ANNUAL RESEARCH REPORT 2014

VOLUME XX

CAMS RESEARCH 2014

FACTS & FIGURES

- **3,139,283.204 RO Total Budget**
- **62 Research Projects in Total**
  - **29 Internal Grant Projects (10 awarded in 2014)**
  - **5 Strategic Projects (1 awarded in 2014)**
  - **28 Other Externally-Funded Projects (9 awarded in 2014)**
- **376 Publications**
  - **109 Refereed Journals**
  - **6 Books (5 edited)**
  - **57 Book Chapters**
  - **165 Conference Presentations**
  - **14 Technical Reports**
  - **25 Others**

Annual Research Report
2014

Volume XX

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Foreword

In these increasingly difficult times, the main mission of the College of Agricultural and Marine Sciences to "*develop human resources to meet challenges in producing food while conserving the natural environment and its biodiversity, processing food, add value to agricultural products and trading food to ensure food security in Oman*" remains of great actuality. To support this ambitious mission, CAMS research aims "*to utilize terrestrial and marine resources in a sustainable and profitable manner that results in positive impacts for Omani society and the international academic community*". The following pages summarize the successes of our faculty, members of staff and students towards this strategic objective during 2014.

The total new research funds attracted by CAMS researchers in 2014 amounted to nearly 1 million OR (RO 912,761) of which 82% are contributions external to SQU. This diversification illustrates the research culture of the College as well as the desire of its research staff to seek external funding.

The year 2014 saw the completion of several important projects, the use of biomaterials to create value added functional food products on the screening and identification of bioactive compounds from Oman marine organisms and for instance on the development of computer vision to assess date quality. These few projects are only examples of the wide scope of the research carried out at CAMS and of the multidisciplinary basis of agricultural and marine research. The number of new research projects (20 in 2014) carries our vision to become a leader in agricultural and marine research and education in the region. In 2014 CAMS published a total of 109 refereed papers (so far its highest output), more than 63 books and book chapters and CAMS faculty and staff presented 165 conferences papers across the world. The total number of scientific publications in the College was 376 including by postgraduate students.

The research summaries and various lists of publications that compose this report illustrates well the scope of the research activities conducted at CAMS but do not always reflects the wide variety of people that support this research activity: scientific collaborators and research assistants, in and outside of Oman, administrators, students and graduate students, sometimes volunteers, industrial partners. We are, as always, grateful to these indispensible partners inside and outside SQU.

Michel R. Claereboudt
Assistant Dean for Postgraduate
Studies and Research

Research Committee (2014)

Dr. Michel Claereboudt, *Chair*

Prof. Isam Kadim

Dr. Rashid Al-Yahyai

Dr. Mostafa Waly

Dr. Sergey Piontkovski

Dr. Slim Zekri

Dr. Manickavasagan Annamalai

The Year in Review

Introduction

The College of Agricultural and Marine Sciences keeps increasing its input (research funds) and its output (research publications). More than 80% of its research funds came from external sources and nearly 1 million Omani Rials were earned by CAMS researchers of which 750,000 came from various external sources. The total number of peer-reviewed papers was109 with a total of 376 recorded publications. More than165 publications were presented to national and more importantly international conferences. As always, we have emphasized a few of the many research projects that were completed in 2014 to illustrate the breadth of the research carried-out in our College.

As an acknowledgment to the important role our graduate students in the research effort of the College we invited them to present their research during University Day; abstracts of these presentations are also part of this annual report.

We hope that this annual report underlines the role that research at CAMS plays in the betterment of the Omani Society and in the international recognition of Sultan Qaboos University as a Research Institution.

Research Projects and Budgets

Table 1. Summary of research and development projects in 2014.

Source of Fund	No. of Proj.	Budget (RO)	Total (RO)
SQU Internal Grants (IG)			
Awarded in 2014	10	70,700	
Awarded from previous years	8	73,900	
Completed in 2014	11	90,900	**235,500**
His Majesty's Trust Fund (SR)			
Awarded in 2014	1	93,000	
Awarded from previous years	2	162,300	
Completed in 2014	2	185,100	**440,400**
The Research Council (TRC) FURAP			
Completed in 2014	2	4,800	**4,800**
The Research Council (RC)			
Awarded from previous years	3	325,350	
Completed in 2014	2	244,850	**570,200**
Collaborative Research (CL)			
Awarded in 2014	2	163,641.504	**163,641.504**
Contract Research (CR)			
Awarded in 2014	2	160,090	
Awarded from previous years	4	834,505	
Awarded in 2014 and completed in the same year	1	11,000	
Completed in 2014	4	33,468	**1,039,063**
External Grants (EG)			
Awarded in 2014	4	409,430	
Awarded from previous yrs	4	276,948	**686,378**
Total	**62**		**3,139,283,204**

Internal Grant Research and Development Projects

Table 2. Internally-funded research and development projects awarded in 2014.

No.	Title of Research	Principal Investigator	Amount (RO)
1	Investigation of *Ehrlichia ruminantium* and its tick vectors in the livestock population of Dhofar Region of Oman	*P. Bobade*	8,400
2	Knowledge diffusion with respect to pesticide related decision-making processes within the farming community of Oman	*M. Deadman*	5,000
3	Agro-ecology of traditional date palm farms in Oman	*R. Al-Yahyai*	7,000
4	Effect of walnuts on experimental Parkinson's disease: *in vitro* and *in vivo* approach	*M. Essa*	9,000
5	Dietary and lifestyle risk factors in the etiology of colorectal cancer in Oman	*M. Waly*	6,150
6	Development of value-added products from date fruit	*M. K. Al-Khusaibi*	6,150
7	A meta-analysis of available information on Oman's exploited finfish and elasmobranchs	*A. Govender*	6,000
8	Intra- and inter-annual variability in ichthyoplankton occurrence, diversity and growth pattern in Sea of Oman waters of Muscat	*A. Malzahn*	9,000
9	Nutrification of traditional desserts with Omani Dates	*M. Annamalai*	9,000
10	Enhancement of groundwater recharge in Al-Khoud dam area	*A. Al-Maktoumi*	5,000
		Total	**70,700**

Table 3. Ongoing in 2014 - internally-funded research and development projects awarded from previous years.

No.	Title of Research	Year Granted	Principal Investigator	Amount (RO)
1	Catching and economic performance of the demersal longline fishery	2011	*H. Al-Masroori*	6,000
2	Feasibility of soft-coral and sea-cucumber identification using fluid particle imaging and automated shape analysis	2012	*M. Claereboudt*	9,000
3	Characterization of fungal pathogens associated with root rot and wilt of Date palms in Oman	2013	*A. Al-Sadi*	11,000
4	Atmospheric cyclones and biological productivity of the ocean	2013	*S. Piontkovski*	11,000
5	The population dynamics, pathology and treatment of parasites on commercially important demersal fishes in Oman	2013	*G.Yoon*	11,000
6	Effects of processing methods on retaining bioactive compounds and antioxidant activity of some mushroom cultivars	2013	*N. Guizani*	11,000
7	Estimating the capital stock and investment in artisanal fishery: a case study of Wilayat Al-Seeb	2013	*S. Bose*	4,900
8	The preferences and determinants of dairy farmer's participation in alternative marketing channels: a study of the small-scale dairy farmers in Oman	2013	*M. Mbaga*	10,000
			Total	**73,900**

Table 4. Internally-funded research and development projects completed in 2014.

No.	Title of Research	Year Granted	Principal Investigator	Amount (RO)
1	Diabetes education in primary health care in Oman: factors predicting diabetes control, effect on knowledge and metabolic control	2010	*L. Al-Subhi*	6,400
2	Extraction and value addition to Omani basil oil	2011	*A. Al-Maskri*	6,500
3	Glycemic index and glycemic load of traditional Omani foods: studies on the effects of methodological and food factors	2011	*A. Ali*	8,000
4	Plant-soil approach for irrigation scheduling of fruit crops	2011	*S. Al-Jabri*	8,000
5	Possibility of utilization solar stills to provide greenhouse water demand in arid environments	2011	*A. Al-Ismaili*	5,000
6	Identification of camel meat quality parameters using proteomics	2012	*I. Kadim*	10,250
7	Utilization of *Prosopis juliflora* for feeding Omani livestock	2012	*O.M. Gaafar*	8,850
8	Influence of crop duration and grafting on crop productivity and quality in greenhouse cucumber	2012	*M. Khan*	8,850
9	Bioactive compounds from Oman marine organisms	2012	*S. Dobretsov*	10,250
10	Evaluation of the effect of soil compaction and tillage management on the growth and yield of crops	2012	*H. Jayasuriya*	8,550
11	Computer simulation model for improving wheat production	2012	*Y. Al Mulla*	10,250
			Total	**90,900**

His Majesty's Strategic Research Projects

Table 5. Strategic research project awarded in 2014 funded through His Majesty's Trust Fund (HMTF).

No.	Title of Research	Principal Investigator	Amount (RO)
1	A novel molecular approach to study brucellosis in cattle, sheep, goats and camels in the Sultanate of Oman	*Y. ElTahir*	**93,000**

Table 6. On-going in 2014 – strategic research projects awarded from previous years funded through HMTF.

No.	Title of Research	Year Granted	Principal Investigator	Amount (RO)
1	Economical, social and environmental impacts of marine biofouling in the Sultanate of Oman	2010	*S. Dobretsov*	80,000
2	Characterizing the nature of resistance to Witches' Broom Disease in Omani lime	2013	*A. Al-Sadi*	82,300
			Total	**162,300**

Table 7. Strategic rsearch projects completed in 2014 funded through HMTF.

No.	Title of Research	Year Granted	Principal Investigator	Amount (RO)
1	Potential sources of soil-borne plant pathogenic fungi and bacteria into farms in Oman	2010	*A. Al-Sadi*	95,600
2	Value-added functional products from less-utilized biomaterials locally available in the Sultanate	2011	*M.S. Rahman*	89,500
			Total	**185,100**

Other Externally-Funded Research Projects

Table 8. Research projects completed in 2014 funded through The Research Council-Faculty Mentored Undergraduate Research Award Program (FURAP). We list here the faculty mentoring the project which was subsisted, carried-out by teams of students):

No.	Title	Principal Investigator	Amount (RO)
1	The efficiency of household water filters in various regions	*A. Al-Maktoumi*	2,400
2	Characterization of urban soil at A'Seeb area	*S. Al-Ismaily*	2,400
		Total	**4,800**

Table 9. On-going in 2014 - research projects awarded from previous years funded by The Research Council (TRC), Oman.

No.	Title	Principal Investigator	Year Awarded	Amount (RO)
1	Effect of dietary supplementation of fruits grown in Oman on cognitive decline in Alzheimer's dementia, mild cognitive impairment, vascular cognitive impairment and traumatic brain injury	*M. Essa*	2011	201,000
2	Monitoring groundwater using energy water smart meters and precision irrigation	*S. Zekri*	2012	173,350
3	Numerical modeling of ocean circulation to investigate the regional marine environment and climate around Sultanate of Oman	*S. Piontkovski*	2012	131,000
			Total	**325,350**

Table 10. Research project completed in 2014 funded by TRC, Oman.

No.	Title	Principal Investigator	Year Granted	Amount (RO)
1	Oceanographical regime shift in the Sea of Oman	*S. Piontkovski*	2010	146,000
2	Development of Computer Vision (CV) technology for quality assessment of Dates in Oman	*M. Annamalai*	2011	98,850
			Total	**244,850**

Table 11. Research projects awarded in 2014 funded through Collaborative Research (CL).

No.	Title	Principal Investigator	Sponsor/ Agency	Amount (RO)
1	Studies on the distribution, nature of damage and future control strategies for the Tomato Leafminer (*Tuta absoluta*) in Oman and UAE	*A. Al-Wahaibi*	United Arab Emirates University (UAEU)	12,500.000
2	Effects of feeding date palm by-products on the productive and reproductive performance of Awassi sheep	*O.M. Gaafar*	Ministry of Environ-ment, Qatar	151,141.504
			Total	**163,641.504**

Table 12. Research projects awarded in 2014 funded through Contract Research (CR).

No.	Title	Principal Investigator	Sponsor/ Agency	Amount (RO)
1	Who's eating the dubas bug? Characterization of biological control through molecular gut analysis	*A. Al-Wahaibi*	The Research Council, Oman	108,750
2	Modeling of dubas bug habitat and population density in Oman based on associations with environmental and climatological factors	*A. Al-Wahaibi*	TRC, Oman	51,340
			Total	**160,090**

Table 13. On going in 2014 **-** research projects awarded from previous years funded through CR.

No.	Title	Principal Investigator	Year Granted	Sponsor/ Agency	Amount (RO)
1	Evaluation and assessment of treated sludge (KALA Fertilizer) application in agriculture	*A. Al-Busaidi*	2012	Haya Water	27,000
2	Mapping, monitoring and mitigation of land degradation in Oman	*M. Al-Wardy*	2013	Ministry of Environment and Climatic Affairs, Oman	728,145
3	Monitoring coral communities and artificially created substrates near Musandam Gas Processing Plant	*M. Claereboudt*	2013	Oman Oil Co. Exploration and Production, LLC (OOCEP)	68,800
4	Characterization and treatment of textile industry effluents using nanotechnology	*M. Ahmed*	2013	Caledonian College of Engineering, Oman	10,560
				Total	**834,505**

Table 14. Research project awarded in 2014 and completed in the same year funded through CR.

No.	Title	Principal Investigator	Sponsor/ Agency	Amount (RO)
1	Soil classification and analyses for the million palm project	*H. AbdelRahman*	Institute for Development of Water Resources "Jaruslav Cerni" AD (Serbia)	11,000
			Total	**11,000**

Table 15. Other research projects completed in 2014 funded through CR.

No.	Title	Principal Investigator	Year Granted	Sponsor/ Agency	Amount (RO)
1	Wastewater treatment reuse at A'Saffa Poultry Farm at Thamrait, Dhofar Governance	*M. Ahmed*	2012	IIC, Oman/ A'Saffa	20,400
2	The role of small and medium enterprises (SMEs) and agricultural cooperatives in promoting sustainable agriculture for rural development and food security	*S. Bose*	2013	The Research Council, Oman	7,040
3	Screening of viral, viral-like and bacterial diseases in Citrus	*A. Al-Sadi*	2013	Royal Court Affairs, Oman	4,428
4	Implementation and performance evaluation of environmental technologies for oil contaminated soils and water	*M. Claereboudt*	2013	Ray Inter-national, LLC	1,600
				Total	**33,468**

Table 16. Research projects awarded in 2014 funded through External Grants (EG).

No.	Title	Principal Investigator	Sponsor/ Agency	Amount (RO)
1	Desalination for agriculture in the Sultanate of Oman: challenges and opportunities	*S. Al-Jabri*	Ministry of Agriculture & Fisheries, Oman	30,000
2	Addressing food security in Oman through WTO Multi-lateral trading system and market-oriented food policies	*H. Boughanmi*	World Trade Organization, Geneva, Switzerland	84,200
3	Application of near-real time monitoring systems for irrigated agriculture in MENA [MENA NWC (Middle East and North Africa Network of Water Centers of Excellence)]	*Y. Al-Mulla*	USAID/FABRI	191,550
4	Bioluminescent field of the Omani coastal waters	*S. Piontkovski*	Office of Naval Research Global, UK	103,680
			Total	**409,430**

Table 17. On-going in 2014 - research projects awarded from previous years funded through EG.

No.	Title	Principal Investigator	Year Granted	Sponsor/ Agency	Amount (RO)
1	Determination of chemical contaminates of meat and meat products which threaten human health sold in Oman	*I. Kadim*	2011	Ministry of Agriculture, Oman	164,500
2	Role of nurseries and propagation techniques in spreading citrus pathogens	*A.M. Al-Sadi*	2012	VALE Brazil thru Univ of Federal Viscosa, Brazil	29,948
3	Studies on Citrus diseases caused by Citrus Tristeza Virus (CTV), phytoplasma and viroid in Oman	*A. Al Sadi*	2012	VALE Oman Pelletizing Co., LLC	47,500
4	Mango wilt disease in Oman: resistance, resistance mechanisms and environmental interactions	*M.L. Deadman*	2012	VALE Oman Pelletizing Co., LLC	35,000
				Total	**276,948**

University Day
May 4, 2014

Oral Presentations by Students

(organized by the Office of Asst Dean of Postgraduate Studies & Research)

Abstracts

Investigation on the Presence of Chlorination By-Products and Other Quality Parameters in Desalinated Drinking Water System

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Disinfection is important in the supply of safe drinking water. Chlorination is the major disinfectant process for drinking water. However, the reaction between the disinfection and the organic matter could form disinfection by-products like trihalomethanes (THMs). The study was done in order to check the presence of chlorination by-products in drinking water system in Muscat. This study presented the monitoring results of Muscat with collaboration with Public Authority of Electricity and Water (PAEW) in the period of June 9, 2013 to August 1, 2013. Seventeen drinking water reservoirs were selected to assess the presence of the chlorination by-products. The chlorination by-products were analyzed or detected by using the Gas Chromatography Mass Spectrometry (GCMS) instrument. According to the analyses, the concentration of the THMs did not exceed 0.3 ppb. Also, Chloroform, Bromodichloromethane and Dibromochloromethane concentrations were not exceeded 1.6 ppb while the Bromoform reached 28 ppb. Therefore, the results showed that the Bromoform concentration is the most dominant THM species observed in all the samples. The Bromoform concentration and the THMs concentrations did not exceed the maximum value of the Omani standard for drinking water (1 mg/l). The drinking water quality in Muscat governate is considered as high water quality based on the THMs standards. Thus, at present, there is no health concern associated with the presence of THMs in the drinking water.

