in act II of *The Ingratitude*

Revenge by Lope de Vega: "and I can dance the canarie, / I'm a native of there, / and among sugar brought up", and therefore Sandoval writes, talking about black *guineos*,

Among them there are many good musicians, to such a degree that from them people learned in Spain [...], the so celebrated dance, called the Canario, reformed Guineo by the Isleños Canarios (Sandoval, 1647: 45).

For this same reason, Mr. Pedro Calderón de la Barca (1600-1681) makes the king say, at the end of his burlesque comedy *Cephalus and Procris*, "The giant with the owners / come out the guineo to dance" (Calderón de la Barca, 1691: 416).

Fernando Ortiz already highlighted the need to give the corresponding gentilic name to certain nouns, with which they become dense signs of identity. Blacks and "then whites", he says, used in America the African names to "distinguish certain things from other similar things, according to their origins". Thus, it is said *fowl of Guinea*, *yerba of Guinea*, *plátano guineo*, *plátano burro* (which is *mature* in carabalí [Calabar]), *jutía arará*, etc." (Ortiz, 1987: 370).

In the general Spanish, the expression *guineo* soon became to identify slaves. Covarrubias defines *guineo*, in first meaning as a black of Guinea, and in second as "certain dance of prestos [rapid] and hasty movements". Guinea was "the land of the blacks" (Covarrubias, 1611: 457 v). Therefore, *guineo* meant black, and black was equivalent to slave. Sandoval says that such "Ethiopian guineos" were the most beloved of the Spanish. "These guineos are", he states, the most esteemed, sought-after and expensive blacks, "and those we commonly call honest, good-natured, with sharp wit, beautiful and willing, joyful of heart" (Sandoval, 1627: 41 v; Sandoval, 1647: 45).

Cervantes, in his comedy *La Entretenida* (*Jornada I*, 606-612), introduces Ocaña, a footman who complained about being treated like a *guineo*:

¿Yo no veo
Que, cual si fuera guineo,
Bezudo y bozal esclavo,
Apenas entro en la sala
Por alguna niñería,
Cuando cualquiera me envía,
Si no en buena, en hora mala?

It should not be very difficult to identify certain types of *Musaceae* with the name *guineo* or *plátano de Guinea* because, in fact, they were the favorite of the slaves, they were nutritious, versatile and intensely familiar and, therefore, with a powerful identity value. Viera y Clavijo, unlike other authors, equated the smaller bananas with those called *dominicos*,

In our islands that species is preferred with good reason, which gives the smallest bananas,

called *dominicos*, because of its delicate, soft and creamy of all its flesh, and which Linnaeus distinguished by the name of *Musa sapientum*, considered without doubt the daily bread of the philosophers of India (Viera y Clavijo, 1869, II: 203).

Although he tells below, once again, Berlanga's expedition in 1516 as well as the vision of Fernández de Oviedo in the Franciscan monastery of Las Palmas, four years later, he does not say that that was, specifically, the chosen species, perhaps because as a good naturalist he sensed that from the beginning of the history there had lived together in the island territory *Musaceae* taxa which, brought from Guinea and Andalusia, grew in monasteries' vegetable gardens, real spaces of culture of the oasis, before moving to the New World. After all, as Benítez-Padilla (1959: 147) wrote, "the function of the island is that of the oasis in the open field of the oceanic desert. It is nourished by caravans, at the same time it nourishes them".

In the fourteenth and fifteenth centuries when Portuguese navigators explored the most remote coasts of West Africa, "somatic mutations obviously occurred, resulting in a large number of clones and a secondary centre of diversity in Africa" (Robinson & Galán-Saúco, 2011: 2).

XI. CONCLUSION

In 1483, almost a decade before the discovery of America, the first efforts were being made to make the fertile virgin lands of Gran Canaria profitable. During the following decade of 1490, the islands of La Palma and Tenerife joined the Crown of Castile and were also incorporated in an intense production phase. The three islands were, along with Madeira and Santo Tomé, well equipped to start the first draft of Atlantic model of sugar plantation.

Why should we limit ourselves to think it was only one biotype which was moved, from the Gulf of Guinea to the Canary Islands, to feed the emerging endowments of slaves, and which then moved from the Canaries to Hispaniola? Perhaps it should be suggested the possibility of the reception, in the Canaries, of clones from Guinea, Cape Verde and other parts of Africa, as well as from Andalusia, the latter brought to the Canaries by Franciscan or Dominican missionaries, as a result of the conquest of Gran Canaria, La Palma and Tenerife, the richest in water and the most populated by indigenous (*canarios*, *benahoaritas* and *guanches*), who were also enslaved as, in fact, happened in America.

When the possibility of obtaining sufficient gold resources were exhausted in the Antilles, and the system diverted towards a model of sugar plantation, the islands of Macaronesia were put at the service of the new centers of demand for goods, equipment and services. Thus, technicians, slaves, and traditional food and resources were moved. The gentilic name served to

differentiate plants, animals and humans. Under the pain of an extraordinary historical birth, these people were building new worlds, new spaces of effort, sacrifice and intense cultural diversity.

Nobody called the cane (*Saccharum officinarum*), cane of the East, of Sicily, of Spain, of Madeira or of the Canaries, though of course there are different varieties, since it was always known as sweet cane or sugarcane; white, unique and shining as a Roman goddess. The plantain and the banana needed a gentile name to be recognised and differentiated, since, depending on the circumstances, they became viand (cooking banana) or smiling fruit, but its clusters are always bended towards the ground as if they recognise their humble origins.

XII. ACKNOWLEDGEMENTS

Financed by the project HAR2012-37455-C03-01, CSIC (Spain). My gratefulness to Catarina Alexandra Costa Rodrigues for the English translation.

REFERENCES RÉFÉRENCES REFERENCIAS

- Acosta, José de (1590) *Historia natural y moral de las Indias*. Juan de León, Sevilla.
- Anghiera, Pietro Martire de (1530) *De Orbe Nouo [...] decades*. Michaellem de Eguia, Compluti.
- Arias-Marín de Cubas, Tomás (1986) *Historia de las siete islas de Canaria*. Real Sociedad Económica de Amigos del País, Las Palmas de Gran Canaria.
- Aznar, Eduardo (1983) *La integración de las Islas Canarias en la corona de Castilla (1478-1520)*. Universidad de La Laguna, Santa Cruz de Tenerife.
- Aznar, Eduardo; Corbella, Dolores & Tejera, Antonio (editors) (2012) *La Crónica de Guinea. Un modelo de etnografía comparada*. Casa de África, Barcelona.
- Badger, George Percy (editor) (1863) *The Travels of Ludovico di Varthema*. The Hakluyt Society, London.
- Barona-Villar, Josep L. & Gómez-Font, Xavier (editors) (1998) *La correspondencia de Carolus Clusius con los científicos españoles*. Universidad de Valencia, Valencia.
- Benítez-Padilla, Simón (1959) *Gran Canaria y sus obras hidráulicas: bases geográficas y realizaciones técnicas*. Cabildo Insular, Las Palmas.
- Benítez-Rojo, Antonio (1996) *The Repeating Island. The Caribbean and the Postmodern Perspective*. Translated by James E. Maraniss. Duke University Press, Durham.
- Bergeron, Pierre (1629) *Traicté de la navigation et des voyages*. Jean de Heuqueville, Paris.
- Bergeron, Pierre (1735) *Voyages faits principalement en Asie dans les XII, XIII, XIV et XV siècles*. Jean Neaulme, La Haye.
- Bonnet, Buenaventura (1933) "Nuevas aportaciones históricas. Descripción de las Canarias en el año 1526, hecha por Thomas Nicols, factor inglés". *Revista de Historia*, 39-40: 206-216.
- Borges, Analola (1980) "Comentario a un relato del siglo XVI sobre el Nuevo Mundo". *Anuario de Estudios Atlánticos*, 26: 351-398.
- Boutelou, Claudio & Boutelou, Esteban (editors) (1878) *Libro de Agricultura. Su autor el doctor excelente Abu Zacaria lahi*. Biblioteca Científico-Literaria, Sevilla.
- Burgos, Andree de (editor) (1557) *Relaçam verdadeira dos trabalhos que ho governador don Fernando de Souto [...] descobrimento da prouincia da Frolida*. Andree de Burgos, 1557.
- Byron, John (1769) *Viage del comandante Byron alrededor del mundo*. Translated by Casimiro Gómez de Ortega. Casa de don Francisco Mariano Nipho, Madrid.
- Cairasco de Figueroa, Bartolomé (1615). *Templo Militante: Flos Sanctorum [...]*. Pedro Crasbeeck, Lisboa.
- Calbet Camarasa, J. M. (1988) "Presentación". In *Juan Frago. Tratado de las declaraciones*, edited by Corbella, Jacint, Promociones y Publicaciones Universitarias, Barcelona, pp. 7-8.
- Calderón de la Barca, Pedro (1691) *Novena parte de comedias del célebre poeta español, don Pedro Calderón de la Barca*. Francisco Sanz, Madrid.
- Cantero, Justo Germán; García-Mora, Luis M. & Santamaría-García, Antonio (2005) *Los Ingenios: colección de vistas de los principales ingenios de azúcar de la isla de Cuba*. CSIC, Madrid.
- Carney, Judith A. & Rosomoff, Richard Nicholas (2009) *In the shadow of slavery: Africa's botanical legacy in the Atlantic world*. University of California Press, Berkeley.
- Casas, Bartolomé de Las (1876) *Historia de las Indias*. Imp. de Miguel Ginesta, Madrid.
- Casas, Bartolomé de Las (1956) *Historia de las Indias*. Biblioteca Ayacucho, Caracas.
- Castillo, Francisco Javier (1992) "The English Renaissance and the Canary Islands: Thomas Nichols and Edmund Scory", *SEDERI: yearbook of the Spanish and Portuguese Society for English Renaissance Studies*, 2: 65-77.
- Castillo, Francisco Javier (2000) "Las Canarias en las Crónicas de Richard Hakluyt y Samuel Purchas". *Revista de Filología de la Universidad de La Laguna*, 18: 75-112.
- Castillo, Francisco Javier (2009) "Fuentes inglesas del siglo XVIII: el texto de J. Edens". *Revista de Filología de la Universidad de La Laguna*, 27: 31-51.
- Cavazzi da Montecuccolo, Giovanni A. (1687) *Istorica descrizione de tre regni Congo, Matamba et Angola situati nell'Etiopia inferiore occidentale*. Giacomo Monti, Bologna.
- Ceverio de Vera, Juan (1598) *Viaje de la Tierra Santa*. Matías Mares, Pamplona.