Characterization of Urban Soils in A'Seeb Area

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The alterations and manipulations of soils by human activities in highly populated areas result in the formation of Urban Soils. Hence, the physiochemical and biological properties of these soils could be highly different than the soils in less populated or unpopulated areas. The modern life style and high population in urban areas could result in perilous use of these soils which needs immediate attention. Therefore, the changes in physiochemical and biological properties of urban soils have been studied in many parts of the world but the relevant information is lacking in Oman. Therefore, the aim of this study is to investigate the impacts of different human activities on the characteristics of urban soils of a densely populated area of A'Seeb. The study area was visited and surveyed many times to find common and more likely soil manipulating anthropogenic activities. A questionnaire was also designed to evaluate the perception of people about the possible impacts of their activities on the surrounding soils. Throwing garbage outside its containers, irrigating agronomic crops with untreated grey and sewage waters, and wall-paint falling on soils were found among the most common practices/phenomena in the study area. Moreover, various soil properties were also studied to establish baseline information of such soils in Oman. Pedological studies on excavated pedons revealed that throwing garbage on soil contributed to distinctive changes in the characteristics of the sub-soil horizons near garbage container. Due to the lethal effects of pathogens on human beings, particular emphasis was given to study the influences of selected activities on multiplication and propagation of some pathogens like Salmonella, E. Coli, Staphylococcus, Total and Fecal coliform in these soils. Top soil samples were collected randomly from North Al Hail and North Al Mawalih. They were analyzed for presence of the above mentioned pathogenic bacteria by using selective media. The biological analyses of the Total Plate Count (TPC) showed that bacterial colonies in soils were high. Also, Coliform bacteria as depicted by Most Probable Number (MPN) were greater than 2400 CFU/100 ml which is eleven times more than the allowable limit given by the Ministry of Regional Municipalities and Water Resources. The direct contact or ingestion of these soils and inhalation of dust by human beings may contribute to diarrhea, fever and abdominal pain.

Consumers' Preferences for Seafood in Oman

Jaynab Begum

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The main objective of this study is to learn about consumers' preferences for seafood and identify the influencing factors associated with the frequency of purchasing seafood. In addition, the study also intends to grasp a good understanding of how the respondents perceive 'seafood quality'. The data for the study was collected by designing a questionnaire administered through online (N= 729) at Sultan Qaboos University, local hypermarkets (N=93), and souq (N=35). The collected data were analyzed using descriptive statistics and a binary choice modeling technique. The preliminary findings of the study indicates that a majority of the respondents prefer seafood for home consumption and also prefer their seafood to be fresh (cleaned and cut). The most preferred species are Kingfish followed by Longtail tuna. Majority of the respondents were government employee or working at private companies. Respondents' awareness about seafood consumption is found to be influenced by 'friends and relatives'. With regard to the rating of product preferences, it is found that seafood is ranked 1 (where 1 = most preferred) followed by vegetables. The findings from the binary choice model indicate that nationality, past experience in seafood consumption, seafood quality, household size, and income are significantly influencing the purchasing frequency of seafood. It is hoped that the seafood industry in Oman will find this baseline study useful as a guide to develop further targeted research.

Extraction of Bioactive Compounds from Omani Fish and Crustacean Waste and Evaluation of their Activity

Laila Al-Naamani, Sergey Dobretsov

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The main aim of this project is investigate the presence of bioactive compounds in fish and crustacean waste generated in Oman. In order to utilize crustacean (shrimp, lobster, and crab shells) waste and unwanted fish parts (skin, head, bones, scales and internal organs), they were converted to value add products. Endogenous enzymes, such as pepsin and other proteases, were successfully extracted from fish stomach and intestine with protein concentration of 1.5 - 2 mg/ml. Extraction of bioactive peptides was carried out by enzymatic hydrolysis of fish parts using different concentrations of commercial (pepsin and papain) and fish-based enzymes during different time intervals. Degree of hydrolysis (DH) gives an indication of how much peptides are produced from the raw sample. Hydrolysis using 0.3% enzymes for 1 hour at 37°C using crude enzyme extract, partially purified enzyme extract and commercial papain gave DH of 15.7%, 16.5% and 21%, respectively. It proved that intestinal enzyme extracts were as efficient as the commercial enzyme in enzymatic hydrolysis. Hydrolysis using higher enzyme concentrations and longer hydrolysis time resulted in higher DH. Hydrolysate generated with 1% commercial papain for 1 hour at 37°C showed 32% DH. Using the same enzyme concentration and temperature but 3 hours hydrolysis time, resulted in 75% DH.

Various bioactive peptides with antimicrobial, antitumor, antihypertensive and antioxidative properties could be isolated from fish waste. Chitosan, which could be extracted from crustacean waste and fish scales, is a biopolymer which display a wide range of applications in different fields, e.g. in cosmetics, agriculture, food, pharmaceutical, paper industry and also as absorbent materials for wastewater treatment. Fish protein and shrimp hydrolysates were analyzed for their content of bioactive peptides and chitosan, respectively and some of their characteristics were evaluated. FTIR analysis showed 70% match between the crude chitosan extract from shrimp shells and the commercial chitosan. Varying degrees of antioxidative activities were showed by the different extracts with the highest DPPH radical-scavenging activity (32%) was obtained from chitosan prepared by hydrolysis of shrimp shell waste followed by 30% and 23% for protein hydrolysates prepared by hydrolysis of fish fins and tails and fish muscles respectively.

In conclusion, our project suggested that fish and crustacean waste contained variety of bioactive compounds that can be used in different industrial applications. Finally, recommendations for the optimal usage of fish waste will be provided.

Long-Term Microbial Fouling on Commercial Biocidal Coatings

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Due to the general ability of many commercial biocidal coatings to prevent macro-fouling, there is increasing interest in the impact of micro-fouling on ship performance. The current study aims to investigate microbial community composition of biofilms developed on several commercial biocidal coatings upon immersion in Marina Bandar Rowdha (Muscat, Sea of Oman) for 1 year. Coatings tested included examples of the three main biocidal technologies in widespread current use, namely Self-Polishing Copolymer, Self Polishing hybrid coatings and Controlled Depletion Polymer coatings. Unlike the control surface which was heavily fouled with both macro- and micro-fouling, all biocidal coatings were free of macro-fouling and only microbial biofilms were present. All the biocidal coatings significantly reduced the total bacterial density and the total wet weight of the biofilm. However there was no significant influence on the abundance of phototrophic organisms within the biofilms. Pyrosequencing of 16S rRNA genes revealed the presence of bacteria belonging to 31 different classes. The most common were *Cyanobacteria*, *Flavobacteria*, *Alphaproteobacteria* and *Gammaproteobacteria*. Distinct bacterial community structures were observed on self-polishing copolymer and self-polishing hybrid coatings. A novel group of bacteria, *Maritimimonas rapanae* was detected for the first time on biocidal coatings in the tropical waters of Oman. The current investigation demonstrated that the nature and quantity of biofilm present differed from coating to coating. These differences may reflect the coating technology, the biocidal component of the coatings and the response of the coating chemistries to the population of micro-fouling organisms at Marina Bandar Rowdha.

Near Infrared Hyperspectral Imaging to Classify Fungal Infected Dates

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The present manual sorting technique to detect microbial infection in dates is facing lots of challenges especially at the early stages of infection. The potential of non-destructive computer vision technique to detect fungal contamination of edible dates was inspected in this study. Hyperspectral images of *Aspergillus flavus* infected dates were acquired using an area scan hyperspectral imaging system from 75 image slices at 10 nm intervals between 960 to 1700 nm after every 48 h of inoculation for 10 days. The top four most significant wavelengths corresponding to the highest factor loadings of the first principal components were selected and used for feature extraction. From each selected wavelength, 16 features were extracted and applied in the statistical classifiers (linear and quadratic) to develop two-class and six-class models. 100% classification was obtained in detecting fungal contamination on dates at an early stage (day 2) even before development of any visible infection symptoms on the date surface. In general quadratic discriminant analysis yielded better accuracy than linear discriminant analysis in all the classification models tested.

Development of Transgenic Tomatoes Expressing Resistance Against *Tomato Yellow Leaf Curl Virus*-Oman (TYLCV-OM) and its Associated Betasatellite

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Tomato yellow leaf curl disease (TYLCD) is considered to be the most serious viral disease affecting tomato cultivation in Oman and elsewhere. Despite efforts to manage the disease using cultural and chemical methods, incidence of the disease is still very high in several farms in Oman. Genetic engineering is an alternating approach to develop broad-spectrum resistance against this viral disease. A hairpin (hp) construct targeting four different regions of *Tomato yellow leaf curl virus*-Oman (TYLCV-OM) including pre-coat protein, overlapping region of coat protein gene, replication associated protein and part of conserved intergenic region was designed and cloned in both sense and antisense orientation under the control of 2X 35S promoter and its terminator in pGreen 0029 plant transformation vector. The multi-target hpRNAi construct was transformed in *Solanum lycopersicum L.* plants and eleven independent transgenic lines were developed through *Agrobacterium* mediated transformation. T_1 generation of nine confirmed transgenic lines expressing hpRNAi construct were challenged with TYLCV-OM alone or together with ToLCB-OM. All wild type tomato plants developed typical symptoms of TYLCV-OM or TYLCV-OM/ToLCB-OM at 27 dpi. Transgenic plants inoculated with TYLCV-OM did not develop symptoms even after 60 dpi while transgenic lines inoculated with TYLCV-OM/ToLCB-OM showed mild symptoms in few plants at 60 dpi. Presence of virus was checked in all asymptomatic plants using PCR and Southern blot hybridization. Both methods failed to detect virus accumulation in transgenic plants. A real-time quantitative PCR analysis showed low levels of viral DNA in all transgenic lines. The low titer of viral DNA in inoculated transgenic tomato plants suggest that virus movement and/or replication were impaired that lead to resistance of plants against geminivirus disease complex infecting tomato plants in Oman. This study is the first in Oman to produce transgenic tomatoes expressing resistance to TYLCV.

Some Significant Research Completed in 2014

Some Significant Research Completed in 2014

Research Theme: *Industry-related research*

Value Added Functional Products from Less Utilized Biomaterials Locally Available in the Sultanate (SR/AGR/FOOD/11/01)

Mohd Shafiur Rahman (Principal Investigator)[1], Ahmed Al Alawi (Co-Principal Investigator)[1], Nejib Guzani[1], Mohamed Essa Mohamed[1], Sardar Farook[2], Samir Al-adawi[3], Mohammad Zakir Hossain[4], Masoud Al-Maskari[3], Lyutha Al-Subhi[1], Amanat Ali[1], Nooria Al-Kharusi[5], Mohammad Khadem[6], Khalid Al Hashmi[1], and Mostafa Waly[1] (Co-Investigators)

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Summary:

One of the many components of food security and economic gain, includes the development of value added functional products using waste or less utilized bio-materials. In this project, different functional products were developed using un-utilized bio-materials (i.e. seaweeds from marine source) and waste from food processing industry (i.e. date-pits and pomegranate skin).

The first part encompassed the measurement of physico-chemical, thermal and structural characteristics of bio-materials, which are needed to process these bio-materials into value added functional products. Moisture, protein, oil, ash, crude fiber, neutral detergent fiber and starch of biomaterials were measured. The moisture sorption isotherm of date-pits powder showed a characteristic of type II sigmoidal shape and modeled by BET and GAB equations. The BET and GAB monolayer values of date-pits, which are important to determine its stability during storage and processing, were estimated as 4.3 and 4.1 g/100 g dry-solids. Cellular structure of date-pits as captured by Scanning Electron Microscopy (SEM) images showed a strongly packed (i.e. very low pore volume) structure, and these pores (i.e. mainly cracks) are in the nano-size. The Differential Scanning Calorimetry (DSC) thermogram of freeze-dried date-pits showed an endothermic peak due to the melting of oil, and a second endothermic peak of solids-melting (i.e. non-fat). The onset of glass transition was observed at 43.0^{o}C at 5^{o}C/min heating and solids-melting was observed at 106^{o}C. Other structural charactersitics were determined by varying moisture content, heating rate

and anealing. It was observed very low water-solids interaction, and multi-component relaxation in the rubbery state.

Thermal, mechanical and magnetic resonance relaxation characteristics of complex pomegranate skin were measured. DSC thermogram showed a shift (i.e. onset glass transition at 20°C) followed by an endothermic peak (i.e. solids-melting peak at 165°C and enthalpy 140 kJ/kg). Overlapping of the glass transition and melting was observed in the DSC thermogram, however more sensitive modulated DSC allowed to separate two transitions (i.e. glass transition from reversible and melting from non-reversible thermograms). The onset glass transition from the reversible heat flow was observed at 11°C, and solids-melting peak from non-reversible heat flow at 152°C (i.e. enthalpy 167 kJ/kg). The onset of mechanical glass-rubber transition from Differential Mechanical Thermal Analysis (DMTA) was observed 122°C with a shift in the storage modulus (E'), however onset of liquid-like or entangled-reaction dominating transition was observed at 70°C (i.e. onset peak in loss modulus, E'') and peak at 184°C. In addition onset peak in phase angle (i.e. $tan\ \delta$) was observed at 113°C and peak at 201°C. Spin-spin (T_2 relaxation) and spin-lattice (T_1 relaxation) relaxations in Time Domain Nuclear Magnetic Resonance (TD-NMR) was modeled by two-exponential relaxation curve (i.e. rigid and flexible domains). T_2 relaxation showed maximum peak with an onset at 40°C with maximum peak at 150°C. Rigid domain of T_1 relaxation showed a minimum peak onset at 40°C and a minimum peak at 120°C, whereas flexible component showed an onset at 20°C and a minimum peak at 160°C. The moisture isotherm data of pomegranate peel and extract was fitted to BET and GAB equations; BET-monolayer values for whole-peel and eater-extract were 8.37 and 9.83 g/100 g dry-solids, respectively. A water-soluble extract of pomegranate peel was prepared and freeze-dried; and thermal characteristics were measured as a function of moisture and temperature. A state diagram of the extract was developed by measuring the freezing curve, glass transition line and ultimate maximal-freeze-concentration conditions. This diagram can be used to determine the stability of the bio-active components during storage and processing.

The second part included the measurement of the health functional bioactive components in these selected biomaterials. The melting peak of date-pits oil was varied from -2.3 to -0.3°C and contained mainly oleic acid followed by lauric, myristic acid, palmitic acid and linoleic acid; predominated by oleic acid (i.e. 47.5% of total fatty acids). Date-pits oil showed oxidative stability at 30°C for at least 91 days, while the oxidative parameters (i.e. acid value, peroxide value, p-anisidine, oxidation resistance) changed remarkabily high when stored at 100 and 130°C. The types of solvent (i.e. polar and non-polar) used for extracting polyphenols from date-pits played an important role.

In the case of pomegranate peel, total phenolic content of ethanol extracts of freeze-dried peels was comparable to that of fresh peels, whereas air and vacuum-dried peels had significantly lower phenolic contents. Air

dried at 60°C had highest phenolic content as compared to air dried samples at 40 or 90°C, whereas vacuum-dried peels did not show any trends with drying temperature. The analysis of Mass Spectroscopy (ESI-MS/MS) revealed the presence of 61 distinct polyphenols in the pomegrannate peel-extract among which 12 hydroxycinnamic acids, 14 hydrolysable tannins, 9 hydroxybenzoic acids, 5 hydroxybutanedioic acids, 11 hydroxycyclo-hexanecarboxylic acids and 8 hydroxyphenyls. Major compounds were tannins and flavonoids such as; ellagic acid, gallic acids, punicalin, and punicalagin.

Five extraction methods were used to extract polysaccharides from different species of red seaweeds. The poyphenols and sulfated contents were measured to determine their health functionality. Molecular weight distribution of one extract showed a wider peak and another one showed a sharp peak, whereas other extracts showed bimodal molecular distribution. The glass transition of the extracts varied within a narrow temperature range, while wider variation was observed for solids-melting temperature. Fourier Transform Infrared (FTIR) analysis indicated that four extracts contained mainly agar, while one extract contained mainly sugar.

The third part included the health functionality of different extracts prepared from selected bio-materials using in-vitro and in-vivo animal studies. Water extract of date-pits contained phytonutrients that inhibited azoxymethane (AOM) induced oxidative stress in rat colonic cells as evident by a significant decrease in the malondialdehyde (MDA) and dichlorofluoresceine fluorescence (DCF); and increase in intracellular Total Antioxidant Capacity (TAC) and glutathione; thus possessed anti-carcinogenic properties. Rats with high fat diet significantly increased the body weight and develop non-alcoholic liver dysfunction, liver steatosis, accompanied by hyperlipidemia, oxidative stress, and elevated liner enzymes. Administration of pomegranate peel extract (POE) ameliorated the hepatic morphology, reduced body weight (i.e. obesity) through modulation of lipid metabolism, improved liver enzymes and inhibited lipogenesis. The results of this study provided in-vivo evidence that POE, papaya skin extract (PAE) and seaweed extract (SE) reduced the AOM induced colon cancer in rats, through their potent anti-oxidant, anti-carcinogenic and anti-inflamatory activities. AOM induced aberrant crypt foci (ACF) development and pathological changes in the colonic mucosal tissues, increased bone marrow induced micronuclei (MN) cells, oxidative stress (glutathione depletion, lipid peroxidation), and antioxidant enzymes in rate colonic cells. The concomitant treatment of AOM with POE, PAE, or SE significantly ameliorated the cytotoxic effects of AOM. The observed chemopreventive effect of these natural extracts on AOM-mediated carcinogenesis and oxidative stress in rat colon was attributed to its bioactive components, such as polyphenols and flavonoids contents.

One PhD., 4 MSc. and 23 undergradute students completed their theses and final year research projects from this project and another Ph. D. student is currently working on her thesis. One Ph. D. student won the first position

in the oral presentation at the International Conference on Food and Nutrition Technology for Public Health (ICFNP-2012), IISMAAS, 4-5 May 2012, New Delhi, India and received training on the cell line techniques from Professor Gilles Guillemin, University of New South Wales, Sydney, Australia. In addition, 15 part-time (on-request) research assistants have been trained from the support of this project. Total 75 publications (35 refereed journal papers, 2 books, 12 book chapters, 3 conference proceeding papers, 21 conference/workshop papers and 2 popular articles) were published through direct or indirect support from this project. In addtion, 24 news items have been released in the local print media and TV interviews. Two major equipments (TD-NMR and infrared moisture analyzer) and ultra-low freezer (-120^{o}C) were purchased and installed in the department's laboratory. These are now beeing used for teaching and research projects for the graduate and undergraduate SQU students from different colleges. One faculty member from Pibulsongkram Rajabhat University, Thailand visited and trained on the DSC and TD-NMR.

Research Theme: *Environmental and biological research*

Bioactive Compounds from Oman Marine Organisms (IG/AGR/FISH/12/01)

Sergey Dobretsov[1] (Principal Investigator), Ikram Burney[2] (Co-Principal Investigator), Jamal Al-Sabahi[1], Raeid Abed[3], Yahya Tamimi[4], Michael Deadman[1] and Miaad Rashid Al Maamari[1] (Co-Investigators)

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Summary:

Marine organisms have different secondary metabolites in comparison to terrestrial organisms. Quorum sensing (QS) is a "chemical language" of bacteria that allows the control of bacterial growth and attachment without killing them. The main aim of this project was to screen and isolate anti-QS and anti-cancer compounds from marine organisms with potential use as pharmaceuticals. This was a collaborative project between researchers from the Department of Marine Science and Fisheries, SQU hospital and the Biochemistry Department of the College of Medicine. During this project we extracted and purified substances of different marine organisms (bacteria, algae, sponges, tunicates, soft corals and tunicates) collected in Oman coastal waters. Then, antimicrobial, anti-cancer and quorum sensing inhibitory activities of extracts were screened. Overall, 85 extracts of marine organisms were obtained and screened. Extracts of soft corals *Sarcophyton* sp. and *Acanthogorgia* sp. collected from Bandar Al-Khayran area (Muscat, Oman) induced apoptosis in the breast cancer cell line MCF-7 as indicated by nuclear condensation, fragmentation and the increased expression of caspase-3 and p53 proteins. QS inhibitory compounds were obtained from several microbial isolates. Purification of dichloromethane extracts of *Marinobacter* sp. SK3 resulted in isolation of 4 different diketopiperazines (DKPs). Cyclo (L-Pro-L-Phe) and cyclo (L-Pro-L-iso-Leu) inhibited QS dependent production of violacein by *Chromobacterium violaceum* CV017. Cyclo(L-Pro-L-Phe), cyclo(L-Pro-L-Leu), and cyclo(L-Pro-L-iso-Leu) reduced QS dependent luminescence of the reporter *Escherichia coli* pSB401 induced by 3-oxo-C6-HSL. None of isolated DKPs affected QS dependent luminescence of the reporter *E. coli* pSB1075 induced by 3oxo-C12-HSL. This study shows high anti-cancer and anti-QS potential of Omani marine organisms. During this project several SQU students have been trained in the field of marine biotechnology and medicine. Additionally, assays for screening anticancer activity of marine natural products have been developed at the Biochemistry department. Results of this study have been presented in 4 peer-review publications and 5 international conferences and meetings. One publication has been submitted to the journal.

Research Theme: *Industry-related research*

Development of Computer Vision (CV) Technology for Quality Assessment of Dates in Oman (RC/AGR/SOILS/11/01)

Manickavasagan Annamalai[1] (Principal Investigator), Rashid Al Yahyai[1] (Co-Principal Investigator), Lazhar Kriji[2], Mohamed Essa Mohamed[1] (Co-Investigators), and Seif Al-Adawi[1] (Technician)

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Summary:

The main aim of this project was to determine the feasibility of computer vision technology for assessing surface and internal qualities of dates. Algorithms have been developed in CV for the detection of hardness, surface-crack, insect-infestation, microbial-contamination and total soluble solids (TSS) of different Omani date varieties.

RGB color imaging system was used to classify dates based on hardness (hard, semi-hard and soft dates). Dates from three common varieties in Oman (Fard, Khalas and Naghal) were used (3300 samples in total). The RGB image of individual date sample was taken by a CCD camera and analyzed using proprietary software developed in Matlab.. Thirty nine features (13 features in each R, G and B channel) were extracted from each image and analyzed. Three classes (hard, semi-hard and soft) and two classes (hard and soft —"semi-hard and soft were the considered together as "soft"—) classification models were developed using linear discriminant analysis (LDA) with all features and stepwise discriminant analysis (SDA) with selected features (based on level of contribution to classification). In the three classe approach, the overall classification accuracy was 69%, 87% and 82% for Fard, Khalas and Naghal varieties, respectively with the LDA algorithm. Using the SDA algorithm. it was 68%, 86% and 81% for Fard, Khalas and Naghal varieties, respectively. The classification accuracy was improved in two classes approach. It was 84% (LDA) and 83% (SDA) for Fard, 90% (LDA) and 91% (SDA) for Khalas, and 96% (both in LDA and SDA) for Naghal varieties.

The dates were classified based on surface crack using RGB color imaging technique. The samples of three grades of dates (*no-crack* dates, *low-crack* dates and *high-crack* dates) were imaged individually using a color camera (105 dates in each grade). Eleven features were extracted from each image and used in classification models. Red hue and value intensities of three grades of dates were significantly different from each other. In a three classes model, the classification accuracy was 62%, 58% and 78% for *high-crack*, *low-crack* and *no-crack* dates, respectively using LDA. It yielded a classification accuracy of 88% and 75% for the dates *with-crack* and *without-*

crack, respectively in a two classes model. In pairwise discrimination, the highest classification (96%) was achieved between *high-crack* and *no-crack* dates, and the lowest accuracy (59%) was between *low-crack* and *high-crack* dates.

The potential of hyperspectral imaging techniques to detect fungal contamination of dates was also investigated. The samples were treated as three groups: untreated control (UC), sterile control (SC) (surface sterilized, rinsed and dried) and inoculated samples (IS) (surface sterilized, rinsed, dried and inoculated). Hyperspectral images of control samples and *Aspergillus flavus* inoculated date fruits were acquired using an area scan hyperspectral imaging system from 75 image slices at 10 nm intervals between 960 to 1700 nm after every 48 h of inoculation for 10 days. The top four most significant wavelengths corresponding to the highest factor loadings of the first principal components (PC) were selected and used for feature extraction. A total of 64 features (16 features from each selected wavelength) were extracted and used in the statistical classifications (LDA and quadratic discriminant analysis, QDA). The classification accuracies for IS were compared with UC and SC separately using a six-class model (control, infected day 2, day 4, day 6, day 8 and day 10), two-class model (control vs infected (all stages of infection together) and pair-wise model (control vs each stage of infection). The mean classification accuracy (LDA and QDA) of IS was 91.5%, 91.0% and 99.0% for six-class model, two-class model and pairwise-model, respectively while comparing with SC. Similarly, it was 92.4%, 100.0% and 99.6% for six-class model, two-class model and pairwise-model, respectively while comparing with UC.

The capability of X-ray imaging in detecting internal infestations caused by the saw-toothed beetle (Oryzaephilus surinamensis Linnaeus) in stored dates was investigated. Artificially infested dates were incubated at 30◦C and 70% relative humidity. A total of 200 un-infested and infested dates were x-rayed for different life stages (egg, larvae, pupae, and adult) of O. surinamensis. An algorithm was developed to extract 44 features (histogram and textural attributes) from the X-ray images. LDA was used to discriminate the un-infested and infested dates using extracted features. The histogram features contributed more for classification of un-infested and infested dates than textural features. An overall classification accuracy of 80% was achieved when the infestation by different life stages were treated separately (four classes: un-infested, larvae, pupae, and adult). Bootstrapping shows that it is possible to detect infested dates as one group without separating them into different stages of infestation (larvae, pupae, or adult). The discrimination efficiency of 87.5% was identified when the X-ray images of infested and un-infested dates were treated as two classes (un-infested versus infested dates [larvae, pupae, and adult]). In pairwise discriminant analysis, the highest classification accuracy (96.9%) was achieved between un-infested dates and dates infested with adults.

The potential of a near infrared (NIR) imaging technique to determine TSS content of dates was evaluated. Date samples of three cultivars (Fardh,

Khalas and Naghal) at tamar stage (n=400 fruits) and two ripening stages (tamar and khalal) of Khalas cv. (n=400 fruits) were used. The area scan NIR camera which covers the full spectrum range of 900–1,700 nm was used to capture the images of individual date fruits. Immediately following image acquisition, the TSS content (ºBrix) of each sample was measured using a digital refractometer. The TSS content of dates was in the range of 34–63° Brix and 14–37 °Brix for tamar and khalal stages, respectively. Similarly, the percentage of NIR reflectance was 12–38 and 39–64 for tamar and khalal stages, respectively (Fig. 3). A multiple linear regression (MLR) prediction model along with a dummy variable concept was established between measured TSS and NIR reflectance. NIR reflectance was inversely proportional to the TSS content of dates. The correlation coefficient (r) between TSS content and NIR reflectance was 0.62 and 0.98 for three cultivars and two ripening stages, respectively.

Through this project, 13 candidates (1 PhD student + 6 MSc students + 2 Technical staff + 4 Research Assistants) were trained in various aspects of CV technology. The PhD student and 1 Technical staff got specialized training in CV at the University of Manitoba, Canada (PhD student-15 weeks; technical staff-3 weeks). This project enabled strong international research collaboration especially with University of Manitoba, Canada.

A workshop on "Computer Vision Technology for Agricultural and Food Industries" was organized as part of this Project on March 30 2014. People from food industries, Municipalities, Ministries, SQU and various private colleges attended this workshop.

The outcomes of this project were presented as 24 papers or posters in various conferences. Also 11 peer reviewed papers have been published in international journals. In addition, 1 book (Springer publisher) and 6 book chapters have been produced in this project. One of the MSc students, who worked in this project, received the “Excellent Paper Award” in an international conference at Singapore organized by the “Asia-Pacific Chemical, Biological & Environmental Engineering Society” in 2013. The activities and achievements of this project received “Green Research Award – 2014” in Green Awards & Summit event held on 21 September 2014 under the patronage of HE Mohammed Bin Salim Bin Said Al Toobi, Minister of Environment and Climate Affairs.

Summary of Internal Grant Projects Awarded in 2014

Investigation of the Prevalence of *Ehrlichia ruminantium* and its Tick Vectors in the Livestock Population of Dhofar Region of Oman

Patrick Akinlehin Bobade, *P.I.*

Duration: 3 years **Budget (RO):** 8,400

In a previous study of ticks and tick-borne diseases of goats in the Sultanate of Oman, we detected *Ehrlichia ruminantium* (*E. ruminantium*) in the blood of a number of goats in Dhofar Region. *E. ruminantium* is an obligate intracellular rickettsial organism that causes a disease known as heartwater in all domestic ruminants and some wild ruminants. The organism is usually transmitted by ticks of the genus *Amblyomma*. In our study of ticks in Dhofar region, *Amblyomma variegatum,* a member of the genus *Amblyomma*, was found at many locations. Heartwater is a serious disease with mortality rates of up to 80 - 90% and a morbidity rate of close to 100% in ruminants. The disease therefore has an adverse economic impact due to enormous losses of livestock and restriction of the upgrade of local stock through the introduction of high-producing animals. The infection is maintained within the livestock population by recovered and subclinically infected animals which may remain infective for ticks for up to 11 months or more. Heartwater has been reported in camels in Sudan. Also there are suggestions that variants of *E. ruminantium* may be capable of causing fatal infections in human beings. Clinical diagnosis of heartwater in animals is difficult because there are no pathognomonic signs. Also most laboratory tests for the disease have drawbacks. The only reliable methods for diagnosis of E*. ruminantium* infection are PCR-based molecular techniques, of which PCR using the pCS20 genetic region is specific and the most sensitive. All current methods of controlling heartwater have serious drawbacks and there is no an effective vaccine. *E. ruminantium* and heartwater have never been reported in the Sultanate of Oman before now. Therefore there is no information about the prevalence and epidemiology of *E. ruminantium* and heartwater in the country. However, in interviews with goat owners in Dhofar Region their responses gave indications that some of their goats might have died from a disease whose clinical signs could be attributable to heartwater. It is therefore necessary to investigate the epidemiology of. *E. ruminantium* infection in Oman.

This study will aim to establish an understanding of the distribution and dynamics of the tick vectors involved in the transmission of the disease among the different species of livestock in Dhofar Region; and determine the genotypes of *E. ruminantium* present using molecular diagnostic methods. Whole blood will be collected from cattle, goats,

sheep and camels by jugular venipuncture for hematological analysis, clinical chemistry, and PCR by reverse line blot (RLB) hybridization, real-time PCR using pCS20 probe respectively, as well as any other PCR assay that may be necessary. All ticks on each selected animal will be collected. The ticks will be identified and classified using morphometric methods. The hematological analysis will include determination of the haemogram for each animal using a Cell-Dyne® 3700 hematology system while clinical chemistry analyses for protein, liver, muscle, and renal profiles will be carried out using a Cobas c 111® chemistry analyzer. All results obtained will be analyzed using the latest version of SPSS or any other computer program that may be available.

At the end of this study, it is expected that information will be available as to the prevalence of the *E. ruminantium* variant(s) present in Dhofar region, and the factors involved in the transmission of the organism in the region. The information will be used for further studies into the epidemiology of heartwater in the region and for proposing control measures for the disease. If implemented, the control measures will enhance the productivity of susceptible animals and also allow the successful importation and utilization of high-producing animals from heartwater-free regions.

Knowledge Diffusion with Respect to Pesticide Related Decision-making Processes within the Farming Community of Oman

Michael Deadman, *P.I.*

Duration: 3 years **Budget (RO):** 5,000

Although agriculture in Oman is not usually considered a major component of the economy, government policy has been directed towards diversification of national income and as a result there has been an increasing emphasis on revenue from agriculture and an enhancement of production via the use of irrigation, machinery and inputs such as pesticides. In recent years this has been tempered with a range of interventions to encourage more sustainable production. Certain pesticides have been prohibited; there has been a promotion of organic agriculture and an emphasis on education and awareness programs for farmers. The last point is of especial relevance given the nature of the farm labour market in Oman and a reliance on expatriate and often untrained labour. The research will draw out the process by which agricultural policy is developed by the upper levels of the government executive within a centralised system, including support for international agreements and protocols, and the mechanisms by which these policies are implemented and how impact is perceived at the farm level especially in relation to pesticide use and pesticide safety.