29. Cheesman, Ernest E. (1948) "On the nomenclature of edible bananas". *Journal of Genetics*, 48: 293-296.
30. Cheesman, Ernest E. (1950) "Classification of the Bananas. III. Critical Notes on Species. q. *Musa coccinea* Andrews". *Kew Bulletin* 5 (1): 29-31.
31. Clusius, Carolus (1605) *Exoticorum libri decem: quibus animalium, plantarum, aromatum. Ex Officinam Plantinianam Raphelengii*, Leiden.
32. Corrales, Cristóbal & Corbella, Dolores (2009) *Diccionario ejemplificado de canarismos*. Instituto de Estudios Canarios, La Laguna de Tenerife.
33. Cortés-López, José L. (1989) *La esclavitud negra en la España peninsular del siglo XVI*. Universidad de Salamanca, Salamanca.
34. Costa de Macedo, Joaquim José da (editor) (1844) *Relaçam verdadeira dos trabalhos que ho governador don Fernando de Souto [...] descobrimento da provincia da Frolida*. Academia Real das Sciencias, Lisboa.
35. Covarrubias Orozco, Sebastián (1611) *Tesoro de la lengua castellana o española*. Luis Sánchez, Madrid.
36. Crane, Jonathan H. & Balerdi, Carlos F. (2012) "Los plátanos en Florida". University of Florida, IFAS Extension, on line. <http://edis.ifas.ufl.edu/hs275> [accessed 06/March/2014]
37. Cuesta-Domingo, Mariano (2007) "Los Cronistas oficiales de Indias. De López de Velasco a Céspedes del Castillo". *Revista Complutense de Historia de América*, 33: 115-150.
38. Cuevas, Héctor E. (1999) *El azúcar se ahogó en la melaza: quinientos años de azúcar*. Instituto Tecnológico de Santo Domingo, Santo Domingo. República Dominicana.
39. Daniels, John & Daniels, Christian (1988) "The Origen of the Sugarcane Roller Mill". *Technology and Culture*, 29 (3): 493-535.
40. Essa, Ahmed; Ali, Othman (2010) *Studies in Islamic Civilization: The Muslim Contribution to the Renaissance*. The International Institute of Islamic Thought, Herndon.
41. Fabrellas, María Luisa (1952) "La producción de azúcar en Tenerife". *Revista de Historia*, xviii: 455-475.
42. Fernández-Armesto, Felipe (2002) *Civilizaciones: la lucha del hombre por controlar la naturaleza*. Taurus, Madrid.
43. Fernández de Oviedo, Gonzalo (1526) *Oviedo de la natural hystoria de las Indias*. Ramón de Petras, Toledo.
44. Fernández de Oviedo, Gonzalo (1535) *La historia general de las Indias*. luam Cromberger, Sevilla.
45. Fernández de Oviedo, Gonzalo (1547) *Coronica de las Indias: la hystoria general de las Indias agora nuevamente impressa, corregida y emendada*. Juan de Junta, Salamanca.
46. Fernández de Oviedo, Gonzalo (1851) *Historia general y natural de las Indias*. Real Academia de la Historia, Madrid.
47. Fernández de Oviedo, Gonzalo (1959) *Historia general y natural de las Indias*. Atlas, Madrid.
48. Figueras-Vallés, Estrella (2010) *Fray Tomás de Berlanga: una vida dedicada a la Fe y a la Ciencia*. Ochoa Editores, Barcelona.
49. Fragoso, Juan (1572) *Discursos de las cosas aromáticas, árboles y frutales, y de otras muchas medicinas simples que se traen de la India Oriental*. Francisco Sánchez, Madrid.
50. Fresquet-Febrer, José L. (1995) "Materia médica americana en textos médicos españoles del siglo XVI". *Cirugía y cirujanos*, 63 (2): 72-79.
51. Friedman, Saul S. (2000) *Jews and the American slave trade*. Rutgers-The State University, New Brunswick.
52. Fuentes-Rebollo, Isabel (2002) "Addenda a los documentos sobre Canarias en el Registro General del Sello (1501-1510)". *Boletín Millares Carlo*, 21: 229-292.
53. Galán-Saúco, Víctor & Cabrera, Juan (1992) *Gran Enana: un nuevo cultivar comercial de platanera para Canarias*. Gobierno de Canarias, La Laguna de Tenerife.
54. García-Álvarez, Alejandro (2001) "Santo, seña y ruta histórica del plátano hasta Cuba". *Revista de Indias*, 221: 141-166.
55. García-Arranz, José J. (1989) "Notas en torno a los grabados de la obra de Vasco Díaz Tanco *Los veinte triumphos*". *Norba-Arte*, 9: 29-44.
56. Garcilaso de la Vega, Inca (1609) *Primera parte de los Commentarios Reales*. Pedro Crasbeeck, Lisboa.
57. Garcilaso de la Vega, Inca (1723) *Primera parte de los Commentarios Reales*. Oficina Real, Madrid.
58. Gillij, Filippo Salvatore (1780) *Saggio di Storia Americana*. Luigi Perego Erede Salvioni, Roma.
59. Glick, Thomas F. (1994) "Hydraulic Technology in Al-Andalus". In *The legacy of Muslim Spain*, edited by Jayyusi, Salma Khadra, E. J. Brill, Leiden, pp. 974-985.
60. Green, Toby (2012) *The rise of the trans-Atlantic slave trade in western Africa, 1300-1589*. Cambridge University Press, New York
61. Griffiths, Mark (2007) "Clifford's Banana: How Natural History was made in a Garden". In *The Linnean Special Issue N° 7. The Linnaean Collections*, edited by Gardiner, B. & Morris, M., Wiley-Blackwell, Oxford.
62. Guzmán, Juan de (editor) (1795) *Las Geórgicas de Publio Virgilio Marón [...] con muchas notaciones [...] por Juan de Guzmán [...]. En Salamanca en Casa de Juan Fernández. Año 1586*. Oficina de los Hermanos de Orga, Valencia.