The research will explore the state of knowledge at farm-level regarding the safe use of pesticides and what factors could enhance or indeed operate against the spread and implementation of that knowledge. The effectiveness of the existing extension services in relation to pesticide safety will be explored through a detailed survey of current pesticide use, labour awareness of pesticide regulation and transfer of knowledge between farmers. From these results the potential for development of farmer-lead knowledge diffusion models is being explored. A database of pesticides found at the farm level will be established to determine the extent of illegal/restricted pesticides and the market infiltration by so-called “me-too” formulations.

Agro-ecology of Traditional Date Palm Farms in Oman

Rashid Al Yahyai, *P.I.*

Duration: 3 years **Budget (RO):** 7,000

Cultivation of horticultural, agronomic and field crops have been going on for thousands of years in Oman. Methods of cultivation followed traditional practices that were meant to resolve the adverse climatic conditions (such as excessive heat) and shortage of water. As modernization of the traditional farming systems are being replaced with modern practices such the use of modern irrigation systems and orchard and tree management, information is being lost on the settings that made farming under extreme weather sustainable. The proposed study aims to study the agricultural ecology of traditional farming systems, particularly those relevant to date palm and the under story fruit and other crops. Field studies will be conducted to determine the component of the traditional farming systems that included (but not limited to): Diversity of crops under date palm and species abundance, species distribution, species richness. The study will compare these variables in several governorates. The ultimate objective is to determine the level of biodiversity that currently exists under traditional farming systems compared to modern systems.

Effect of Walnuts on Experimentatl Parkinson's Disease: *In vitro* and *In vivo* Approach

Mohd Essa Mohd Musthafa, *P.I.*

Duration: 3 years **Budget (RO):** 9,000

Introduction: Parkinson's disease (PD), a progressive neurodegenerative movement disorder, is known to be caused by diverse pathological conditions resulting from dysfunction of the ubiquitin-proteasome system (UPS), mitochondria, and oxidative stress leading to preferential nigral dopamine (DA) neuron degeneration in the substantia nigra. Today, only symptomatic and non-neuro-protective therapies are available for the treatment of PD. Pharmacotherapy is a major contributor to direct health care costs and only have short term retention and expensive . Therefore it is important to focus on neuro-protective therapy using alternative methods.

Objective: Reports suggests that dietary supplementation with food groups such as tree nuts, fruits and vegetables rich in flavonoids, polyphenols, vitamins, micronutrients, and minerals improves cognition and memory. Till now, there are no studies were reported on the effect of walnuts against Parkinson's disease models. To fill the information gap the current study is planned to find the effect of walnut experimental PD models.

Methods: Effect of walnut on biochemical changes during rotenone induced neurotoxicity in SH-SY-5Y cell lines *in vitro* will be done. The effect of walnut on biochemical and behavioral changes in 1-methyl-4-phenyl-1,2,3,6-tetrahydropyridin (MPTP) induced Parkinson's disease in C57BL/6 mice model (*in vivo*) will be done.

Outcome: Walnut has been reported to offer neuro-protection to other neurodegenerative diseases and this study will show whether the walnut has neuro-protective effect on experimental PD. The outcome of this study may give a lead for novel therapeutic approach for the PD treatment.

Dietary and Lifestyle Risk Factors in the Etiology of Colorectal Cancer in Oman

Mostafa Waly, *P.I.*

Duration: 3 years **Budget (RO):** 6,150

Problem Statement: Cancer is the second leading cause of death among adults in most affluent countries. Colorectal cancer (CRC) is the most preventable type of cancers worldwide. Although genetic influences the development of CRC, the striking changes in this cancer rate within countries and different populations demonstrate the importance of non-inherited factors, such as diet and physical activity. In Oman, the overall cancer rates among adults vary modestly, yet the CRC is high as compared to other Gulf countries.

Study Hypothesis: Westernization in dietary pattern and sedentary lifestyle contribute to increasing the risk of CRC among Omani adults.

Main Goal of the Study: Identification of dietary and lifestyle risk factors in the etiology of colorectal cancer in Oman.

Expected Outcomes: (1) Establish a biochemical profile and lifestyle characteristics baseline data for early diagnosis and screening of CRC among Omani adults, (2) Develop long-term behaviour modification programs for primary prevention of CRC in Oman.

Development of Value-added Products from Date Fruit

Mohammed Al-Khusaibi, *P.I.*

Duration: 3 years **Budget (RO):** 6,150

Introduction: The quality of dates depends on storage, processing and handling conditions. Numbers of dates varieties are not preferred for human consumption, thus it is considered as waste or used as animal feed. In addition, the old-stock dates are low in quality as compared to the dates from new-season. Date syrup is commonly derived from dates by the traditional methods, but its production and utilization is still limited.

Objectives: This project aims to develop high quality date syrup and date powder from old-stock dates and to explore its potential utilization in many value-added products.

Methodology: The syrup will be produced by extracting conventional heat treatment and by utilizing ultrasound at room temperatures. The optimum extraction conditions will also be determined as a function of time, temperature and solids-solvent ratio. In order to produce free flowing (i.e. non-sticky) dates powder, the syrup will then be dried by spray or freeze drying with or without adding selected hydrocolloids, such as dextrose, and carboxymethyl cellulose. Finally the quality characteristics of date syrup and date powder will be determined by measuring its structural characteristics using Differential Scanning Calorimetry (DSC), Differential Mechanical Thermal Analysis (DMTA), Fourier Transformed Infrared Analysis (FTIR) and Time-Domain Nuclear Magnetic Resonance (TD-NMR).

Expected outcomes: The project is expected to evaluate the possible utilisation of old-stock dates to produce value-added products. Optimisation of the production of dates syrup and date powder will be developed. The project is expected also to evaluate the scope of using FTIR and TD-NMR in the quality evaluation and classification of dates products.

A Meta-analysis of Available Information on Oman's Exploited Finfish and Elasmobranchs

Anesh Govender, *P.I.*

Duration: 3 years **Budget (RO):** 6,000

A large body of information exists on Oman's exploited finfish, shark and ray fisheries. Some are published in peer-reviewed journals and books while the majority of such information materials are found in unpublished theses, technical reports, conference abstracts, poster presentations, newspaper articles and other forms of grey literature. The primary aim of this research will be to prepare a technical report outlining the available knowledge on a particular species or family of fishes. This "one-stop" booklet will allow fisheries managers, researchers and students to identify knowledge gaps as well as to use the available information to manage Oman's fisheries, recognizing that some fisheries are data-poor.

Intra- and Inter-annual Variability in Ichthyoplankton Occurrence, Diversity and Growth Pattern in Sea of Oman Waters of Muscat

Arne Malzahn, *P.I.*

Duration: 3 years **Budget (RO):** 9,000

In this research I want to investigate seasonality and inter-annual variability in the diversity and composition of the Omani coastal larval fish community from Bandar al Khyran and Marina Bandar Al Rowdha. These sampling sites are located at the Sea of Oman near Muscat. Sampling at Bandar al Khyran will be on a monthly base. This campaign will be attached to the ongoing monitoring carried out at these stations regularly. Samples will be taken using traditional sampling gear. Sampling in Marina Bandar Al Rowdha will utilize light traps, which will be deployed two times per week. Samples will be stored in ethanol until further analyses in the laboratory. The ichthyoplankton community will be taxonomically assessed to the lowest possible taxonomic level and intra- and inter-annual patterns in community composition will be analyzed using appropriate statistical methods. Selected key species will be used for further analysis. These are investigations on growth rates and patterns utilizing otolith microstructure. Finally these data should be analyzed in concert with the biotic and abiotic data from the ecological long-term monitoring collected in parallel to the ichthyoplankton.

The proposed research will provide insights into the temporal dynamic of larval fish assemblage of coastal Omani waters which are not available at present. Further it will assess the growth response of selected key fish species on fluctuating environmental situations. Such baseline data is necessary for further studies on the role of mortality and survival of early life stages of fish for subsequent recruitment.

Nutrification of Traditional Desserts with Omani Dates

Manickavasagan Annamalai, *P.I.*

Duration: 3 years **Budget (RO):** 9,000

Diet related diseases are increasing at an alarming rate globally. Restriction on added sugar in our daily diet is one of the major components in healthy diet. World health authorities recommend adding fruits as a sweetener instead of added sugar during food preparation. In Asia, dessert is one of the major foods through which more added sugar is consumed. There are many popular traditional desserts across the continent in which sugar is the main ingredient. In this study 2 traditional desserts (*Al-Khabeesah* – Omani traditional dessert + *Kesari* – Indian traditional dessert) will be reformulated by replacing added sugar with various forms of Omani dates such as syrup, dhibs, paste and powder. Instrumental and sensory qualities of the reformulated desserts will be determined. The expected benefits from this project are: 1. Demand creation for Omani dates in domestic and international market so that Omani farmers will be in a position to get higher price for their products 2. Awareness creation among Omani people about the need to reduce the intake of added sugar by wisely reformulating the traditional foods 3. Training to Omani students and staff in the field of healthy product development and awareness creation 4. Publication about nutritional merits and blendability of Omani dates in the international scientific conferences and journals.

Enhancement of Groundwater Recharge in Al-Khoud Dam Area

Ali Khamis Sulaiman Al-Maktoumi, *P.I.*

Duration: 3 years **Budget (RO):** 5,000

Problem Statement: Recharge dams in Oman represent one of the few practical engineering techniques available to augment water resources. Formation of a relatively low-permeable cake as due to deposition of soil particles which brought by runoff water is a common problem in recharge dams and it has been observed in Al-Khoud recharge dam. This adversely affects the original storage capacity of the dam. In addition, this continuum accumulation of surface sediments may impact many of the hydrological properties of the dam's reservoir area including: low water infiltration and percolation rates, higher water loss via evaporation, and ultimately lower groundwater recharge.

The downstream recharge area of Al-Khoud dam is currently shrinking due to urbanization, which will result in less soil exposed to infiltration and hence intensifying the surface runoff and reducing the groundwater recharge. There is an evident development is taking place in the downstream recharge area of the dam (construction of buildings, farms, and roads) and will continue in the future. Provided that the reservoir area of the dam is relatively large (3.2 km^2) and taking into account the importance of the aquifer as a strategic reservoir for water supply of the whole capital of Oman, there is a need to improve the recharge efficiency upstream the dam area to compensate the reduction that has initially started and will continue to take place due to urbanization in the downstream area of the dam.

Objectives and Approach: Based on the experimental results on soil evolution in the Al-Khoud dam area which have already illustrated, surface and subsurface pedological and hydrological properties intertwined with the growing urbanization in the recharge area downstream the dam, there is a need to enhance the recharge rate to the subjacent aquifer. *The primary objective* of this research proposal is to explore the impact of some suggested geotechnical engineering and hydro-ecological practices and assessments on improving the recharge process inside the reservoir bed. This will be explored and tested using both analytical and numerical modeling as well as field experiments.

Outcomes: The study is of paramount importance for the country and for areas of similar water resources situation and climatic condition. The study will help in exploring some possible solutions to combat or reduce the potential adverse effects of siltation and growing urbanization and hence improve recharge efficiency. Understanding of hydrological aspects in recharge dam areas in Oman is of critical importance for better management strategies and will provide the foundation for future decision making by the Ministry of Regional Municipalities and Water Resources and other governmental agencies.

Summary of
Strategic Research Project
Awarded in 2014

A Novel Molecular Approach to Study Brucellosis in Cattle, Sheep, Goats and Camels in the Sultanate of Oman

Yasmin ElTahir, *P.I.*

Duration: 3 years **Budget (RO):** 93,000

Zoonoses are infectious diseases that are transmitted from animals to humans and place a significant burden on public health services. An estimated 60% of human pathogens are zoonotic in origin and underline that human health is inextricably linked to animal health and welfare. Among the most notorious of zoonotic diseases is brucellosis, which is considered one of the most significant maladies affecting not only livestock but children and adults alike.

The present project aims to establish the true incidence of brucellosis in sheep, goat, cattle and camels in different regions of the Sultanate of Oman. This has previously not been possible because of the use of outdated serological methods that are less than adequate in the validity of the information they provide. This is due to a number of reasons. Firstly, vaccinated animals could not be differentiated from naturally infected ones. However, in a preliminary study, we demonstrated that a unique structural protein of *Brucella* (Bp26) not only binds to a number of host tissues but also allows the differentiation of vaccinated animals from naturally infected ones.This was a milestone because whereas the former do not represent a human health hazard the latter are potential source of infection for both animals and man. Similarly, and perhaps more important is that until recently, the technology did not exist to appropriately identify the most important source of infection and transmission of this disease, namely carrier animals. These are animals that are infected but are apparently clinically normal. We intend to utilize a Multiplex PCR that will not only diagnose carrier animals infected with *Brucella* but also in a single step be able to identify the most important *Brucella* species. Ultimately, the utilization of these two strategies will allow us to correlate our serological findings using Bp26 as our antigen with those derived from the Multiplex PCR to determine the suitability of the serological response to identify actively infected and carrier animals. The end result of this study will allow us to recommend suitable control measures to limit the spread of brucellosis in the Sultanate and above all protect its citizens from this devastating malady.

Research by Graduate Students

Summary of Research Proposals

PhD Students

Proposed Thesis Title: Nutritional Management of Hyperhomocysteinemia-mediated Oxidative Stress in Omani Population

Student Name : **Smitha Padmanabhan**
Supervisor : Dr. Mostafa Waly
Department : Food Science and Nutrition

The high rate of urbanization and a steady increase in the per capita income in the Sultanate of Oman during the past years has resulted in drastic changes in the Omani's dietary pattern and lifestyle. Many studies have documented that traditional Omani foods are being replaced with Western-style ready-to-eat foods, with a low consumption of plants-based foods (fruits and vegetables). Whereas the consumption of red meat, dairy products, saturated fats, fast foods, and high glycemic index foods has increased during the past years. Adopting a sedentary life style in daily life and other related activities has also been reported among Omani adults. The Ministry of Health in Oman, has conducted a series of national health surveys that clearly indicated a trend of positive association between diet, obesity, and the increased risk of chronic diseases (cancer, cardiovascular diseases and type 2 diabetes) among the Omani adults population. It has been suggested that such chronic diseases, will continue to drain Oman's human and financial resources, if appropriate interventions are not developed and introduced to current health care system; and early diagnosis and primary prevention of these chronic diseases are missed.

Elevated blood concentrations of homocysteine (hyperhomocysteinemia) and oxidative stress are well known risk factors for many chronic diseases, yet the etiologic relationship of hyperhomocysteinemia to oxidative stress-mediated chronic disorders remains poorly understood. The B-vitamins (Folate, vitamins B6 and B12) modulate cellular homocysteine availability by either sulfuration into cysteine, which is the precursor for de-novo synthesis of reduced glutathione or by methylation into methionine and formation of S-adenosyl methionine, the major epigenetic ethylating agent. Glutathione (GSH) is the major intracellular antioxidant and it undergoes oxidation to the disulfide form (GSSG), oxidized form, when scavenging reactive oxygen species that are highly unstable molecules, a reduced GSH/GSSG ratio is an indication of oxidative stress. Oxidative stress is a condition under which the intracellular antioxidant (GSH), antioxidant enzymes (glutathione peroxidase, superoxide dismutase, and catalase), and dietary antioxidants are not counterbalancing the reactive oxygen species-mediated cellular oxidative damage. Therefore an effective strategy to combat chronic diseases

is to early diagnose and/or screen high risk groups by measuring the specific metabolites which are involved in the pathogenesis of chronic diseases.

The general goal for this proposal is the primary prevention of hyperhomocysteinemia among the Omani adults' population as a high risk group for chronic diseases. The specific objectives will be attempted to: (1) Biochemical assessment of B-vitamins (folate, B6 and B12); using an automated random-access immunoassay system from Siemens Medical Solutions Diagnostics, ADVIA Centaur (Bayer ADVIA Centaur) Analyzer. (2) Thiol metabolites measurements using electrochemical detection by the Isocratic HPLC auto analyzer system (ESA Biosciences, Inc., Chelmsford, MA, USA, www.esainc.com). (3) Oxidative stress biomarkers measurements (total antioxidant capacity, glutathione peroxidase, catalase, superoxide oxidase). The early screening will allow in making an action plan; and then health cost could be reduced for secondary treatments and to keep efficiency of the country's work force.