63. Haddad, O. & Borges, O. (1971) "Identificación de clones de bananos (cambures y plátanos) en Venezuela". *Agronomía Tropical*, 21 (4): 227-228.
64. Hall, Robert L. (2009) "Food Crops, Medicinal Plants, and the Atlantic Slave Trade". In *African American foodways: explorations of history and culture*, edited by Bower, Anne L., University of Illinois, Chicago, pp. 17-42.
65. Hakluyt, Richard (1599) *The Principal Navigations, Voyages and Discoveries of the English Nation*. George Bishop, London. <http://ebooks.adelaide.edu.au/h/hakluyt/voyages/v06/chapter3.html> [accessed 25/February/2014]
66. Herreros Tabernero, Elena (1998) *Las Geórgicas de Virgilio en la literatura española*. Tesis doctoral. Universidad Complutense, Madrid.
67. Humboldt, Alexander de (1822a) *Political essay on the Kingdom of New Spain*. Translated by John Black. Longman, Hurst, Rees, Orme, and Brown, London.
68. Humboldt, Alexander Von (1822b) *Ensayo político sobre el reino de la Nueva España*. Translated by Vicente González-Arno. Casa de Rosa, Paris.
69. Juan, Jorge & Ulloa, Antonio de (1748) *Relación histórica del viaje a la América Meridional*. Antonio Marín, Madrid.
70. Langdon, Robert (1993) "The Banana as a Key to Early American and Polynesian History". *The Journal of Pacific History*, 28 (1): 15-35.
71. Lassoudière, André (2010) *L'histoire du bananier*. Éditions Quae, Paris.
72. Leal-Cruz, Pedro N. (1996) "Lenguaje del cultivo del plátano en Canarias". *Tebeto: Anuario del Archivo Histórico Insular de Fuerteventura*, 9: 207-232.
73. Linnaeus, Carl (1736) *Musa Cliffortiana florens Hartecampi 1736 prope Harlemum*. [s. n.] Lugduni Batavorum [Leiden].
74. Lobo-Cabrera, Manuel (1982) *La esclavitud en las Canarias orientales en el siglo XVI (negros, moros y moriscos)*. Cabildo Insular de Gran Canaria, Las Palmas.
75. López-Gómez, Antonio (1972) "El cultivo del plátano en Canarias". *Estudios Geográficos*, 126: 5-68.
76. López-Piñero, José María & Pardo-Tomás, José (1996) *La Influencia de Francisco Hernández (1515-1587) en la constitución de la botánica y la materia médica modernas*. Universidad de Valencia-CSIC, Valencia.
77. Macías-Hernández, Antonio M. (2011) "Canarias, 1800-2000: la singularidad de la historia económica isleña". *Historia Contemporánea*, 42: 225-259.
78. Maldonado-Macanaz, Joaquín (1870) "El comercio de América y los filibusteros". *Revista de España*, XVI: 5-30.
79. Marin, Douglas H.; Sutton, Turner B. & Barker, Kenneth R. (1998) "Dissemination of Bananas in Latin America and the Caribbean and its Relationship to the Occurrence of *Radopholus similis*". *Plant Disease*, 82 (9): 964-974.
80. Martínez-Figueroa, Concepción & Serra-Rafols, Elías (editors) (1964) *Juan Cerverio de Vera. Viaje de la Tierra Santa*. Instituto de Estudios Canarios, La Laguna de Tenerife.
81. Mira-Caballeros, Esteban (2010) *La Española, epicentro del Caribe en el siglo XVI*. Academia Dominicana de la Historia, Santo Domingo.
82. Morera, Marcial (2006) *Diccionario histórico-etimológico del habla canaria*. Cabildo Insular, Puerto del Rosario (Fuerteventura).
83. Morreale, Margherita (2002) "El Nuevo Mundo en las «notaciones» de Juan de Guzmán a su versión de las Geórgicas (1586)". *Bulletin Hispanique*, 104 (2): 577-626.
84. Nelson, Scot C.; Ploetz, Randy C., & Kepler, Angela K. (2006) "*Musa* species (banana and plantain)", ver. 2.2. In *Species Profiles for Pacific Island Agroforestry. Permanent Agriculture Resources*, edited by Elevitch, C. R., Hōlualoa, Hawai'i. <http://www.traditionaltree.org> [accessed 05/March/2014]
85. Ngou-Mve, Nicolás (1994) *El África bantú en la colonización de México (1595-1640)*. CSIC, Madrid.
86. Nuez-Yáñez, Juan S. (2005) *El mercado mundial de plátanos y las empresas productoras en Canarias, 1800-2000*. Instituto de Estudios Canarios, La Laguna de Tenerife.
87. Orta, García de (1563) *Coloquios dos simples, e drogas he cousas medicinais da Índia*. Ioannes de Endem, Goa.
88. Orta, García de & Clusius, Carolus (1567) *Aromatum, et simplicium aliquot medicamentorum apud Indos nascentium historia*. Christophori Plantini, Antuerpiae.
89. Ortiz, Fernando (1987) *Contrapunteo cubano del tabaco y el azúcar*. Biblioteca Ayacucho, Caracas.
90. Patiño, Víctor Manuel (1969) *Plantas cultivadas y animales domésticos en América equinoccial*. Imp. Departamental, Cali. <http://www.banrepcultural.org/blaavirtual/historia/puti/indice.htm> [accessed 24/ February/ 2014]
91. Paz-Sánchez, Manuel de (2008) *Alfred Diston: historia de un hombre atrapado en un jardín*. Ediciones Idea, Santa Cruz de Tenerife.
92. Pellicer de Tovar, Joseph (1649) *Misión evangélica al Reyno de Congo por la seráfica religión de los capuchinos*. Domingo García y Morrás, Madrid.
93. Pérez-Embid, Florentino (1948) *Los descubrimientos en el Atlántico y la rivalidad castellano-portuguesa hasta el tratado de Tordesillas*. Escuela de Estudios Hispano-Americanos, Sevilla.
94. Pérez-Marrero, Luis M. (2000) *El plátano canario en el contexto internacional. Su historia agro-comercial*. Asprocan, Islas Canarias.

95. Pérez de Tudela Bueso, Juan (1959) "Estudio preliminar". In *Historia general y natural de las Indias* de Gonzalo Fernández de Oviedo, Atlas, Madrid, I, pp. V-CLXIX.
96. Pérez-Vidal, José (1983) "Catalanes y valencianos en la propagación de la industria azucarera". In *América y la España del siglo XVI*, edited by Solano Pérez-Lila, Francisco de P. & Pino-Díaz, Fermín, CSIC, Madrid, II, pp. 305-314.
97. Phillips, Jr., William D. (1985) *Slavery from Roman times to the early transatlantic trade*. Manchester University Press, Manchester.
98. Pichardo, Esteban (1836) *Diccionario provincial de voces cubanas*. Imp. de la Real Marina, Matanzas.
99. Pichardo, Esteban (1849) *Diccionario provincial casi-razonado de voces cubanas*. Imp. de M. Soler, Habana.
100. Pichardo, Esteban (1861) *Diccionario provincial casi-razonado de voces cubanas*. Imp. del Gobierno, Habana.
101. Ploetz, Randy C.; Kepler, Angela K.; Daniells, Jeff & Nelson, Scot C. (2007) "Banana and plantain—an overview with emphasis on Pacific island cultivars", ver. 1. In *Species Profiles for Pacific Island Agroforestry. Permanent Agriculture Resources*, edited by Elevitch, C. R., Hōlualoa, Hawai'i. <http://agroforestry.net/tti/Banana-plantain-overview.pdf> [accessed 05/March/2014]
102. Puig-Samper Mulero, Miguel A. & Rebok, Sandra (2007) *Sentir y medir. Alexander Von Humboldt en España*. Doce Calles, Madrid.
103. Ramírez, Marleni; Ortiz, Rodomiro; Suketoshi, Taba; Sebastián, Leocadio; Peralta, Eduardo; Williams, David E.; Ebert, Andreas W. & Vézina, Anne (2013) "Demonstrating interdependence on plant genetic resources for food and agriculture". In *Crop genetic resources as a Global Commons: challenges in international law and governance*, edited by Halewood, Michael; López Noriega, Isabel & Louafi, Selim, Routledge, Oxon-Abingdon.
104. Retamero, Félix (2009) "La sombra alargada de Wittfogel. Irrigación y poder en Al-Andalus". In *Al-Andalus/ España. Historiografías en contraste. Siglos XVII-XXI*, edited by Marín, Manuela, Casa de Velázquez, Madrid, pp. 263-293.
105. Rivero-Suárez, Benedicta (1990) *El azúcar en Tenerife: 1496-1550*. Instituto de Estudios Canarios, La Laguna de Tenerife.
106. Robinson, John C. & Galán-Saúco, Víctor (2011) *Plátanos y bananas*. Mundi-Prensa, Madrid.
107. Rodríguez, Manuel & Macías, Francisco J. (2012) *Materiales útiles. Datos para la historia de su aprovechamiento en la agricultura [...], de Tenerife durante los siglos XV-XVIII*. RSEAPT, La Laguna de Tenerife.
108. Rodríguez-Moñino, Antonio R. (1934) "Los Triunfos Canarios de Vasco Díaz Tanco", *El Museo Canario*, II, 4: 11-35.
109. Rosa-Olivera, Leopoldo de la (1978) *Estudios históricos sobre las Canarias orientales*. Mancomunidad de Cabildos, Las Palmas.
110. Rubio y Moreno, Luis (c. 1930) *Pasajeros a Indias: catálogos metodológicos de las informaciones y licencias de los que allí pasaron, [...] colonización de América 1492-1592*. Editorial Ibero-Americana, Madrid.
111. Rumeu de Armas, Antonio (1947) *Los viajes de John Hawkins a América (1562-1595)*. Escuela de Estudios Hispano-Americanos, Sevilla.
112. Sánchez-Valerón, Rafael & Martín-Santiago, Felipe E. (2003) *Génesis y desarrollo de Ingenio durante el siglo XVI*. Ayuntamiento de la Villa de Ingenio, Las Palmas.
113. Sandoval, Alonso de (1627) *Naturaleza, policía sagrada i profana, costumbres i ritos, [...] de todos etiopes*. Francisco de Lira, Sevilla.
114. Sandoval, Alonso de (1647) *De Instauranda Aethiopum Salute Historia de Aethiopia*. Alonso Paredes, Madrid.
115. Sarmiento-Pérez, Marcos; Batista-Rodríguez, José J.; Gutiérrez-Alonso, Eduardo (2012) *Estudios e impresiones de Hermann Schacht sobre Canarias y Madeira*. Centro de la Cultura Popular Canaria, La Laguna de Tenerife.
116. Simmonds, Norman W. (1966) *Bananas*. Logmans, Londres.
117. Simón, Pedro (1626) *Primera parte de las Noticias historiales de las conquistas de Tierra Firme en las Indias occidentales*. Domingo de la Iglesia, Cuenca.
118. Sosa, José de (1849) *Topografía de la isla afortunada Gran Canaria*. Imprenta Isleña, Santa Cruz de Tenerife.
119. Sosa, José de (1941) *Topografía de la isla afortunada Gran Canaria*. Imprenta Valentín Sanz, Santa Cruz de Tenerife.
120. Torres-Asensio, Joaquín (editor) (1892) *Fuentes históricas sobre Colón y América. Pedro Mártir Anglería*. Imp. de la S. E. de San Francisco de Sales, Madrid.
121. Trillo-San José, Carmen (2004) *Agua, tierra y hombres en Al-Andalus. La dimensión agrícola del mundo nazarí*. Universidad de Granada, Granada.
122. Vesa-Figueras, Marta (2003) "La comida cubana". In *Conquista y comida: consecuencias del encuentro de dos mundos*, edited by Long, Janet, UNAM, México, pp. 71-87.
123. Viera y Clavijo, José de (1772) *Noticias de la historia general de las Islas de Canaria. Tomo Primero*. Blas Román, Madrid.
124. Viera y Clavijo, José de (1773) *Noticias de la historia general de las Islas de Canaria. Tomo Segundo*. Blas Román, Madrid.