Proposed Thesis Title: Stability of Functional Components in Broccoli (*Brasica oleracea*) with Respect to Micro-regions in the State Diagram and Health Functionality of Broccoli-extracts

Student Name : **Sithara Suresh Chandran**
Supervisor : Prof. Shafiur Rahman
Department : Food Science and Nutrition

Broccoli (*Brassica oleracea var. italica*) is a member of Brassicaceae family which is found along the Mediterranean region. It is a winter season vegetable crop with high nutrients and has been deemed as anti-cancerous food by the American Cancer Society. Broccoli is known as the "Crown Jewel of Nutrition" with a good source of vitamins, minerals, dietary fibre and other health functional active components. It is a significant source of biologically active components, such as flavonol glycosides, hydroxycinnamic acids and sulphur-containing compounds, such as the glucosinolates. It is also rich in vitamin C, a major antioxidant in Brassica vegetables. A great deal of research regarding cruciferous vegetables has focussed on sulforaphane, which is a hydrolysis product of glucosinolate found in broccoli. Sulforaphane is of interest since it primarily modulates the activities of phase II enzymes that convert carcinogens to inactive metabolites, thus it is documented for its carcinogenic properties. In addition, sulforaphane may have a positive influence on controlling diabetes. The processing methods, such as cutting, blanching, canning, freezing, drying and cooking as well as storage conditions affect the stability of the active components; and their activity and bioavailability. In the literature, negligible work has been reported to determine the stability of active components in broccoli during processing and storage (i.e. as a function of moisture and temperature). Therefore, the objectives of this study will be: (i) to develop a state diagram of broccoli by measuring its monolayer moisture, glass transition, solids-melting, freezing point and maximal-freeze-concentration condition, (ii) to determine stability of bioactive components at different micro-regions in the state diagram (i.e. varied moisture content and temperature), and to examine the health functionality of different types of extracts on diabetes rats. The different micro-regions of the state diagram will be developed by measuring its moisture sorption isotherm using isopiestic method; and thermal and thermodynamic characteristics using thermal analysis by Differential Scanning Calorimetry (DSC). Broccoli will be stored at different micro-regions by varying its moisture content and temperature. In the literature, thirteen micro-regions were proposed and it was hypothesized that micro-region 1 is the most stable and micro-region 13 is the least stable. The degradation kinetics of the active components will be modelled considering its decaying mechanisms and rate constants will be determined. The stability hypothesis based on the micro-region will be tested by comparing reaction

rate constants at different micro-regions. In addition, broccoli matrix mobility will be determined by Time Domain Nuclear Magnetic Resonance (TD-NMR). An attempt will be made to explain the stability of micro-regions considering their matrix mobility. The beneficial effects of broccoli-extracts will be determined on streptozotocin induced diabetic rats. The scientific findings would be beneficial to the food and pharmaceutical industry in order to develop health functional supplements in preventing and alleviating diseases.

Proposed Thesis Title: Alternative Protein Sources for White Shrimp *Penaeus indicus* Formulated Diet

Student Name : **Ahmed Said Saif Al Suti**
Supervisor : Dr. Wenresti Gallardo
Department : Marine Science and Fisheries

Fishmeal is the principal source of protein in commercial aquatic feeds. As a result of the steep increase in price of fishmeal and the decline in fishery resources that go into the fishmeal production, there is an interest in developing alternatives to this finite component. The objective of this study is to replace fish meal with chicken feather meal and microalgal meal in the formulated diet for Penaeus indicus juveniles. This study is designed to assess the efficacy and potential of various combinations of laboratory preparations of chicken feather meal, microalgal meal, soybean meal, wheat bran, wheat flour and fish oil in practical diets for juvenile marine shrimp, P. indicus. The quality of diets will be evaluated in terms of their effects on growth, survival and whole body composition of shrimp, feed intake, feed conversion ratio, protein efficiency ratio, apparent protein utilization, protein gain, attractability and palatability. The cost and benefit of using chicken feather meal and microalgal meal as ingredient in formulated feed will be assessed.

Proposed Thesis Title: Green Technology for the Prevention of Biofouling by ZnO Nanorods Modified Substrata

Student Name	:	**Priyanka Sathe**
Supervisor	:	Dr. Sergey Dobretsov
Co-supervisor	:	Prof. Joydeep Dutta
Department	:	Marine Science and Fisheries

Marine biofouling is the undesirable growth of micro and macro-organisms on man-made surfaces. It causes enormous problems in the maintenance of ships, boats, fishing nets, cages and desalination plants worldwide and in the Sultanate of Oman, in particular. One of the novel ways to prevent biofouling is based on using metal oxide nano-coatings. The proposed project aims at obtaining a better understanding of the biofouling processes in Omani waters by investigating the diversity and function of micro- and macro-fouling communities and the development of biofouling defence methods testing antimicrobial, anti-algal and anti-macrofouling activities of ZnO nanorod coatings in the field experiments.

Proposed Thesis Title: A Molecular Genetic Approach to Unveil the Genetic Structure of Tropical Spiny Lobster (*Panulirus homarus*)

Student Name : **Rafida Dhuai Gharib Al Breiki**
Supervisor : Dr. Sergey Dobretsov
Co-supervisor : Dr. Madjid Delghandi
Department : Marine Science and Fisheries

Spiny lobsters (Palinuridae) are classed as a luxury food and support valuable fisheries, which are of considerable socio economic importance worldwide. There are twenty different species (genus Panulirus) described, five in the Atlantic and fifteen in the Indo-Pacific Oceans (Holthuis, 1991). The scalloped spiny lobster, Panulirus homarus, contains three sub-species; P.h. homarus (Linnaeus, 1758), P.h. megasculpus (Pesta, 1915) and P.h. rubellus (Berry, 1974). P. h. homarus is the most widely distributed among the three subspecies of *P. homarus* and is found throughout the Indo-Pacific region with centres of high concentrations in East Africa and Indonesia (Berry, 1974; Pollock, 1993). The other two subspecies, P.h. megasculptus and P.h. rubellus are restricted to the Arabian Sea and southeast coasts of Madagascar and Southern Africa, respectively. Over-harvesting and destructive fishing practices, along with the degradation of the natural habitat from pollution and human activities have caused decline in the wild populations (FIGIS, 2012; Folmer et al., 1994). Understanding the genetic status of spiny lobster species is a prerequisite to achieve a rational conservation management plans for spiny lobster.

Genetic markers such as microsatellites and single nucleotide polymorphisms (SNPs) have been routinely used in fish population genetic and phylogenetic studies. Reports utilising microsatellite and SNP-marker analyses to study tropical spiny lobster population are limited, mainly due the lack of informative genetic markers. To date, only few microsatellite markers have been reported for Panulirus homarus (Naro-Maciel et al., 2011) and no SNP markers are known for the same species. Therefore, unique microsatellite- and SNP-markers still need to be developed for this species.

The proposed research project aims to obtain genetic data to support sustainable fishery management and stock enhancement of Panulirus homarus. In particular, intra- and interpopulation genetic diversity will be determined based on microsatellite and SNP markers in samples from different regions along the Arabian coast of Oman, South Africa, Australia and India. Approximately 100 microsatellite- and 1000 SNP-markers will be developed in co-operation with the research group of Professor Dean Jerry at the James Cook University, Queensland, Australia, using already established 454 whole-genome- and next generation- sequencing platforms. Significant number of samples will be collected from each region and genotyped using unique microsatellite- and SNP- markers developed in this project. Genotypes will be analysed statistically to determine the genetic

differences between samples collected from different locations. This study will be the first of its type to understand the genetic differences between Panulirus homarus subspecies inhabiting the Oman coastline, providing a tool for fishery management and stock assessment of this species in the region, or wherever the species is harvested.

Proposed Thesis Title: The Evaluation of Dates Supply Chain Performance in Oman from the Farm to the Export Markets

Student Name : **Mohammed Suleiman Rashed Al Shabibi**
Supervisor : Dr. Msafiri Daudi Mbaga
Department : Natural Resource Economics

The Vision 2020 strategy to diversify the Oman economy aims at increasing the contribution of non-oil sectors to the GDP. Under this vision, agriculture is expected to grow by 4.1% annually so as to contribute 3.1% to the GDP of Oman by 2020. Agricultural commodities produced in Oman include date palms, fruits, vegetables and livestock. Dates production is one of the most important agricultural activities in Oman, with an estimated 7.8 million trees grown throughout the Sultanate, occupying about 50 percent of the planted area.

Despite 50 percent of the planted area in Oman being under date palms, statistics shows that Oman is ranked 9th in the world in dates production far behind her neighbors such as Egypt, Saudi Arabia, Iran, United Arab Emirates and Pakistan. In fact, dates production has been declining since 2001, the year that date production reached its highest level in Oman in recent years. Export price per ton for Oman dates is also low compared to other countries such as Tunisia and Saudi Arabia.

Poor quality dates and the lack of a well-coordinated supply chain have been claimed to be among the reasons behind the observed poor performance. The objective of this thesis therefore is to evaluate the dates supply chain performance in Oman from the farm to the export market. The evaluation will be undertaken in three stages. In the first stage the production efficiency of date farmers will be analyzed to identify factors that hamper efficiency. In the second stage this research will look at the procurement of dates from farmers, financing, transportation to the factories, processing and packaging of dates for export. In the third stage this thesis will look at dates export performance, as well as, consumer preferences in the importing countries. Both stage two and three will involve benchmarking Oman with the leading dates exporting countries such as Tunisia and Saudi Arabia, in order to, identify gaps that will be key in improving the dates industry in Oman.

Proposed Thesis Title: The Effect of Trade Integration and Facilitation on the MENA Region Using General Equilibrium Approach

Student Name : **Ahmed Salem Said Al Shammakhi**
Supervisor : Dr. Houcine Boughanmi
Department : Natural Resource Economics

Over the past few years there have been a strong debate among economists regarding the effects of regional trade agreements between developed nations and developing world. The proposed study aims to assess the effects of intra/inter-regional trade agreement (FTA) on the Cooperation Council for the Arab States of the Gulf (GCC) under the Great Arab Free Trade Agreement (GAFTA) and the proposed FTA with European Union (EU), for which negotiations are underway. The objective of this paper is to assess the impact regional trade arrangement schemes in the MENA region using a global general equilibrium model and focusing on the GCC sub-region. In particular we will address the issue of whether fostering trade partnership with the rest of GAFTA is a better incentive for the GCC than engaging into preferential trade arrangements with well established trade blocs outside the region focusing on the contemplated GCC-EU free trade area. The study will employ the latest database of 2007 provided by GTAP 8.0 version. Results are expected to be in line with the global trend on trade liberalizations. Rest of GAFTA countries are expected to gain more than the GCC sub-region and that potential increase when elimination of NTBs is combined with increase in import efficiencies. It also expected that the impacts on the EU will be minor and relatively bigger for GCC economies with even better result when deeping integration between the two regions. Thre GCC may capture most of the gain from some sectors like oil and gas and petrochemical industries. However, EU may increase its marginal benefits in sectors like manufacturing and cars. It is also expected that GCC improved access to the large EU market increases opportunities for GCC exports, attract foreign investment, and stimulate economic development with trade as the engine of growth.

Proposed Thesis Title: An Empirical Assessment of Technical Efficiency and Capacity in a Regional Fishery of Oman

Student Name : **Mohammed Sulaiman Nasser Al Siyabi**
Supervisor : Dr. Shekar Bose
Department : Natural Resource Economics

Overall fisheries sector lacks an economics performance measurement for comparison, benchmarking and decision making. Efficiency is an important indicators because it involves cost, prices and margin. Although the government intend to invest more than 500 million Omani rail in the fisheries sector until 2020.

The main aim of this research is to evaluate economic performance for a regional fishery. More specific key objectives including examine the current economic efficiency states of harvesting practices, as well as, post-harvesting distributional performances and it will examine the economic consequences of the current situation both in harvesting and post-harvesting sectors. Finally, the study discusses the implication of the fisheries and recommend the policy options.

The study in Dhofar based on strong data quality and availability, as well as, community stewardship to the fishers, also, fish resources potential in the Arabian Sea and the fish sector in Dhofar is dominated by local fishers (23.6% of total fishermen in Oman).

The study will use two alternative frameworks Data Envelopment Analysis (DEA) and the Stochastic Production Frontier (SPF) for our empirical implementation to allow a comparison across method.

The framework of study will be the time series data for quantity landed from data base of Ministry of Agriculture and Fisheries to identify capacity and capacity utilization and field questionnaires will be submitted to identify the attitude and the opinion of fishermen and fish traders on fisheries distributional system in Dhofar Governorate in addition collection data about their dealings and difficulties and their suggestions of improving distributional efficiency.

The study is expected to find a considerable degree of inefficiency in harvesting and post harvesting operations. It is hoped that the findings from this study will help making informed and effective decisions for managing fisheries resources in the Governorate. Finally, this study could be used as a baseline study for investigating the extent of technical inefficiency in the fisheries sector in Oman.

Proposed Thesis Title: Economic Valuation of Natural Reserves in the Sultanate of Oman (Case of Marine Turtles).

Student Name : **Mariam Mohammed Yaqoub Al Busaidi**
Supervisor : Dr. Shekar Bose /Dr. Michel Claereboudt
Department : Natural Resource Economics

Oman has numerous natural resources, which contribute all to its geographical, social and economic wealth. In particular, Oman harbors a large diversity of species and ecosystems. The government of the Sultanate under the leadership of His Majesty Sultan Qaboos bin Said, has recognized the importance of nature conservation and developed a series of management practices implemented by the Ministry of Environment and Climate Affairs (MECA) to ensure the sustainable use of these resources. This responsibility focuses not only on national resources but also, through international agreements, conventions and memoranda of understandings extends at the international level. Part of the conservation strategy imparted to the Ministry of Environment and Climate Affairs is the designation and proclamation of Protected Areas (PA's). PA's now covers 3.78% of Oman territory. However, conservation of some species is severely threatened by various forms of economic development in several sites considered as essential to Oman's biodiversity. Among these species, are sea turtles. Four species of marine turtles nesting in Oman are classified as endangered or critically endangered according to International Union of Conservation of Nature (IUCN) red list. Although, the biology and ecology of these 4 species have been extensively studied in and outside of protected areas, the economics of the conservation effort granted by MECA has never been elucidated in Oman.

This research aims to provide an empirical valuation of the economic opportunities that can be generated from the conservation programs of sea turtles in Oman. Two sites, with contrasting characteristics, Masirah Island and the Turtles reserve at Ras Al-Hadd will be studied. The study will include economic valuation through applying the techniques of Contingent Valuation Method (CVM) and/or Travel Cost Method (TCM). CVM investigates the respondents Willingness To Pay (WTP) for improvement or their Willingness To Accept (WTA) a certain level of compensation for loss or degradation of a resource whereas, TCM involves the estimation of a demand function and therefore prices (cost) for recreation or other uses (activities) associated with a site. A subsequent comparison of the two sites using Conjoint Analysis (CA), which is based on the principle of breaking a product or a service down into its constituent parts (attributes) then to test combinations of these parts in order to find out what respondents prefer. In addition, the results of the valuation studies will be analyzed under The Economic of Ecosystem and Biodiversity (TEEB) approach to develop the best policy options for the different stockholders (MECA, MAF, MOT, ESO).

The primary data will be collected through two main questionnaires aimed at the economic valuation (QU1) and community perception (QU2) targeting the specific requirements of each method. QU1' focus groups will be different than those of QU2, in which QU1 will target visitors/ tourists, fishermen, researchers, officials, resort's owners, tourists companies and locals. QU2 however, will target the community members which includes resorts owners, fishermen, locals, researchers and officials A series of secondary data will also be collected from the main stakeholders involved in turtle conservation and management (MECA, MAF, MOT, ESO) and some players from the private sector (National Ferries Company, Ras Al Jinz Scientific and Visitor Centre, Hotels).

This study is the first focusing on the economic valuation of nature conservation, particularly for turtles. It will also provide a baseline, pilot study on using TEEB approaches in Oman and in the region. It will give MECA an overview of the costs and benefits of its conservation strategy for Marine Turtles both economically and socially. In addition, the project will give Oman and international visibility through collaboration with US and a commitment to the IUCN, the United Nations Environmental Program (UNEP) and the Marine Turtle Memorandum of Understanding of the Indian Ocean and South-East Asian region (IOSEA) .

Proposed Thesis Title: Role of Extremophilic Bacteria and Compost in Instigating Drought and Salinity Stress Tolerance in *Zea mayz* and *Triticum aestivum*

Student Name : **Nazia Hasan Hasan**
Supervisor : Dr. Baby Shaharoona
Department : Soils, Water and Agricultural Engineering

Crop production, particularly in arid regions is facing increasing stresses which are caused due to natural and anthropogenic factors. Increased incidence of water and salinity stresses has become major cause for stagnation of productivity in principal crops. Shortage of water and high salts in the soils are affecting the productivity of agricultural crops in arid region such as Sultanate of Oman. Extremophilic microorganisms could survive under extreme conditions of environment as drought, high soil salinity, and high temperature. These microorganisms could be used to help the plants to grow under stress conditions like drought, salinity and high temperature. Ethylene is the only gaseous hormone which is produced under stress conditions (abiotic or biotic stress) in plants and it is called stress ethylene. Ethylene prevents roots growth and so plant growth. Plant growth promoting bacteria PGPB decrease the plant ethylene levels by enzyme 1-aminocyclopropane-1-carboxylate (ACC) deaminase this enzyme break down the ethylene precursor ACC to α-ketobutyrate and ammonium and hence decreasing ethylene concentration will occur in stressed plant which thereby improve plant growth. This project is proposed to evaluate the effects of PGPR in abiotic stresses. Techniques like practicing to inoculate crop seeds with certain extremophiles before germination and increase fertility of soil by using compost will be used. Extremophiles will be collected from natural harsh climate of Oman. While, compost will be collected from there commercial source and will be enriched with nutrient and biologically active substances. The efficacy of PGPR and compost will be evaluated under green house and field trials. In future the outcomes will be helpful in designing the strategies for better crop yield by overcoming abiotic stresses by using PGPR. Production of eco-friendly bio fertilizer for increasing crop yield and bio control for weeds in harsh climate of Oman will help to increase the production of field crops.

Proposed Thesis Title: Assessment of Land Resources Changes Due to Salinization, Coastal Tourism Activities, Urbanization, Infrastructure Development, Population Growth, and Climate Change Using Remote Sensing Techniques: A Case Study of Al-Batinah Region in Oman

Student Name : **Sawsana Hilal Salim Al Rahbi**
Supervisor : Dr. Yaseen Al-Mulla
Department : Soils, Water and Agricultural Engineering

Land degradation, caused by various modern human activities, has become a major global issue. Soil salinization is one of the main causes of land degradation in arid and semi-arid regions. Where the accumulation of salts on soil surface reduces crop yields and land production. Approximately 52% of Al-Batinah region lands are affected by soil salinity and within 5 years (2000-2005) the percentage has increased by 7%. Remote sensing has been recognized as the most cost effective technique in soil salinity mapping and it is accurate, labor-saving and low time consuming technique. Thus, the overall objective of this study is using remote sensing techniques to assess the impacts of the environmental and anthropogenic changes on land resources in Al-Batinah coastal region. More precisely, the specific objectives are, to produce maps delineating the types of plants and the levels of soil salinities across the study area, to detect the temporal changes in land resources including plantation and salinity level, and to develop a model to predict the status of soil salinity and vegetation in the future. Remote sensing data from different satellites sources including WorlView-2 of the study area will be acquired for the years 1994, 2004 and 2015. ERDAS software will be used for the remote sensing analysis of the satellites data. Pre-processing corrections will be performed on the images. Then, in addition to analysis of spectral indices, spectral signatures of different features on the ground especially the vegetation will be computed and used for the assessment. Ground truthing will include collecting soil samples from different sites around the study area which will be analyzed in the laboratory to characterize soil texture, structure, pH, electrical conductivity (EC), Exchangeable Sodium Percentage (ESP) and Sodium Adsorption Ratio (SAR). In addition, ground truthing will also include a collection of through information on the vegetation types and distribution using global positioning systems (GPS) and portable spectrometer. Statistical analysis will be performed to assess the correlation between the measured, modelled data and the spectral data.

Proposed Thesis Title: Influence of Root Zone Temperature of Soilless Cultivation System on the Production of High Value Crops to Enhance Food and Nutrition Security

Student Name : **Muthir Saleh Said Al Rawahi**
Supervisor : Dr. Salim Ali Al-Rawahy
Department : Soils, Water and Agricultural Engineering

Soilless culture (Hydroponics) is a technique for growing plants without the conventional soil but rather in an inert growing media or directly in nutrient solution where plant requirements of water and nutrients are available in the right balance to satisfy crop requirements. Hydroponics has been widely adopted by growers in large commercial scale all over the world in particular for high value vegetable crops grown under greenhouse. In Oman, greenhouse growers are facing problems associated with water scarcity and quality coupled with soil salinity and soil-borne pests and diseases. Therefore, the adoption of soilless growing techniques (hydroponics) is inevitable for the production of high value nutritious vegetable crops. Soilless growing techniques were introduced to Omani growers some ten years ago through the technical collaboration between the Ministry of Agriculture and the International Centre for Agricultural Research in Dry Areas (ICARDA). The techniques are highly successful with Omani growers where they produce high quality crops with high economic returns. However, the high temperature during summer time is affecting the nutrient solution quality and hence affecting plant growth and development negatively. The proposed research program is planned to investigate the problem with a number of research experiments to study (1) the influence of nutrient solution temperature on the solution oxygen level and its effect on root and plant growth and development, yield and quality of products; (2) Study the effect of root zone temperature on nutrient uptake and plant growth and development, yield and quality; (3) Enhancing system design including growing canals, pots and media to avoid the negative effects associated with root zone temperature to maximize yield and quality.

Proposed Thesis Title: Challenges in Developing CEA in Arid Areas: A Case Study in Oman

Student Name : **Nawal Khamis Khalfan Al-Mezeini**
Supervisor : Dr. Abdulrahim Al-Ismaili
Department : Soils, Water and Agricultural Engineering

Oman, as an arid climate, suffers from significantly high temperatures and severe water shortages. Controlled environment agriculture (CEA), particularly greenhouses, is an option adopted to overcome these two factors by providing relatively cool atmosphere and by increasing land and water productivities as compared with open-field cultivation. In Oman, it was found that greenhouse cultivation increased land productivity by almost 12 times and water productivity by almost double. As a result, farmers' willingness to shift from open-field cultivation to CEA is very noticeable. Number of greenhouses has increased from 782 to 2491 over the period 2001 – 2008; an increase by three and in 2010, it reached 4740 indicating an annual greenhouse growth rate of approximately 40%. Because of the various advantages of CEA, Ministry of Agriculture and Fisheries (MAF) was keen to spread this technology through subsidy programs and awareness campaigns. The subsidy programs were very successful such that every 1.000 Omani Rial invested as a subsidy increased the agricultural net returns by 1.690 Omani Rial. Furthermore, farmers were positively affected by MAF's efforts to disseminate this technology as the number of farmers who built greenhouses on their own expense exceeded those who received support. Nonetheless, MAF & ICARDA (2011) reported that a wide range of farmers still bear some difficulties related to CEA such as problems in marketing their agricultural products and other hindrances related to external competition. Literature does not contain comprehensive and in-depth studies about the status of CEA in Oman except for few statistical data collected via agricultural censuses. This study, therefore, aims to thoroughly study strengths and weaknesses of CEA in Oman. It will also propose strategic plans and mechanisms to develop the CEA agribusiness and overcome all the obstacles. All of this will be advanced with an intense field work to gather the required data about CEA facilities in Oman. Through this study, a comprehensive database about CEA in Oman will be established.

Thesis Abstracts of Postgraduate Students who Graduated in 2014

PhD

Morphological Characterization, Molecular Diversity and Phytochemical Evaluation of Fenugreek (*Trigonella foenum-graecum* L.) in Oman

Student Name : **Issa Taleb Rashed Al Mamari**
Supervisor : Dr. Mumtaz Khan
Department : Crop Sciences

Fenugreek (*Trigonella foenum-graecum* L.) is widely grown in the Arabian countries and is one of the important crops in the Sultanate of Oman. The objective of this study was to characterize the morphological, genetic and nutritional traits of 20 different Omani fenugreek accessions collected from the different districts of Oman. In addition to this another goal was to investigate the genetic relationship (if any) of Omani fenugreek biotypes with four accessions obtained from Iraq and Pakistan.

Field experiments were carried out in a randomized complete block design for two winter seasons (2010/11 and 2011/12). Significant differences ($P < 0.05$) were observed among Omani fenugreek accessions in the mean plant height (26.8 cm ± 0.43), number of branches (3.4 ± 0.07), number of leaves (42.1 ± 0.95), leaf area (2.3 cm^2 ± 0.02), number of pods (32.1 ± 0.61), pod length (9.1 cm ± 0.06), weight of pods (17.3 g ± 0.5), weight of seeds (11.2 g ± 0.34) and number of seeds (134.2 ± 2.9). A higher genetic gain was observed in the character of number of seeds, while the lowest genetic advance was observed in pod length character. The principle component analysis (PCA) yielded 77% of the total variation in two seasons.

Amplified Fragment Length Polymorphism (AFLP) analysis of 24 accessions produced 1852 polymorphic loci. The level of genetic diversity (H) was found to be 0.2146, 0.0844 and 0.1620 for the Omani, Pakistani and Iraqi populations, respectively. The moderate level of genetic diversity of fenugreek in Oman indicated that it has been cultivated in the country for the long time. A very low level of genetic differentiation was observed among populations of fenugreek from different regions (districts) in Oman (Fst = 0.05). Cluster analysis supported these findings and indicated high genetic similarity among Omani populations of fenugreek (mean = 93%).

The analysis of phytochemical of seeds showed significant differences ($P < 0.05$) among the different Omani fenugreek accessions. The mean values for total phenolic contents, tannins, flavonoids and saponins were 133.37 mg GAE/100g, 52.28 mg CAE/100g, 18.79 mg CAE/100g, and 12.99 mg/100g, respectively. The results indicated that accession # 49 was superior in total

phenolic contents (216.47 mg GAE/100g), total flavonoids (32.81 mg CAE/100g) and saponins (17.02 mg/100g). The highest mean content of tannin was found in accession # 209 (74.54 mg CAE/100g). Significant difference ($P < 0.05$) was also observed in the ferric reducing antioxidant power among the Omani fenugreek accessions and the accession # 63 was found to be superior among the Omani accessions (0.259 mMoles/L). Three main principle components analysis of the phytochemical contents produced high variability (86 %).

This is the first study to characterize the phenotypic, genetic diversity and phytochemical composition among the various fenugreek populations in the Arabian Peninsula. The findings of this study indicated that the phenotypic and genetic diversity are moderate within the Omani fenugreek. It also provided an evidence of having a relationship between fenugreek populations from different regions in Oman. The results suggest a frequent exchange of fenugreek genetic material among various regions within Oman. The findings of this study will be helpful in making selection of potential fenugreek accessions based on their phytochemical composition and antioxidant potential for further improvement and development of hybrid Omani fenugreek plant.

Characterization of Vine Decline of Muskmelon in Oman and Evaluation of Grafting for its Management

Student Name : **Qais Saif Aamer Al Maawali**
Supervisor : Prof. Michael Deadman / Dr. Abdullah al-Sadi
Department : Crop Sciences

Muskmelon vine decline disease is the most important factor limiting muskmelon production in Oman. Losses due to this disease have been reported to exceed 90% in several farms. This study was conducted to characterize etiology and response of muskmelon cultivars to vine decline disease, and to evaluate graft success and effect of grafting on resistance to vine decline disease and quality and yield of muskmelon. A survey showed that incidence of the disease ranged from 0% to 80 % (mean 11%). *Monosporascus cannonballus*, *Rhizoctonia solani* and *Pythium aphanidermatum* were found to be the causal agents of vine decline of muskmelon in Oman and were consistently isolated from muskmelon plants on a weekly basis from 14 days until the end of the season. This is the first record of *M. cannonballus* as a causal agent of muskmelon vine decline in Oman. However, symptom development only began with the onset of fruiting, which suggests that fruiting stress may be a factor in vine decline disease development. Field assessment of 11 muskmelon cultivars showed that Shahd F1 was one of the cultivars least susceptible to vine decline disease and was relatively high yielding.

Artificial inoculation of different rootstocks produced no damping-off and very low vine decline disease severity index (DSI) in Mubyeongjangsoo (hybrid squash), Titan (hybrid), Tetsukabuto (hybrid squash), Rsscih7458 (hybrid squash), Squash Ezra F1 and Strong Tosa F1 Hybrid rootstocks. All rootstocks showed high grafting success and lower graft failure with the five selected muskmelon cultivars. Grafted muskmelon cultivars maintained disease levels in both seasons below average disease levels of non-grafted control treatment. Rootstocks enhanced early harvesting of grafted Tamara F1. All rootstocks increased fruit number and fruit weight in grafted Tamara F1. Only Mubyeongjangsoo (hybrid squash) enhanced chlorophyll content of leaves of all grafted muskmelon cultivars. All rootstocks decreased stem diameter of grafted Sawadi and Samit F1 muskmelon and produced various effects on the others. TSS was not affected by grafting of Sawadi muskmelon cultivar, Samit F1, Shahd F1, Caramel F1 and Tamara F1. Fruit shape was not affected by grafting of Sawadi muskmelon cultivar, Shahd F1 and Tamara F1. Grafted Shahd F1 showed no significant difference in rind brightness, redness, and yellowness with the control, and grafted Tamara F1 showed no significant difference in rind brightness (L) and yellowness (b) with the control. No significant differences were observed between seasons among the six treatments and a non-grafted control in consumer preference for odor and firmness or for flesh vitamin C, micronutrient content and pH. The concentration of phosphorus and sodium significantly decreased in both

seasons in all grafted treatments in comparison to the control. In both seasons potassium content significantly increased when Rsscih7458 and Mubyeongjangsoo rootstocks were used. Strong Tosa and Tetsukabuto rootstocks showed the highest consumer acceptance for rind color and flesh color in spring 2013. Tetsukabuto showed a higher rating for overall consumer acceptance in spring 2013 and was also less affected by seasonal changes. This study provides evidence that muskmelon vine decline in Oman is caused by different pathogens. Grafting can reduce damage in the field and improve fruit quality.

Genetically-Engineered Resistance in Tomato Against Tomato Yellow Leaf Curl Disease Prevalent in Oman

Student Name : **Um E Ammara**
Supervisor : Dr. Abdullah Al-Sadi
Department : Crop Sciences

Tomato yellow leaf curl virus (TYLCV) is the most prevalent viral pathogen responsible for heavy yield losses of tomato in Oman. This virus belongs to the genus *Begomovirus* of the family *Geminiviridae.* Despite all efforts to manage TYLCV, there is no natural source of resistance available that can provide 100% resistance against it. This study was carried out to develop broad-spectrum resistance against begomoviruses infecting tomato plants using pathogen-derived resistance.

Firstly, a reliable tomato transformation protocol was established by optimizing the efficiency of *Agrobacterium*-mediated tomato transformation. Cotyledon and epicotyl parts from susceptible tomato cultivars (cvt) Moneymaker, Pusa ruby and Jinan were used as explants and co-cultivated with *Agrobacterium tumefaciens* strain AGL1 harboring different genes. The effects of putrescine, vitamins, explants and growth regulators on plant transformation and regeneration were studied. Conditions were optimized to achieve transformation efficiency up to 49.2% with cotyledons used as explants. After that three genes ($Rep_{syn130,}$ CPsyn and hpRNAi) were cloned and transformed independently in tomato cultivar (cvt) Pusa ruby to test their individual ability to offer resistance to *Tomato yellow leaf curl virus-Oman* (TYLCV-OM) and Tomato leaf curl betasatellite-Oman (ToLCB-OM). Homology-dependent gene silencing of the transgene was avoided using codons highly expressed in tomato. 1) Gene encoded a truncated Rep protein comprising of 130 amino acids from N-terminal of Rep (Rep_{syn130}). The gene was transformed in cvt. Pusa ruby plants and T_1 transgenic plants were co-infiltrated with TYLCV-OM and TYLCV-OM/ ToLCB-OM. Seven out of 9 transgenic lines were found to be resistant to the begomovirus-betasatellite complex. 2) Hairpin construct targeting four different regions of TYLCV-OM including pre-coat protein (V2), overlapping region of coat protein (CP), replication associated protein (Rep) and part of the conserved intergenic region (IR). Nine transgenic lines expressing hpRNAi construct were challenged with TYLCV-OM and TYLCV-OM/ToLCB-OM. Transgenic plants inoculated with TYLCV-OM did not develop symptoms even 60 days post-inoculation (60 dpi) and showed 80-100% resistance while transgenic lines inoculated with TYLCV-OM/ToLCB-OM showed 70-80% resistance. 3) Synthetic codon-optimized CP (CPsyn) of TYLCV-OM which was expressed in transgenic tomato to avoid gene silencing of the transgene upon virus infection. Plants of 3 transgenic lines out of 7 showed resistance against TYLCV-OM and TYLCV-OM/ToLCB-OM. Southern hybridization and real time quantitative PCR data showed that transgenic plants accumulated low

levels of viral DNA. 4) Finally, a single construct was developed by combining Rep_{syn130}, RNAi and CP_{syn} under their independent promoter/terminator to avoid promoter silencing. A total of 24 positive transgenic lines were produced and evaluated for their resistance against TYLCV-OM, *Tomato leaf curl Albatinah virus* (ToLCABV) alone and with ToLCB-OM. Results indicated that 100% resistance level was achieved against TYLCV-OM and ToLCABV when all genes were assembled in a single construct.