125. Viera y Clavijo, José de (1776) *Noticias de la historia general de las Islas de Canaria. Tomo Tercero*. Blas Román, Madrid.
126. Viera y Clavijo, José de (1869) *Diccionario de historia natural de las islas Canarias*. Real Sociedad Económica de Amigos del País, Las Palmas de Gran Canaria.
127. Viera y Clavijo, José de (1950) *Noticias de la historia general de las Islas Canarias. Tomo I*. Goya Ediciones, Santa Cruz de Tenerife.
128. Viera y Clavijo, José de (1951) *Noticias de la historia general de las Islas Canarias. Tomos II-III*. Goya Ediciones, Santa Cruz de Tenerife.
129. Viña-Brito, Ana (2006a) "La organización social del trabajo en los ingenios azucareros canarios (siglos XV-XVI)". *En la España Medieval*, 29: 359-381.
130. Viña-Brito, Ana (2006b) "Canarias en el comercio atlántico de esclavos". In *Esclavos: documentos para la historia de Canarias, VIII*, edited by Archivo Histórico Provincial, Santa Cruz de Tenerife.
131. Viña-Brito, Ana & Macías, Francisco J. (editors) (2012) *Documentos relativos a Canarias en el Registro General del Sello de Corte (Archivo General de Simancas, 1476-1530)*. Gobierno de Canarias, Santa Cruz de Tenerife.
132. Watson, Andrew M. (1983) *Agricultural Innovation in the Early Islamic World*. Cambridge University Press, Cambridge.
133. Watson, Andrew M. (1998) *Innovaciones en la agricultura en los primeros tiempos del mundo islámico*. Universidad de Granada, Granada.



GLOBAL JOURNALS INC. (US) GUIDELINES HANDBOOK 2014

WWW.GLOBALJOURNALS.ORG

FELLOWS

FELLOW OF ASSOCIATION OF RESEARCH SOCIETY IN SCIENCE (FARSS)

Global Journals Incorporate (USA) is accredited by Open Association of Research Society (OARS), U.S.A and in turn, awards “FARSS” title to individuals. The 'FARSS' title is accorded to a selected professional after the approval of the Editor-in-Chief/Editorial Board Members/Dean.



- The “FARSS” is a dignified title which is accorded to a person’s name viz. Dr. John E. Hall, Ph.D., FARSS or William Walldroff, M.S., FARSS.

FARSS accrediting is an honor. It authenticates your research activities. After recognition as FARSB, you can add 'FARSS' title with your name as you use this recognition as additional suffix to your status. This will definitely enhance and add more value and repute to your name. You may use it on your professional Counseling Materials such as CV, Resume, and Visiting Card etc.

The following benefits can be availed by you only for next three years from the date of certification:



FARSS designated members are entitled to avail a 40% discount while publishing their research papers (of a single author) with Global Journals Incorporation (USA), if the same is accepted by Editorial Board/Peer Reviewers. If you are a main author or co-author in case of multiple authors, you will be entitled to avail discount of 10%.

Once FARSB title is accorded, the Fellow is authorized to organize a symposium/seminar/conference on behalf of Global Journal Incorporation (USA). The Fellow can also participate in conference/seminar/symposium organized by another institution as representative of Global Journal. In both the cases, it is mandatory for him to discuss with us and obtain our consent.



You may join as member of the Editorial Board of Global Journals Incorporation (USA) after successful completion of three years as Fellow and as Peer Reviewer. In addition, it is also desirable that you should organize seminar/symposium/conference at least once.

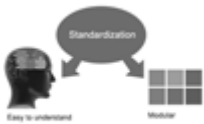
We shall provide you intimation regarding launching of e-version of journal of your stream time to time. This may be utilized in your library for the enrichment of knowledge of your students as well as it can also be helpful for the concerned faculty members.





The FARSS can go through standards of OARS. You can also play vital role if you have any suggestions so that proper amendment can take place to improve the same for the benefit of entire research community.

As FARSS, you will be given a renowned, secure and free professional email address with 100 GB of space e.g. johnhall@globaljournals.org. This will include Webmail, Spam Assassin, Email Forwarders, Auto-Responders, Email Delivery Route tracing, etc.



The FARSS will be eligible for a free application of standardization of their researches. Standardization of research will be subject to acceptability within stipulated norms as the next step after publishing in a journal. We shall depute a team of specialized research professionals who will render their services for elevating your researches to next higher level, which is worldwide open standardization.

The FARSS member can apply for grading and certification of standards of their educational and Institutional Degrees to Open Association of Research, Society U.S.A. Once you are designated as FARSS, you may send us a scanned copy of all of your credentials. OARS will verify, grade and certify them. This will be based on your academic records, quality of research papers published by you, and some more criteria. After certification of all your credentials by OARS, they will be published on your Fellow Profile link on website <https://associationofresearch.org> which will be helpful to upgrade the dignity.



The FARSS members can avail the benefits of free research podcasting in Global Research Radio with their research documents. After publishing the work, (including published elsewhere worldwide with proper authorization) you can upload your research paper with your recorded voice or you can utilize chargeable services of our professional RJs to record your paper in their voice on request.



The FARSS member also entitled to get the benefits of free research podcasting of their research documents through video clips. We can also streamline your conference videos and display your slides/ online slides and online research video clips at reasonable charges, on request.





The FARSS is eligible to earn from sales proceeds of his/her researches/reference/review Books or literature, while publishing with Global Journals. The FARSS can decide whether he/she would like to publish his/her research in a closed manner. In this case, whenever readers purchase that individual research paper for reading, maximum 60% of its profit earned as royalty by Global Journals, will be credited to his/her bank account. The entire entitled amount will be credited to his/her bank account exceeding limit of minimum fixed balance. There is no minimum time limit for collection. The FARSS member can decide its price and we can help in making the right decision.

The FARSS member is eligible to join as a paid peer reviewer at Global Journals Incorporation (USA) and can get remuneration of 15% of author fees, taken from the author of a respective paper. After reviewing 5 or more papers you can request to transfer the amount to your bank account.



MEMBER OF ASSOCIATION OF RESEARCH SOCIETY IN SCIENCE (MARSS)

The ' MARSS ' title is accorded to a selected professional after the approval of the Editor-in-Chief / Editorial Board Members/Dean.

The “MARSS” is a dignified ornament which is accorded to a person’s name viz. Dr. John E. Hall, Ph.D., MARSS or William Walldroff, M.S., MARSS.



MARSS accrediting is an honor. It authenticates your research activities. After becoming MARSS, you can add 'MARSS' title with your name as you use this recognition as additional suffix to your status. This will definitely enhance and add more value and repute to your name. You may use it on your professional Counseling Materials such as CV, Resume, Visiting Card and Name Plate etc.

The following benefits can be availed by you only for next three years from the date of certification.



MARSS designated members are entitled to avail a 25% discount while publishing their research papers (of a single author) in Global Journals Inc., if the same is accepted by our Editorial Board and Peer Reviewers. If you are a main author or co-author of a group of authors, you will get discount of 10%.

As MARSS, you will be given a renowned, secure and free professional email address with 30 GB of space e.g. johnhall@globaljournals.org. This will include Webmail, Spam Assassin, Email Forwarders, Auto-Responders, Email Delivery Route tracing, etc.





We shall provide you intimation regarding launching of e-version of journal of your stream time to time. This may be utilized in your library for the enrichment of knowledge of your students as well as it can also be helpful for the concerned faculty members.

The MARSS member can apply for approval, grading and certification of standards of their educational and Institutional Degrees to Open Association of Research, Society U.S.A.



Once you are designated as MARSS, you may send us a scanned copy of all of your credentials. OARS will verify, grade and certify them. This will be based on your academic records, quality of research papers published by you, and some more criteria.

It is mandatory to read all terms and conditions carefully.



AUXILIARY MEMBERSHIPS

Institutional Fellow of Global Journals Incorporation (USA)-OARS (USA)

Global Journals Incorporation (USA) is accredited by Open Association of Research Society, U.S.A (OARS) and in turn, affiliates research institutions as “Institutional Fellow of Open Association of Research Society” (IFOARS).

The “FARSC” is a dignified title which is accorded to a person’s name viz. Dr. John E. Hall, Ph.D., FARSC or William Walldroff, M.S., FARSC.



The IFOARS institution is entitled to form a Board comprised of one Chairperson and three to five board members preferably from different streams. The Board will be recognized as “Institutional Board of Open Association of Research Society”-(IBOARS).

The Institute will be entitled to following benefits:



The IBOARS can initially review research papers of their institute and recommend them to publish with respective journal of Global Journals. It can also review the papers of other institutions after obtaining our consent. The second review will be done by peer reviewer of Global Journals Incorporation (USA). The Board is at liberty to appoint a peer reviewer with the approval of chairperson after consulting us.

The author fees of such paper may be waived off up to 40%.

The Global Journals Incorporation (USA) at its discretion can also refer double blind peer reviewed paper at their end to the board for the verification and to get recommendation for final stage of acceptance of publication.



The IBOARS can organize symposium/seminar/conference in their country on behalf of Global Journals Incorporation (USA)-OARS (USA). The terms and conditions can be discussed separately.

The Board can also play vital role by exploring and giving valuable suggestions regarding the Standards of “Open Association of Research Society, U.S.A (OARS)” so that proper amendment can take place for the benefit of entire research community. We shall provide details of particular standard only on receipt of request from the Board.



Journals Research
inducing researches

The board members can also join us as Individual Fellow with 40% discount on total fees applicable to Individual Fellow. They will be entitled to avail all the benefits as declared. Please visit Individual Fellow-sub menu of GlobalJournals.org to have more relevant details.



We shall provide you intimation regarding launching of e-version of journal of your stream time to time. This may be utilized in your library for the enrichment of knowledge of your students as well as it can also be helpful for the concerned faculty members.



After nomination of your institution as “Institutional Fellow” and constantly functioning successfully for one year, we can consider giving recognition to your institute to function as Regional/Zonal office on our behalf.

The board can also take up the additional allied activities for betterment after our consultation.

The following entitlements are applicable to individual Fellows:

Open Association of Research Society, U.S.A (OARS) By-laws states that an individual Fellow may use the designations as applicable, or the corresponding initials. The Credentials of individual Fellow and Associate designations signify that the individual has gained knowledge of the fundamental concepts. One is magnanimous and proficient in an expertise course covering the professional code of conduct, and follows recognized standards of practice.



Open Association of Research Society (US)/ Global Journals Incorporation (USA), as described in Corporate Statements, are educational, research publishing and professional membership organizations. Achieving our individual Fellow or Associate status is based mainly on meeting stated educational research requirements.

Disbursement of 40% Royalty earned through Global Journals : Researcher = 50%, Peer Reviewer = 37.50%, Institution = 12.50% E.g. Out of 40%, the 20% benefit should be passed on to researcher, 15 % benefit towards remuneration should be given to a reviewer and remaining 5% is to be retained by the institution.



We shall provide print version of 12 issues of any three journals [as per your requirement] out of our 38 journals worth \$ 2376 USD.

Other:

The individual Fellow and Associate designations accredited by Open Association of Research Society (US) credentials signify guarantees following achievements:

- The professional accredited with Fellow honor, is entitled to various benefits viz. name, fame, honor, regular flow of income, secured bright future, social status etc.



- In addition to above, if one is single author, then entitled to 40% discount on publishing research paper and can get 10% discount if one is co-author or main author among group of authors.
- The Fellow can organize symposium/seminar/conference on behalf of Global Journals Incorporation (USA) and he/she can also attend the same organized by other institutes on behalf of Global Journals.
- The Fellow can become member of Editorial Board Member after completing 3yrs.
- The Fellow can earn 60% of sales proceeds from the sale of reference/review books/literature/publishing of research paper.
- Fellow can also join as paid peer reviewer and earn 15% remuneration of author charges and can also get an opportunity to join as member of the Editorial Board of Global Journals Incorporation (USA)
- • This individual has learned the basic methods of applying those concepts and techniques to common challenging situations. This individual has further demonstrated an in-depth understanding of the application of suitable techniques to a particular area of research practice.

Note :

//

- In future, if the board feels the necessity to change any board member, the same can be done with the consent of the chairperson along with anyone board member without our approval.
- In case, the chairperson needs to be replaced then consent of 2/3rd board members are required and they are also required to jointly pass the resolution copy of which should be sent to us. In such case, it will be compulsory to obtain our approval before replacement.
- In case of “Difference of Opinion [if any]” among the Board members, our decision will be final and binding to everyone.

//



PROCESS OF SUBMISSION OF RESEARCH PAPER

The Area or field of specialization may or may not be of any category as mentioned in 'Scope of Journal' menu of the GlobalJournals.org website. There are 37 Research Journal categorized with Six parental Journals GJCST, GJMR, GJRE, GJMBR, GJSFR, GJHSS. For Authors should prefer the mentioned categories. There are three widely used systems UDC, DDC and LCC. The details are available as 'Knowledge Abstract' at Home page. The major advantage of this coding is that, the research work will be exposed to and shared with all over the world as we are being abstracted and indexed worldwide.

The paper should be in proper format. The format can be downloaded from first page of 'Author Guideline' Menu. The Author is expected to follow the general rules as mentioned in this menu. The paper should be written in MS-Word Format (*.DOC,*.DOCX).

The Author can submit the paper either online or offline. The authors should prefer online submission.Online Submission: There are three ways to submit your paper:

(A) (I) First, register yourself using top right corner of Home page then Login. If you are already registered, then login using your username and password.

(II) Choose corresponding Journal.

(III) Click 'Submit Manuscript'. Fill required information and Upload the paper.

(B) If you are using Internet Explorer, then Direct Submission through Homepage is also available.

(C) If these two are not convenient, and then email the paper directly to dean@globaljournals.org.

Offline Submission: Author can send the typed form of paper by Post. However, online submission should be preferred.



PREFERRED AUTHOR GUIDELINES

MANUSCRIPT STYLE INSTRUCTION (Must be strictly followed)

Page Size: 8.27" X 11"

- Left Margin: 0.65
- Right Margin: 0.65
- Top Margin: 0.75
- Bottom Margin: 0.75
- Font type of all text should be Swis 721 Lt BT.
- Paper Title should be of Font Size 24 with one Column section.
- Author Name in Font Size of 11 with one column as of Title.
- Abstract Font size of 9 Bold, "Abstract" word in Italic Bold.
- Main Text: Font size 10 with justified two columns section
- Two Column with Equal Column with of 3.38 and Gaping of .2
- First Character must be three lines Drop capped.
- Paragraph before Spacing of 1 pt and After of 0 pt.
- Line Spacing of 1 pt
- Large Images must be in One Column
- Numbering of First Main Headings (Heading 1) must be in Roman Letters, Capital Letter, and Font Size of 10.
- Numbering of Second Main Headings (Heading 2) must be in Alphabets, Italic, and Font Size of 10.

You can use your own standard format also.

Author Guidelines:

1. General,
2. Ethical Guidelines,
3. Submission of Manuscripts,
4. Manuscript's Category,
5. Structure and Format of Manuscript,
6. After Acceptance.

1. GENERAL

Before submitting your research paper, one is advised to go through the details as mentioned in following heads. It will be beneficial, while peer reviewer justify your paper for publication.

Scope

The Global Journals Inc. (US) welcome the submission of original paper, review paper, survey article relevant to the all the streams of Philosophy and knowledge. The Global Journals Inc. (US) is parental platform for Global Journal of Computer Science and Technology, Researches in Engineering, Medical Research, Science Frontier Research, Human Social Science, Management, and Business organization. The choice of specific field can be done otherwise as following in Abstracting and Indexing Page on this Website. As the all Global

Journals Inc. (US) are being abstracted and indexed (in process) by most of the reputed organizations. Topics of only narrow interest will not be accepted unless they have wider potential or consequences.

2. ETHICAL GUIDELINES

Authors should follow the ethical guidelines as mentioned below for publication of research paper and research activities.

Papers are accepted on strict understanding that the material in whole or in part has not been, nor is being, considered for publication elsewhere. If the paper once accepted by Global Journals Inc. (US) and Editorial Board, will become the copyright of the Global Journals Inc. (US).

Authorship: The authors and coauthors should have active contribution to conception design, analysis and interpretation of findings. They should critically review the contents and drafting of the paper. All should approve the final version of the paper before submission

The Global Journals Inc. (US) follows the definition of authorship set up by the Global Academy of Research and Development. According to the Global Academy of R&D authorship, criteria must be based on:

- 1) Substantial contributions to conception and acquisition of data, analysis and interpretation of the findings.
- 2) Drafting the paper and revising it critically regarding important academic content.
- 3) Final approval of the version of the paper to be published.

All authors should have been credited according to their appropriate contribution in research activity and preparing paper. Contributors who do not match the criteria as authors may be mentioned under Acknowledgement.