This study shows that the resistance response of transgenic plants against TYLCV-OM and TYLCV-OM/ToLCB can be improved by combining genes for resistance in a single construct. The developed multi construct transgenic lines can be further evaluated for their resistance potential against diverse heterologous geminiviruses reported from Oman.

Biodiversity of Begomoviruses Associated with Tomato in Oman and the Role of Coat Protein Gene (ORF V1) and Rep Gene (ORF C1) in Pathogenesis of *Tomato Yellow Leaf Curl Virus* Oman

Student Name : **Abdulrahman Mohammed Obeid Al Matroushi**
Supervisor : Dr. Abdullah Al Sadi
Department : Crop Sciences

Tomato yellow leaf curl virus (TYLCV) and other members of the genus begomovirus are major constraint to tomato production in Oman. They are either bipartite (DNA-A and DNA-B) or monopartite (DNA-A). Monopartite begomoviruses have six Open Reading Frames (ORFs), among them coat protein gene (ORF-V1) and Rep gene (ORF-C1) are encoded on virion sense strand and complementary strand, respectively. Tomato yellow leaf curl disease is caused by a complex of TYLCV species as well as other begomoviruses.

The objectives of this work are to determine the diversity of begomoviruses and associated betasatellite in tomato crop, to study the role of betasatellite associated with tomato begomoviruses in symptom development and to elucidate the role of TYLCV-OM ORF-V1 and ORF-C1 in pathogenesis. Symptomatic tomato leaves were collected from different Welayat and total genomic DNA was extracted. The viral DNAs were amplified using Rolling Circle Amplification (RCA). The viral genomic components were cloned using unique restriction endonucleases and were completely sequenced. Agroinfectious constructs of TYLVC-OM DNA-A and DNA-ß were made in a binary vector. Their infectivity was checked individually as well as in different combinations on tobacco and tomato plants. Site directed mutagenesis on ORF-C1 and deletion mutagenesis on ORF-V1 were performed. The infectivity of the mutants was tested by Agro-inoculation and symptom development was compared. Five different begomoviruses were found to be associated with tomato in Oman. Tomato yellow leaf curl virus strain Oman (TYLCV-OM) was found to be confined to the northern governorates of Oman. *Tomato leaf curl Al Batinah virus* (ToLCABV), the recombinant between *Chili leaf curl virus strain Oman* (ChLCV-OM) and *Tomato leaf curl Oman virus* (ToLCOMV) was found to be confined to Al Batinah governorate in the Northern part of Oman. ToLCOMV was also found to be confined to Al Batinah. ToLCSDV was found in Dhofar, the Southern governorate and Manah of A'Dakhliah governorate in the North. However, *Chili leaf curl virus* strain Oman (ChLCV-OM) was found to be associated with tomato in all governorates of Oman. TYLCV-OM, ToLCOMV and ChLCV-OM were found to be associated with betasatellite. On the other hand, ToLCABV and ToLCSDV were not found to be associated with betasatellite. Betasatellite was found to be able to interact with these begomoviruses and change the phenotype of the symptoms. ORF-V1 and ORF-C1 of TYLCV-OM were found to be essential for pathogenicity of the virus. The data presented here is the first comprehensive study of begomoviruses and their associated betasatellite and suggest that begomoviruses of diverse origins were introduced into Oman through trade and these viruses are rapidly evolving by recombination.

Physico-Chemical Characteristics of Pericarp from *Punica granatum* L. Cultivated in Oman and its Amelioration of Azoxymethane Induced-Carcinogenesis and Oxidative Stress in Rat Colon

Student Name : **Amani Salim Mohammed Al-Rawahi**
Supervisor : Prof. Mohd Shafiur Rahman
Department : Food Science and Nutrition

Polyphenols are known to possess anti-inflammatory, anti-carcinogenic, and antioxidant properties. Pomegranate pericarp has a high content of polyphenols. No research has been done using pomegranate pericarp from Omani variety; *Hellow*. This study was undertaken to characterize the physiochemical properties of pomegranate pericarp, analyze the individual phenols present in the pericarp and investigate the effect of the pericarp extract on the azoxymethane (AOM) induced-carcinogenesis and oxidative stress in rat colon. Pomegranate pericarp was dried by freeze-drying, air-drying, vacuum-drying and sun- drying. The moisture sorption isotherm was measured and modelled using the Brunauer–Emmett–Teller (BET) and Guggenheim–Anderson–De Boer (GAB) models. Two solvents (methanol and ethanol) and water were used to extract the phenolic compounds in pomegranate fruit pericarp. All drying methods reduced the extractable polyphenols irrespective of the solvent used. Freeze-drying pericarp retained the highest level of polyphenols in comparison to the other drying methods.

Thermal characteristics of pomegranate pericarp extract (PomPE) were measured as a function of moisture and temperature. A state diagram of the extract was developed by measuring the freezing curve, glass transition line and ultimate maximal-freeze-concentration conditions. The freezing point and glass transition were modelled using Chen's model based on the Clausius-Clapeyron equation, and Gordon-Taylor equation, respectively.

Total phenols, total flavonoids and total antioxidant capacity tests of pomegranate pericarp extract were assayed. The extract was subjected to ESI-MS/MS. Results revealed high contents of total phenols, total flavonoids and total antioxidant capacity. The analysis revealed the presence of 61 different polyphenols in the extract. Major compounds were tannins and flavonoids such as; ellagic acid, gallic acids, punicalin, punicalagin and malic acid.

The chemopreventive effect of pomegranate pericarp extract against AOM-induced oxidative stress and carcinogenesis in rat colon was investigated. The colon tissues were examined microscopically for pathological changes and aberrant crypt foci development, genotoxicity, micronuclei cells enumeration, and measurement of glutathione and lipid peroxidation. Results showed that the concomitant treatment of AOM with PomPE had significantly ameliorated the observed AOM cytotoxic effects.

In conclusion, this study was able to analyze the effect of different drying methods on the retention of polyphenolic content of pomegranate pericarp extracts, develop the state diagram of the extract, characterize 61 individual polyphenols present in the pomegranate pericarp extract and reveal the anti-carcinogenic and anti-inflammatory ameliorating effect against AOM-induced cytoxicity in rat colon.

Functional and Textural Properties of Date Palm (*Phoenix dactylifera* L.) Fruits

Student Name : **Vandita Singh**
Supervisor : Prof. Nejib Guizani
Department : Food Science and Nutrition

Locally grown date palm fruit varieties such as Fardh, Khasab and Khalas at *tamar* and *rutab* stages were analyzed for bioactive compounds. Date Fruit (DF) extract was investigated for its antioxidant activities using several assay methods and for its protective effect against 3-nitropropionic acid (3-NP) induced neurotoxicity in pheochromocytoma (PC12) cells. The extraction of the polyphenols was conducted by changing solvents, temperature and pH. The stability of the polyphenols was also investigated. In addition the textural properties of DF (9 batches) were investigated using sensory, instrumental texture and physico-chemical properties to derive a correlation between these properties.

Among the three DF varieties Fardh variety had showed the highest phenolic and flavonoid contents and exhibited maximum antioxidant capacity. Further its extract was found to offer significant protection to 3-NP induced neurotoxicity significantly in PC12 cells by means of increasing the cell viability, improving the antioxidant status and by reducing the free radical generation. However, the exact mechanism of action is unknown and further extensive studies are warranted.

In the extraction studies the highest recovery of polyphenols was obtained by using a combination of low pH (=2) and high temperature (60°C) using methanol: water (4:1) mixture. Textural studies including Cluster analysis (CA) and principal component analysis (PCA) classified the 9 batches of DFs into 3 groups (hard-chewy, soft-medium-chewy and soft-non-adhesive) on the basis of their sensory and physico-chemical properties. Similarly, the results of instrumental TPA (Texture profile analyser) and physico-chemical properties classified them into 3 groups (hard-resilient, soft-springy and firm-adhesive). Significant correlation was obtained between sensory and instrumental textural attributes and with physico-chemical properties.

MSc

Determination of Quality, Nutritive Value and Chemical Contaminants of Broiler Chicken Meat in Oman

Student Name : **Arwa Suleiman A'Rujaibi**
Supervisor : Prof. Isam Kadim
Department : Animal and Veterinary Sciences

Poultry meat safety and quality are the two top priorities of great concern for consumers today. Safety issues are associated with consumer's health with hazard include chemical, biological and physical contaminants in food. Quality issues reflect the level of quality characteristics of food products in terms of nutritional value, composition and quality parameters as well as consumer's acceptance of the product. In this study a total of 90 broiler poultry products (frozen, fresh, minced, sausages, burgers and mortadella meats) were analyzed for quality characteristics (tenderness, pH, expressed juice, sarcomere length, colour), nutritive value (amino acid and fatty acid profiles), proximate composition (dry matter, protein, fat and ash) and chemical contaminates (antibiotics: streptomycin, tetracycline, sulfamethazine and sulfamethoxazole, hormones: testosterone, trenbolone and estrogen, pesticides: 2,4 D, DDT/DDE, triclosan, alachlor and organophosphate/carbonate and melamine concentration levels) using ELISA.

Meat quality characteristics including tenderness, cooking loss, colour, sarcomere length and pH of broiler products available in local market were within the normal range for other broiler products available in elsewhere in the world. There were no significant differences in quality parameters between various brands used in the current study. Proximate chemical analysis of broiler meat products demonstrated small variations between different brands. Stearic acid (C18:0) was the most abundant saturated fatty acid in broiler chicken meat, followed by palmetic stearic acid (C16:0). The predominant monounsaturated fatty acids was palmitoleic acid (C16:1), while linoleic acid (C18:2n6) was the predominant polyunsaturated fatty acid in broiler chicken The ratio of unsaturated to saturated fatty acids in broiler chicken meat ranged from 0.47 to 0.88. Chicken meat partially satisfies nutritional guidelines as it is a better source of polyunsaturated fatty acid compared with red meat. Meat samples contained various levels of residues of different chemical substances tested. With the exception of testosterone and estrogen, levels of the chemical contaminates were below the international allowable levels set by the German Residue Control Plan and the European Union. The range of testosterone (0.22-1.01 ppb) and estrogen (0.23-0.59 ppb) were above the detectable limit (0.10) set by the Germany Residue Control Plan. This study indicated that poultry meat products sold in Oman generally contains some residues of antibiotics, anabolic agents and pesticides. Although the levels were within the allowable limits, their presence may still be regarded as a health hazard as they may cause allergic reactions or produce drug-tolerant bacteria in humans. More care is needed to monitor importation regulations of poultry meat intended for human consumption.

Cultural and Molecular-Based Analysis of Fungal Diversity in Potting Media, Organic Fertilizers and Composts

Student Name : **Safa Said Saif Al Mazrouia**
Supervisor : Dr. Abdullah Al-Sadi
Department : Crop sciences

This study was conducted to investigate diversity of fungi in potting media, organic fertilizers and compost using culture-based and pyrosequencing techniques. Fungal diversity was evaluated using serial dilution, direct plating and baiting with carrot slices, potato slices, radish seeds, cucumber seeds and cucumber cotyledons. Identity of the isolates was confirmed using sequences of the ITS rDNA. Direct plating technique was found superior over other culture-based techniques in the number of fungi detected. It was also found to be a simple and less time consuming technique. Comparing the efficiency of direct plating with pyrosequencing revealed that pyrosequencing detected 12 to 18 times more fungi from potting media (PM), organic fertilizers (OF) and organic composts (OC). Analysis revealed that there were differences between PM, OF and OC in the dominant phyla, classes, orders, families, genera and species detected. Evaluation of products from the USA and European and Asian countries revealed that they have different levels of contamination with pathogenic and saprophytic fungi. *Trichoderma, Aspergillus* and *Penicillium* were the most dominant fungi in all samples. *Simplicillium* spp*., Cladosporium* spp*., Bionectria* spp*., Alternaria* spp. and *Fusarium* spp. were recovered at different frequencies from samples of potting media. *Fusarium* spp. were recovered at high frequencies from samples of organic fertilizers, and organic and non-organic composts. Detection of plant pathogenic fungi in imported agricultural material raises concerns from risks associated with these materials. The evaluated methods in this study, especially direct plating and pyrosequencing, may be used as tools by quarantine officers to help detect and reduce entry of unwanted fungi into Oman.

Genetic Diversity and Variation in Resistance to Hymexazol Among and Within *Fusarium solani* Populations Obtained from Citrus, Cucumber and Date Palm in Oman

Student Name : **Ruqaya Salim Mohammed Al Masoudi**
Supervisor : Dr. Abdullah Al-Sadi
Department : Crop Sciences

A study was conducted to investigate diversity among 80 *Fusarium solani* isolates obtained from date palm (30), citrus (31) and cucumber (19).Characterization based on sequences of the EF1α and ITS rDNA genes of the 80 *Fusarium solani* isolates showed grouping of the isolates in two major clusters, with no relationship with the host or geographical origin from where the isolates were obtained. AFLP analysis using 3 primer pair combinations produced 980 polymorphic and 80 AFLP genotypes. Populations from different hosts and districts showed moderate levels of genetic diversity (H= 0.2494). Clustering of the isolates was not related to host or geographical origin of the isolates. This was supported by analysis of molecular variance (AMOVA) which indicated the existence of low level of genetic differentiation among populations obtained from different hosts (Fst = 0.0162) and regions (Fst= 0.0066). *F. solani* isolates displayed variation in sensitivity to hymexazol, with EC_{50} values ranging from 2 to 5745µg ml^{-1} (mean = 878 µg ml^{-1}).This implies the existence of resistance to hymexazol among *F. solani* isolates in Oman. The study provides evidence for frequent movement of *F. solani* inoculum among hosts and regions in Oman, which could be attributed to cultural practices employed by farmers. Growers should move towards the use of integrated disease management strategies to avoid further development of resistance to hymexazol.

Effect of Daily Iron Supplementation and Nutritional Status of Omani Anemic Pregnant Women

Student Name : **Hekmat Shuwaired Al-Yaqoobi**
Supervisor : Dr. Mostafa Waly
Department : Food Science and Nutrition

Background: Iron deficiency anemia (IDA) during pregnancy is a public health problem in Oman. Although a national anemia control program provides daily iron supplementation for pregnant women through antenatal care services, yet the prevalence of IDA is increasing.

Objectives: This study is aiming to evaluate the impact of daily iron supplementation on iron status of pregnant Omani women and to explore anemia-related perceptions among the enrolled study subjects.

Methods and Subjects: A cross-sectional study approach included pregnant women visiting primary health care. Inclusion criteria were pregnant Omani women on their first trimester and have hemoglobin (Hb) level less than 11 g/dL. The efficacy of the iron supplementation was assessed by comparing the Hb levels of the study subjects at the time of enrollment with that by the end of pregnancy.

Results: fifty four study subjects were recruited on voluntary basis for this study; 42 were complied with the iron supplementation program meanwhile 12 were not complied with the iron supplementation. The enrolled anemic pregnant women who were iron supplemented had no improvement in their Hb level by the end of pregnancy. The reasons of the failure of daily iron supplementation program for the enrolled study subjects were: poor compliance of taking the tablets as a daily dose, late start of the iron supplementation, misconceptions on the effect of iron supplementation and inadequate motivation. In addition all study subjects had low daily dietary intake of iron.

Conclusion: Daily iron supplementation among the enrolled study subjects is not effective in improving their Hb levels. Poor adherence to the required daily dosage and wrong believe were common among the majority of the enrolled study participants.