Acknowledgements: Contributors to the research other than authors credited should be mentioned under acknowledgement. The specifications of the source of funding for the research if appropriate can be included. Suppliers of resources may be mentioned along with address.

Appeal of Decision: The Editorial Board's decision on publication of the paper is final and cannot be appealed elsewhere.

Permissions: It is the author's responsibility to have prior permission if all or parts of earlier published illustrations are used in this paper.

Please mention proper reference and appropriate acknowledgements wherever expected.

If all or parts of previously published illustrations are used, permission must be taken from the copyright holder concerned. It is the author's responsibility to take these in writing.

Approval for reproduction/modification of any information (including figures and tables) published elsewhere must be obtained by the authors/copyright holders before submission of the manuscript. Contributors (Authors) are responsible for any copyright fee involved.

3. SUBMISSION OF MANUSCRIPTS

Manuscripts should be uploaded via this online submission page. The online submission is most efficient method for submission of papers, as it enables rapid distribution of manuscripts and consequently speeds up the review procedure. It also enables authors to know the status of their own manuscripts by emailing us. Complete instructions for submitting a paper is available below.

Manuscript submission is a systematic procedure and little preparation is required beyond having all parts of your manuscript in a given format and a computer with an Internet connection and a Web browser. Full help and instructions are provided on-screen. As an author, you will be prompted for login and manuscript details as Field of Paper and then to upload your manuscript file(s) according to the instructions.



To avoid postal delays, all transaction is preferred by e-mail. A finished manuscript submission is confirmed by e-mail immediately and your paper enters the editorial process with no postal delays. When a conclusion is made about the publication of your paper by our Editorial Board, revisions can be submitted online with the same procedure, with an occasion to view and respond to all comments.

Complete support for both authors and co-author is provided.

4. MANUSCRIPT'S CATEGORY

Based on potential and nature, the manuscript can be categorized under the following heads:

Original research paper: Such papers are reports of high-level significant original research work.

Review papers: These are concise, significant but helpful and decisive topics for young researchers.

Research articles: These are handled with small investigation and applications

Research letters: The letters are small and concise comments on previously published matters.

5. STRUCTURE AND FORMAT OF MANUSCRIPT

The recommended size of original research paper is less than seven thousand words, review papers fewer than seven thousands words also. Preparation of research paper or how to write research paper, are major hurdle, while writing manuscript. The research articles and research letters should be fewer than three thousand words, the structure original research paper; sometime review paper should be as follows:

Papers: These are reports of significant research (typically less than 7000 words equivalent, including tables, figures, references), and comprise:

- (a) Title should be relevant and commensurate with the theme of the paper.
- (b) A brief Summary, "Abstract" (less than 150 words) containing the major results and conclusions.
- (c) Up to ten keywords, that precisely identifies the paper's subject, purpose, and focus.
- (d) An Introduction, giving necessary background excluding subheadings; objectives must be clearly declared.
- (e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition; sources of information must be given and numerical methods must be specified by reference, unless non-standard.
- (f) Results should be presented concisely, by well-designed tables and/or figures; the same data may not be used in both; suitable statistical data should be given. All data must be obtained with attention to numerical detail in the planning stage. As reproduced design has been recognized to be important to experiments for a considerable time, the Editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned un-refereed;
- (g) Discussion should cover the implications and consequences, not just recapitulating the results; conclusions should be summarizing.
- (h) Brief Acknowledgements.
- (i) References in the proper form.

Authors should very cautiously consider the preparation of papers to ensure that they communicate efficiently. Papers are much more likely to be accepted, if they are cautiously designed and laid out, contain few or no errors, are summarizing, and be conventional to the approach and instructions. They will in addition, be published with much less delays than those that require much technical and editorial correction.



The Editorial Board reserves the right to make literary corrections and to make suggestions to improve briefness.

It is vital, that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

Format

Language: The language of publication is UK English. Authors, for whom English is a second language, must have their manuscript efficiently edited by an English-speaking person before submission to make sure that, the English is of high excellence. It is preferable, that manuscripts should be professionally edited.

Standard Usage, Abbreviations, and Units: Spelling and hyphenation should be conventional to The Concise Oxford English Dictionary. Statistics and measurements should at all times be given in figures, e.g. 16 min, except for when the number begins a sentence. When the number does not refer to a unit of measurement it should be spelt in full unless, it is 160 or greater.

Abbreviations supposed to be used carefully. The abbreviated name or expression is supposed to be cited in full at first usage, followed by the conventional abbreviation in parentheses.

Metric SI units are supposed to generally be used excluding where they conflict with current practice or are confusing. For illustration, 1.4 l rather than $1.4 \times 10^{-3} \text{ m}^3$, or 4 mm somewhat than $4 \times 10^{-3} \text{ m}$. Chemical formula and solutions must identify the form used, e.g. anhydrous or hydrated, and the concentration must be in clearly defined units. Common species names should be followed by underlines at the first mention. For following use the generic name should be constricted to a single letter, if it is clear.

Structure

All manuscripts submitted to Global Journals Inc. (US), ought to include:

Title: The title page must carry an instructive title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) wherever the work was carried out. The full postal address in addition with the e-mail address of related author must be given. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining and indexing.

Abstract, used in Original Papers and Reviews:

Optimizing Abstract for Search Engines

Many researchers searching for information online will use search engines such as Google, Yahoo or similar. By optimizing your paper for search engines, you will amplify the chance of someone finding it. This in turn will make it more likely to be viewed and/or cited in a further work. Global Journals Inc. (US) have compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Key Words

A major linchpin in research work for the writing research paper is the keyword search, which one will employ to find both library and Internet resources.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy and planning a list of possible keywords and phrases to try.

Search engines for most searches, use Boolean searching, which is somewhat different from Internet searches. The Boolean search uses "operators," words (and, or, not, and near) that enable you to expand or narrow your affords. Tips for research paper while preparing research paper are very helpful guideline of research paper.

Choice of key words is first tool of tips to write research paper. Research paper writing is an art. A few tips for deciding as strategically as possible about keyword search:



- One should start brainstorming lists of possible keywords before even begin searching. Think about the most important concepts related to research work. Ask, "What words would a source have to include to be truly valuable in research paper?" Then consider synonyms for the important words.
- It may take the discovery of only one relevant paper to let steer in the right keyword direction because in most databases, the keywords under which a research paper is abstracted are listed with the paper.
- One should avoid outdated words.

Keywords are the key that opens a door to research work sources. Keyword searching is an art in which researcher's skills are bound to improve with experience and time.

Numerical Methods: Numerical methods used should be clear and, where appropriate, supported by references.

Acknowledgements: Please make these as concise as possible.

References

References follow the Harvard scheme of referencing. References in the text should cite the authors' names followed by the time of their publication, unless there are three or more authors when simply the first author's name is quoted followed by et al. unpublished work has to only be cited where necessary, and only in the text. Copies of references in press in other journals have to be supplied with submitted typescripts. It is necessary that all citations and references be carefully checked before submission, as mistakes or omissions will cause delays.

References to information on the World Wide Web can be given, but only if the information is available without charge to readers on an official site. Wikipedia and Similar websites are not allowed where anyone can change the information. Authors will be asked to make available electronic copies of the cited information for inclusion on the Global Journals Inc. (US) homepage at the judgment of the Editorial Board.

The Editorial Board and Global Journals Inc. (US) recommend that, citation of online-published papers and other material should be done via a DOI (digital object identifier). If an author cites anything, which does not have a DOI, they run the risk of the cited material not being noticeable.

The Editorial Board and Global Journals Inc. (US) recommend the use of a tool such as Reference Manager for reference management and formatting.

Tables, Figures and Figure Legends

Tables: Tables should be few in number, cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g. Table 4, a self-explanatory caption and be on a separate sheet. Vertical lines should not be used.

Figures: Figures are supposed to be submitted as separate files. Always take in a citation in the text for each figure using Arabic numbers, e.g. Fig. 4. Artwork must be submitted online in electronic form by e-mailing them.

Preparation of Electronic Figures for Publication

Even though low quality images are sufficient for review purposes, print publication requires high quality images to prevent the final product being blurred or fuzzy. Submit (or e-mail) EPS (line art) or TIFF (halftone/photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Do not use pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings) in relation to the imitation size. Please give the data for figures in black and white or submit a Color Work Agreement Form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution (at final image size) ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs) : >350 dpi; figures containing both halftone and line images: >650 dpi.



Color Charges: It is the rule of the Global Journals Inc. (US) for authors to pay the full cost for the reproduction of their color artwork. Hence, please note that, if there is color artwork in your manuscript when it is accepted for publication, we would require you to complete and return a color work agreement form before your paper can be published.

Figure Legends: Self-explanatory legends of all figures should be incorporated separately under the heading 'Legends to Figures'. In the full-text online edition of the journal, figure legends may possibly be truncated in abbreviated links to the full screen version. Therefore, the first 100 characters of any legend should notify the reader, about the key aspects of the figure.

6. AFTER ACCEPTANCE

Upon approval of a paper for publication, the manuscript will be forwarded to the dean, who is responsible for the publication of the Global Journals Inc. (US).

6.1 Proof Corrections

The corresponding author will receive an e-mail alert containing a link to a website or will be attached. A working e-mail address must therefore be provided for the related author.

Acrobat Reader will be required in order to read this file. This software can be downloaded

(Free of charge) from the following website:

www.adobe.com/products/acrobat/readstep2.html. This will facilitate the file to be opened, read on screen, and printed out in order for any corrections to be added. Further instructions will be sent with the proof.

Proofs must be returned to the dean at dean@globaljournals.org within three days of receipt.

As changes to proofs are costly, we inquire that you only correct typesetting errors. All illustrations are retained by the publisher. Please note that the authors are responsible for all statements made in their work, including changes made by the copy editor.

6.2 Early View of Global Journals Inc. (US) (Publication Prior to Print)

The Global Journals Inc. (US) are enclosed by our publishing's Early View service. Early View articles are complete full-text articles sent in advance of their publication. Early View articles are absolute and final. They have been completely reviewed, revised and edited for publication, and the authors' final corrections have been incorporated. Because they are in final form, no changes can be made after sending them. The nature of Early View articles means that they do not yet have volume, issue or page numbers, so Early View articles cannot be cited in the conventional way.

6.3 Author Services

Online production tracking is available for your article through Author Services. Author Services enables authors to track their article - once it has been accepted - through the production process to publication online and in print. Authors can check the status of their articles online and choose to receive automated e-mails at key stages of production. The authors will receive an e-mail with a unique link that enables them to register and have their article automatically added to the system. Please ensure that a complete e-mail address is provided when submitting the manuscript.

6.4 Author Material Archive Policy

Please note that if not specifically requested, publisher will dispose off hardcopy & electronic information submitted, after the two months of publication. If you require the return of any information submitted, please inform the Editorial Board or dean as soon as possible.

6.5 Offprint and Extra Copies

A PDF offprint of the online-published article will be provided free of charge to the related author, and may be distributed according to the Publisher's terms and conditions. Additional paper offprint may be ordered by emailing us at: editor@globaljournals.org.



Before start writing a good quality Computer Science Research Paper, let us first understand what is Computer Science Research Paper? So, Computer Science Research Paper is the paper which is written by professionals or scientists who are associated to Computer Science and Information Technology, or doing research study in these areas. If you are novel to this field then you can consult about this field from your supervisor or guide.

TECHNIQUES FOR WRITING A GOOD QUALITY RESEARCH PAPER:

1. Choosing the topic: In most cases, the topic is searched by the interest of author but it can be also suggested by the guides. You can have several topics and then you can judge that in which topic or subject you are finding yourself most comfortable. This can be done by asking several questions to yourself, like Will I be able to carry our search in this area? Will I find all necessary recourses to accomplish the search? Will I be able to find all information in this field area? If the answer of these types of questions will be "Yes" then you can choose that topic. In most of the cases, you may have to conduct the surveys and have to visit several places because this field is related to Computer Science and Information Technology. Also, you may have to do a lot of work to find all rise and falls regarding the various data of that subject. Sometimes, detailed information plays a vital role, instead of short information.

2. Evaluators are human: First thing to remember that evaluators are also human being. They are not only meant for rejecting a paper. They are here to evaluate your paper. So, present your Best.

3. Think Like Evaluators: If you are in a confusion or getting demotivated that your paper will be accepted by evaluators or not, then think and try to evaluate your paper like an Evaluator. Try to understand that what an evaluator wants in your research paper and automatically you will have your answer.

4. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

5. Ask your Guides: If you are having any difficulty in your research, then do not hesitate to share your difficulty to your guide (if you have any). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work then ask the supervisor to help you with the alternative. He might also provide you the list of essential readings.

6. Use of computer is recommended: As you are doing research in the field of Computer Science, then this point is quite obvious.

7. Use right software: Always use good quality software packages. If you are not capable to judge good software then you can lose quality of your paper unknowingly. There are various software programs available to help you, which you can get through Internet.

8. Use the Internet for help: An excellent start for your paper can be by using the Google. It is an excellent search engine, where you can have your doubts resolved. You may also read some answers for the frequent question how to write my research paper or find model research paper. From the internet library you can download books. If you have all required books make important reading selecting and analyzing the specified information. Then put together research paper sketch out.

9. Use and get big pictures: Always use encyclopedias, Wikipedia to get pictures so that you can go into the depth.

10. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right! It is a good habit, which helps to not to lose your continuity. You should always use bookmarks while searching on Internet also, which will make your search easier.

11. Revise what you wrote: When you write anything, always read it, summarize it and then finalize it.



12. Make all efforts: Make all efforts to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in introduction, that what is the need of a particular research paper. Polish your work by good skill of writing and always give an evaluator, what he wants.

13. Have backups: When you are going to do any important thing like making research paper, you should always have backup copies of it either in your computer or in paper. This will help you to not to lose any of your important.

14. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several and unnecessary diagrams will degrade the quality of your paper by creating "hotchpotch." So always, try to make and include those diagrams, which are made by your own to improve readability and understandability of your paper.

15. Use of direct quotes: When you do research relevant to literature, history or current affairs then use of quotes become essential but if study is relevant to science then use of quotes is not preferable.

16. Use proper verb tense: Use proper verb tenses in your paper. Use past tense, to present those events that happened. Use present tense to indicate events that are going on. Use future tense to indicate future happening events. Use of improper and wrong tenses will confuse the evaluator. Avoid the sentences that are incomplete.

17. Never use online paper: If you are getting any paper on Internet, then never use it as your research paper because it might be possible that evaluator has already seen it or maybe it is outdated version.

18. Pick a good study spot: To do your research studies always try to pick a spot, which is quiet. Every spot is not for studies. Spot that suits you choose it and proceed further.

19. Know what you know: Always try to know, what you know by making objectives. Else, you will be confused and cannot achieve your target.

20. Use good quality grammar: Always use a good quality grammar and use words that will throw positive impact on evaluator. Use of good quality grammar does not mean to use tough words, that for each word the evaluator has to go through dictionary. Do not start sentence with a conjunction. Do not fragment sentences. Eliminate one-word sentences. Ignore passive voice. Do not ever use a big word when a diminutive one would suffice. Verbs have to be in agreement with their subjects. Prepositions are not expressions to finish sentences with. It is incorrect to ever divide an infinitive. Avoid clichés like the disease. Also, always shun irritating alliteration. Use language that is simple and straight forward. put together a neat summary.

21. Arrangement of information: Each section of the main body should start with an opening sentence and there should be a changeover at the end of the section. Give only valid and powerful arguments to your topic. You may also maintain your arguments with records.

22. Never start in last minute: Always start at right time and give enough time to research work. Leaving everything to the last minute will degrade your paper and spoil your work.

23. Multitasking in research is not good: Doing several things at the same time proves bad habit in case of research activity. Research is an area, where everything has a particular time slot. Divide your research work in parts and do particular part in particular time slot.

24. Never copy others' work: Never copy others' work and give it your name because if evaluator has seen it anywhere you will be in trouble.

25. Take proper rest and food: No matter how many hours you spend for your research activity, if you are not taking care of your health then all your efforts will be in vain. For a quality research, study is must, and this can be done by taking proper rest and food.

26. Go for seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.



27. Refresh your mind after intervals: Try to give rest to your mind by listening to soft music or by sleeping in intervals. This will also improve your memory.

28. Make colleagues: Always try to make colleagues. No matter how sharper or intelligent you are, if you make colleagues you can have several ideas, which will be helpful for your research.

29. Think technically: Always think technically. If anything happens, then search its reasons, its benefits, and demerits.

30. Think and then print: When you will go to print your paper, notice that tables are not be split, headings are not detached from their descriptions, and page sequence is maintained.

31. Adding unnecessary information: Do not add unnecessary information, like, I have used MS Excel to draw graph. Do not add irrelevant and inappropriate material. These all will create superfluous. Foreign terminology and phrases are not apropos. One should NEVER take a broad view. Analogy in script is like feathers on a snake. Not at all use a large word when a very small one would be sufficient. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Amplification is a billion times of inferior quality than sarcasm.

32. Never oversimplify everything: To add material in your research paper, never go for oversimplification. This will definitely irritate the evaluator. Be more or less specific. Also too, by no means, ever use rhythmic redundancies. Contractions aren't essential and shouldn't be there used. Comparisons are as terrible as clichés. Give up ampersands and abbreviations, and so on. Remove commas, that are, not necessary. Parenthetical words however should be together with this in commas. Understatement is all the time the complete best way to put onward earth-shaking thoughts. Give a detailed literary review.

33. Report concluded results: Use concluded results. From raw data, filter the results and then conclude your studies based on measurements and observations taken. Significant figures and appropriate number of decimal places should be used. Parenthetical remarks are prohibitive. Proofread carefully at final stage. In the end give outline to your arguments. Spot out perspectives of further study of this subject. Justify your conclusion by at the bottom of them with sufficient justifications and examples.

34. After conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium through which your research is going to be in print to the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects in your research.

INFORMAL GUIDELINES OF RESEARCH PAPER WRITING

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form, which is presented in the guidelines using the template.
- Please note the criterion for grading the final paper by peer-reviewers.

Final Points:

A purpose of organizing a research paper is to let people to interpret your effort selectively. The journal requires the following sections, submitted in the order listed, each section to start on a new page.

The introduction will be compiled from reference matter and will reflect the design processes or outline of basis that direct you to make study. As you will carry out the process of study, the method and process section will be constructed as like that. The result segment will show related statistics in nearly sequential order and will direct the reviewers next to the similar intellectual paths throughout the data that you took to carry out your study. The discussion section will provide understanding of the data and projections as to the implication of the results. The use of good quality references all through the paper will give the effort trustworthiness by representing an alertness of prior workings.



Writing a research paper is not an easy job no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record keeping are the only means to make straightforward the progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear

- Adhere to recommended page limits

Mistakes to evade

- Insertion a title at the foot of a page with the subsequent text on the next page
- Separating a table/chart or figure - impound each figure/table to a single page
- Submitting a manuscript with pages out of sequence

In every sections of your document

- Use standard writing style including articles ("a", "the," etc.)
- Keep on paying attention on the research topic of the paper
- Use paragraphs to split each significant point (excluding for the abstract)
- Align the primary line of each section
- Present your points in sound order
- Use present tense to report well accepted
- Use past tense to describe specific results
- Shun familiar wording, don't address the reviewer directly, and don't use slang, slang language, or superlatives
- Shun use of extra pictures - include only those figures essential to presenting results

Title Page:

Choose a revealing title. It should be short. It should not have non-standard acronyms or abbreviations. It should not exceed two printed lines. It should include the name(s) and address (es) of all authors.



Abstract:

The summary should be two hundred words or less. It should briefly and clearly explain the key findings reported in the manuscript-- must have precise statistics. It should not have abnormal acronyms or abbreviations. It should be logical in itself. Shun citing references at this point.

An abstract is a brief distinct paragraph summary of finished work or work in development. In a minute or less a reviewer can be taught the foundation behind the study, common approach to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Yet, use comprehensive sentences and do not let go readability for briefness. You can maintain it succinct by phrasing sentences so that they provide more than lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study, with the subsequent elements in any summary. Try to maintain the initial two items to no more than one ruling each.

- Reason of the study - theory, overall issue, purpose
- Fundamental goal
- To the point depiction of the research
- Consequences, including definite statistics - if the consequences are quantitative in nature, account quantitative data; results of any numerical analysis should be reported
- Significant conclusions or questions that track from the research(es)

Approach:

- Single section, and succinct
- As a outline of job done, it is always written in past tense
- A conceptual should situate on its own, and not submit to any other part of the paper such as a form or table
- Center on shortening results - bound background information to a verdict or two, if completely necessary
- What you account in an conceptual must be regular with what you reported in the manuscript
- Exact spelling, clearness of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else

Introduction:

The **Introduction** should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable to comprehend and calculate the purpose of your study without having to submit to other works. The basis for the study should be offered. Give most important references but shun difficult to make a comprehensive appraisal of the topic. In the introduction, describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will have no attention in your result. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here. Following approach can create a valuable beginning:

- Explain the value (significance) of the study
- Shield the model - why did you employ this particular system or method? What is its compensation? You strength remark on its appropriateness from a abstract point of vision as well as point out sensible reasons for using it.
- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
- Very for a short time explain the tentative propose and how it skilled the declared objectives.

Approach:

- Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done.
- Sort out your thoughts; manufacture one key point with every section. If you make the four points listed above, you will need a least of four paragraphs.



- Present surroundings information only as desirable in order hold up a situation. The reviewer does not desire to read the whole thing you know about a topic.
- Shape the theory/purpose specifically - do not take a broad view.
- As always, give awareness to spelling, simplicity and correctness of sentences and phrases.

Procedures (Methods and Materials):

This part is supposed to be the easiest to carve if you have good skills. A sound written Procedures segment allows a capable scientist to replacement your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt for the least amount of information that would permit another capable scientist to spare your outcome but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section. When a technique is used that has been well described in another object, mention the specific item describing a way but draw the basic principle while stating the situation. The purpose is to text all particular resources and broad procedures, so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step by step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

- Explain materials individually only if the study is so complex that it saves liberty this way.
- Embrace particular materials, and any tools or provisions that are not frequently found in laboratories.
- Do not take in frequently found.
- If use of a definite type of tools.
- Materials may be reported in a part section or else they may be recognized along with your measures.

Methods:

- Report the method (not particulars of each process that engaged the same methodology)
- Describe the method entirely
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures
- Simplify - details how procedures were completed not how they were exclusively performed on a particular day.
- If well known procedures were used, account the procedure by name, possibly with reference, and that's all.

Approach:

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in every other part of the paper - avoid familiar lists, and use full sentences.

What to keep away from

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings - save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part a entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently. You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.



Content

- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or in manuscript form.

What to stay away from

- Do not discuss or infer your outcome, report surroundings information, or try to explain anything.
- Not at all, take in raw data or intermediate calculations in a research manuscript.
- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

Approach

- As forever, use past tense when you submit to your results, and put the whole thing in a reasonable order.
- Put figures and tables, appropriately numbered, in order at the end of the report
- If you desire, you may place your figures and tables properly within the text of your results part.

Figures and tables

- If you put figures and tables at the end of the details, make certain that they are visibly distinguished from any attach appendix materials, such as raw facts
- Despite of position, each figure must be numbered one after the other and complete with subtitle
- In spite of position, each table must be titled, numbered one after the other and complete with heading
- All figure and table must be adequately complete that it could situate on its own, divide from text

Discussion:

The Discussion is expected the trickiest segment to write and describe. A lot of papers submitted for journal are discarded based on problems with the Discussion. There is no head of state for how long a argument should be. Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implication of the study. The purpose here is to offer an understanding of your results and hold up for all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of result should be visibly described. Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved with prospect, and let it drop at that.

- Make a decision if each premise is supported, discarded, or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."
- Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work
- You may propose future guidelines, such as how the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One research will not counter an overall question, so maintain the large picture in mind, where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

- When you refer to information, differentiate data generated by your own studies from available information
- Submit to work done by specific persons (including you) in past tense.
- Submit to generally acknowledged facts and main beliefs in present tense.



ADMINISTRATION RULES LISTED BEFORE SUBMITTING YOUR RESEARCH PAPER TO GLOBAL JOURNALS INC. (US)

Please carefully note down following rules and regulation before submitting your Research Paper to Global Journals Inc. (US):

Segment Draft and Final Research Paper: You have to strictly follow the template of research paper. If it is not done your paper may get rejected.

- The **major constraint** is that you must independently make all content, tables, graphs, and facts that are offered in the paper. You must write each part of the paper wholly on your own. The Peer-reviewers need to identify your own perceptive of the concepts in your own terms. NEVER extract straight from any foundation, and never rephrase someone else's analysis.
- Do not give permission to anyone else to "PROOFREAD" your manuscript.
- **Methods to avoid Plagiarism is applied by us on every paper, if found guilty, you will be blacklisted by all of our collaborated research groups, your institution will be informed for this and strict legal actions will be taken immediately.)**
- To guard yourself and others from possible illegal use please do not permit anyone right to use to your paper and files.



CRITERION FOR GRADING A RESEARCH PAPER (COMPILATION)
BY GLOBAL JOURNALS INC. (US)

Please note that following table is only a Grading of "Paper Compilation" and not on "Performed/Stated Research" whose grading solely depends on Individual Assigned Peer Reviewer and Editorial Board Member. These can be available only on request and after decision of Paper. This report will be the property of Global Journals Inc. (US).

Topics	Grades		
	A-B	C-D	E-F
<i>Abstract</i>	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
<i>Introduction</i>	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
<i>Methods and Procedures</i>	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
<i>Result</i>	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
<i>Discussion</i>	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
<i>References</i>	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring



INDEX

A

Annonaceae · 34, 50
Anthelminthic · 34, 36, 41, 47, 48, 49, 50
Argentieri · 41, 48

B

Benzoquinones · 25

C

Chlorophacinone · 57, 58
Cymbopogon · 14, 17

D

Detrending · 18

E

Embryonation · 34, 40
Ethnomedicine · 25
Eynon · 4

G

Glucoamylase · 4

H

Heligmosomoides · 34, 36, 38, 43, 44, 45, 46, 47, 49, 50, 51
Hom- Ogeneity · 17

L

Larvicidal · 34

M

Monostearate · 1, 2, 3, 12
Monoterpenoid · 31

P

Perishability · 1
Pharmacopea · 36
Phenolics · 26, 29
Phytochemicals · 26, 32

Q

Quiterpenoids · 25

R

Reconstitutability · 7, 12
Retrogradation · 7
Rodenticides · 57
Rosenonolactone · 25

S

Saponins · 25, 26, 28, 41, 48
Senegalensis · 34
Sesquiterpenes · 25
Spectrascan · 4
Spectrophotometry · 28

T

Torrescasana · 62, 66

X

Xanthoproteins · 28



save our planet



Global Journal of Science Frontier Research

Visit us on the Web at www.GlobalJournals.org | www.JournalofScience.org
or email us at helpdesk@globaljournals.org

ISSN 9755896



© Global Journals