Oxidative Stability of Omani Date-Pits Oil During Storage

Student Name : **Naima Al-Kharousi**
Supervisor : Prof. Mohd Shafiur Rahman
Department : Food Science and Nutrition

Date-pits are considered as waste and value added functional food components could be developed. One of the important value added components could be oil from date-pits. In order to utilize it as cooking or frying oil, it is important to measure its characteristics and oxidative stability during storage. Date-pits contained moisture, protein, fat, fiber, ash and total carbohydrate as 4.1, 6.1, 9.2, 0.92, 31.3 and 79.7 g/100 g date-pits. It also contained significant amount of important minerals. Calcium was the highest (2994 ppm), followed by potassium (1712 ppm), magnesium (687 ppm), selenium (456 ppm), iron (14.8 ppm) and zinc (10.19). Date-pits oil showed a low refractive index (1.450) with density 876.5 kg/m^3 and polyphenols as 22.0 mg/100 g oil. Thermal characteristics of date-pits oil measured by MDSC showed oil crystallization by an exothermic peak during cooling and an endothermic peak during heating. The melting (i.e. non-reversible) showed two peaks and onset at -32.0^{o}C, maximum slope at -10.0^{o}C, peak at -0.3^{o}C, end at 19.6^{o}C and total enthalpy of 60.0 kJ/kg. The onset, mid and end of glass transition were -12.1, -10.4, and -7.8^{o}C, respectively with a specific heat change 308 J/kg K at its transition. Date-pits oil contained six major fatty acids (i.e. $C_{18:1}$, $C_{18:2}$, $C_{18:0}$, $C_{16:0}$, $C_{14:0}$ and $C_{12:0}$); oleic fatty acid ($C_{18:1}$) is the highest level (47.5%). In this study the oxidative stability of Omani date-pits oil was studied during storage at different temperatures (30, 100 and 150^{o}C). The saturated fatty acid increased while the unsaturated fatty acids (mono and polyunsaturated) decreased significantly with increase of storage temperature and time ($p<0.05$). The reduction of linoleic acid ($C_{18:2}$, ω6) was much higher (i.e. 90.0%) than the reduction of oleic acid ($C_{18:1}$, ω9) (i.e. 27.0%) due to the increased sensitivity of $C_{18:2}$ to oxidation. Oxidation parameters (AV, PV and PAV) increased significantly with the increase of storage time and temperature ($p<0.05$). Considering free fatty acid, it was observed that date-pits oil had relatively good oxidative stability at low temperature (i.e. 30^{o}C) at least 90 days as maximum storage time used in this study. However, its acceptability remained up to 49 days of storage at 100^{o}C, while it was 28 days during storage at 150^{o}C. Based on the fatty acid composition and oxidative stability of date-pits oil, it could be used as edible cooking oil. In addition, it could be used in pharmaceutical, cosmetic and other non-food industries.

Relationship Between Nutrition Quality of Life (NQOL) and Depression and Anxiety Among Omani Patients with Type 2 Diabetes Mellitus in Muscat

Student Name : **Masooma Mubarak Al Toobi**
Supervisor : Dr. Lyutha Al-Subhi
Department : Food Science & Nutrition

Diabetes is a global problem with a very high prevalence in Oman. Diabetes has been found to be associated with having a lower Quality of Life (QOL) and higher levels of anxiety and depression. Medical Nutrition Therapy (MNT) has been found to result in better anthropometrics and biochemical values. MNT has also been found to result in higher QOL and lower anxiety and depression levels. *Nutrition Quality of Life* (NQOL) is a new tool that is designed to assess the QOL in patients coping with nutritional problems. Few studies have been conducted to investigate the NQOL among different clinical conditions, but none was conducted on people with diabetes. Thus, the goal of this study is to investigate the relationship between NQOL and depression and anxiety in a sample of Omani patients with type 2 diabetes based on their history of glycemic control, History of Medical Nutrition Therapy (HMNT) and anthropometrics in primary health care.

A sample of 149 adults with type 2 diabetes was randomly included from seven PHCs from all six Willayats of Muscat. NQOL survey version 1.4 was translated into Arabic and used to assess NQOL in participants. Previously translated and validated Arabic version of *Hospital Anxiety and Depression Scale* (HADS) was used to assess anxiety and depression. Demographic data and surveys were filled via face to face interviews. Anthropometrics were measured by a staff nurse and the newest HbA1c value recorded no more than one year from the date of interview was solicited from the participants' medical records. Data analysis was conducted using SPSS program.

Out of the sample study, 69.8% were females, 52.3% were of low income group (≤400 RO per month), 71.1% had uncontrolled diabetes, 85.2% were overweight or obese, 75.8% had undesired waist circumference and 38.9% were illiterate. A high proportion of the sample admitted compliance to diet (61.1%) and physical activity (51.0%) while a small proportion admitted smoking (5.4%) and drinking alcohol (3.4%). Based on the total HADS score, anxiety subscale and depression subscale, 17.5%, 16.1% and 23.5% of the study sample were classified as definite and doubtful cases, respectively. A significant negative correlation was found between NQOL with total HADS (r=-0.590, p=0. 000) and its subscales; anxiety (r=-0.597, p=0. 000) and depression (r=-0.435, p=0. 000). Therefore, MNT should be improved in Oman for better NQOL and lower anxiety and depression levels among people with diabetes.

Effect of Omani Dates (*Phoenix dactylifera L.*) on Behavioral Abnormalities in Alzheimer's disease Transgenic (TgSW2576APP) Mice

Student Name : **Kathiya Khalaf Nasser Awlad Thani**
Supervisor : Dr. Mohammed Essa
Department : Food Science and Nutrition

Alzheimer's disease (AD) is a neurodegenerative disease leading to gradual memory loss, cognitive impairment, decreased or poor judgment and change in personal daily activities and mood. The current treatment options are leading the side effects and studies suggest that diet could risk the disease status. Based on this we have aimed to find out the effect of dietary supplementation of Omani date palm fruits (2% and 4%) on behavioral abnormalities in APPsw/Tg2576 transgenic mice model of AD. Animals were divided into four groups (48 transgenic mice and 16 wild mice for control; n=16) and supplemented with or without dates fruits for 9 months. Behavior tests such as Morris Water Maze (MWM) and T-maze (to examine memory and learning abilities) elevated plus maze (EPM) and open field (to measure motor coordination and anxiety) and rotarod (to evaluate motor coordination) were done before and after treatment. Dates fruits supplementation (4%) to AD mice shown the significant improvement ($P < 0.05$) in terms of memory, learning, anxiety and motor coordination. This improvement offered by dates fruits could be due to the presence of active phytochemicals and natural antioxidants such as ferulic acid, etc. But the exact mechanism is still unclear and further extensive research needed.

Antioxidants Activities of Pomegranate Peel Extract in Experimentally-Induced Fatty Liver *in-vivo* Model in Rat

Student Name : **Siham Nasser Khamis Al-Shaaibi**
Supervisor : Prof. Mohd Shafiur Rahman
Department : Food Science and Nutrition

Pomegranate (*Punica granatum L.*) fruit peel is used as traditional medicine in many parts of the world. The effect of pomegranate peel extract on the primary prevention of dietary-induced fatty liver was studied in *in-vivo* experimental rats. In group A, rats were fed basal diet (i.e. no fat and no pomegranate peel extract, PPE). Other rats were fed 20% fat (i.e. corn or palm oil) in their diet for 2 months (Group B: negative control). Oils were heated at 150^{o}C for 4 days continuously to examine oxidative state and their effects on the bioactivity of rats' liver (Group B: negative control). In group C, rats were fed same diet as group B with PPE treatment. In the case of corn oil, peroxide value (PV) and p-ansidine (PAV) were found significantly increased after heating, while acid value (AV), PAV and oxidative stability index (OSI) were found significantly increased in palm oil (p<0.05). However, vitamin E was not significantly affected by heating in the case of both oils. In the case of rats fed PPE (i.e. group C), weight gain was decreased as compared to the rats in group A and B. The serum Alanine Transaminase (ALT) in the rats (i.e. group C) fed with heated corn oil and PPE was significantly higher as compared to group A and group C fed with corn oil and PPE (p<0.05). However, serum Aspartate Transaminase (AST) was significantly lower in the group C fed with heated palm oil with PPE (p<0.05). AST in liver tissue was lower in all group C (i.e. PPE treated) as compared to group A. In addition, group B fed with heated and non-heated palm oil was significantly lower as compared to same group fed with heated and non-heated corn oil. The elevated level of enzyme indicated that groups B (i.e. corn oil group) had fatty liver. This finding was supported by histopathology analysis. In histopathology, it was observed that fat droplets were found in all groups B. These droplets were less in PPE-treated groups (i.e. group C), but necrosis was observed. PPE had no direct influence on antioxidant enzymes (p>0.05). However, glutathione (intercellular antioxidants; GSH) was significantly lower in PPE-treated groups (i.e. group C), and significantly higher (p<0.05) in group B fed with heated palm oil. This indicating that heated palm oil group had dietary-induced oxidative stress. Thiobarbituric acid reactive substances (TBARS) in liver tissue of group A was significantly higher as compared to group B fed corn oil and group C fed corn oil and heated palm oil as well as PPE (p<0.05). Overall PPE treatment had significant effect on selected biochemical parameters of fatty liver of rats.

Non-destructive Classification of Dates Based on Hardness Using Near-infrared Imaging

Student Name : **Halima Said Al-Dohani**
Supervisor : Dr. Manickavasagan Annamalai
Department : Food Science and Nutrition

Hardness of dates is considered as one of the important quality parameters in the exportation. Visual inspection by manual graders is the current method commonly used for sorting dates in factories. Substituting this method by an automated technique will be more efficient. Therefore, the efficiency of NIR imaging technique was estimated to classify dates of Fardh and Khalas varieties based on their hardness. Histogram and textural features were extracted from NIR images and used in the classification models. Linear Discriminant Analysis (LDA) and Stepwise Discriminant Analysis (SDA) were used to determine the classification accuracies for the developed classification models (three classes model and two classes model) for both date varieties. Three classes model was developed using the three grades (hard, semi-hard and soft), while two classes model was developed using two grades (hard and soft) where soft and semi-hard were grouped together and treated as soft. For Fardh variety, 80.2% and 78.5% were correctly classified using LDA and SDA, respectively in three classes model. In two classes model, 95.7% were properly categorized using both LDA and SDA for the same date variety. However, only 61.8% and 59.8% were correctly categorized in the three classes model of Khalas variety by LDA and SDA, respectively. Similarly, 47.0% and 74.7% were properly classified in the two classes model using LDA and SDA, respectively for Khalas variety. The most contributing features to the discrimination were chosen to correlate with instrumentally measured features. Mean gray value, standard deviation and homogeneity were selected from Fardh variety images. Whereas, mean gray value, standard deviation and contrast features were selected from Khalas variety images. Poor correlation between instrumentally measured attributes and features extracted from NIR images was obtained in both varieties. Further investigation using other machine vision methods is required to improve the classification accuracies.

Nutrients Load and Phytoplankton Abundance in Coastal Water of Sohar Industrial Area, Sea of Oman

Student Name : **Nasser Salem Hamed Al-Azri**
Supervisor : Dr. Adnan Al-Azri
Department : Marine Science and Fisheries

The coastal water of Sohar Industrial Area was studied for ten months (February – October 2012). The sampling program was carried out bi-weekly to investigate the nutrients load and composition and their relationship to phytoplankton abundance and species particularly harmful algal blooms in Majis Industrial Services Company (MISC) facility. Surface temperature, salinity, nutrients, dissolved oxygen, chlorophyll *a* (Chl *a*), and phytoplankton abundance of surface sea water were measured at four selected stations (IN, Mouth, Out & DiCH).

The sea surface temperature followed typical seasonal summer high with significant drop within the period of June and August with water temperature ranging from 29 to 32 ^{o}C). A fluctuation of up to 4 ^{o}C was recorded during August. Salinity showed no particular fluctuation pattern with fairly constant concentration of around 36 PSU.

The concentration of nutrient (except ammonia) and chlorophyll *a* (below 1µg/L) was within range of previously reported in the coastal water of Sea of Oman. Low chlorophyll *a* concentrations were recorded despite the high N concentrations (as ammonia NH_4^+). The calculated N:P ratio (N:P > 50) found to be much higher than that of the Redfield Ratio (16:1).

Phytoplankton taxonomy and cell densities revealed fluctuations with the dominance of diatoms in winter, while dinoflagellates dominated during summer. The maximum cell count was observed during April with abundance of 66,500 cells*L^{-1} whereas, the minimum cell count was observed during June with abundance of 2,000 cells*L^{-1} dominated both with diatoms 96% and 77% respectively. The dominant species during the maximum abundance in April was *Ceratium sp.* comprising *Ceratium furca* 24%. Consistence presence of *Ceratium furca* was observed in subsequent months post *Noctiluca scintillans* bloom occurred at Intake Jetty of MISC. The prevalence of *Ceratium furca* cells at the harbour in comparison with natural semi enclosed system indicates that even "exposed" harbours, subject to frequent tidal renovation and wave action, may represent potential points of harmful species accumulation, source and/ or sink of HABs, as commonly observed in more confined areas. The disturbance of DIN:DIP ratio, is a good indication that elevated nutrient can influence the phytoplankton abundance and composition. Despite the fact of the limitations of this study and bearing in mind the multiple environmental factors which are responsible for phytoplankton blooms outbreak, it can be said that the coastal water of the industrial areas of Sohar could be classified as a fragile ecosystem require continuous monitoring especially in term of nutrient loads. Given the fact that there is limitation in sampling program in the coastal water of Sohar, Sea of Oman, our findings represent baseline for forthcoming research investigating the coastal ecosystem dynamics under multiple environmental stress.

The Use of Novel Fouling-release and Nanotechnology-based Coatings for Marine Biofouling Prevention

Student Name : **Marwan Ahmed Mubarak Al-Fori**
Supervisor : Dr. Sergey Dobretsov
Department : Marine Science and Fisheries

Biofouling is the unwanted accumulation and attachment of marine micro- and macro-organisms in any surfaces submerged in seawater. Biofouling is known by its deteriorating effects on the surfaces it form on, thus, lots of efforts were given to find solutions for this problem. However, due to the environmental impacts caused by common used toxic antifoulants, there is a big demand to search for novel non-toxic methods for prevention of biofouling such as fouling-release antifouling coatings technology and nanotechnology-based antifouling coatings. The main aim of this study was to investigate the efficiency of using the fouling-release silicone-based coating Hempel Hempasil X3® as well as the nanotechnology-based zinc oxide (ZnO) nano-coatings as novel coatings for biofouling prevention. The antifouling performance of the Hempasil X3® was tested in field experiment for 10 months at Marina Bandar Rawdah and Marina Shangri La and its toxicity was tested and compared to a standard toxic copper-based coating in lab experiment using *Artemia salina* larvae. Our results showed good antifouling performance of Hempasil X3® in both marinas with better results at Marina Shangri La. Also, Hempasil X3® was not toxic compared to the copper-based coating. The ZnOnano-coatings were prepared in laboratory by hydrothermal synthesis method using two seeding solutions (5 and 10mM) and two nanorods growing methods (conventional and microwave). Four ZnOnano-coatings, in total, were prepared (5mM conventional, 10mM conventional, 5mM microwave and 10mM microwave) and their photocatalytic antifouling properties were tested in lab experiment using antibacterial (using *Acinetobacter sp. AZ4C*), antilarval (using *Bugula neritina* and *Artemia salina* larvae) and antialgal (using *Tetraselmis sp.*) bioassays under light and dark conditions. All ZnO nano-coatings showed good antifouling activity against the above mentioned organisms under light condition but not in dark. So, our findings show that Hempel Hempasil X3® coating is a promising non-toxic and efficient antifouling coating which could be used as alternative for biocidal ones. Also, ZnO nano-coatings exhibited good antifouling activities and this can be further investigated and exploited as new approach for biofouling prevention.

An Analytical Review of Aquaculture Management Practices: A Case Study of RAS in Oman

Student Name : **Rumaitha Al-Busaidi**
Supervisor : Dr. Hussein Samh Al-Masroori
Department : Marine Science and Fisheries

Aquaculture in Oman is in its early developmental stages with the Government currently working on attracting businesses to venture into the industry. However, management tools and methods are still under development and have not yet been implemented. This study aims to look at the case study of the newly developed Tilapia RAS model farms by Ministry of Agriculture and Fisheries (MAF) that are currently in their initial phases of production to review Better Management Practices (BMP) in relation to aquaculture development, investigate current legislations and regulation in Oman, investigate stakeholder awareness and perceptions on the regulatory mechanics, and identify gaps between international and national BMPs. The stakeholders were divided into two groups; primary stakeholders who are the farmers of the model farms, and secondary stakeholders who are decision makers, academics, and scientists in the country. The results showed that even though aquaculture is in its infancy in Oman, there is need for comprehensive regulations and practices where the main law governing aquaculture is the Fisheries Law that does not take into account all aspects of aquaculture. Furthermore, a gap was witnessed between the primary and secondary stakeholders in their direction for aquaculture based on the sustainable development model; the primary stakeholders focused on the economical dimension while the secondary stakeholders agreed that the institutional dimension is of far more importance to develop aquaculture. This gap identified shows that there is need for a middle ground to meet both directions to provide a comprehensive management framework to include all aspects of importance and concern. Additionally, the study recommended some steps to help in establishing and putting together a basis on what standards must be in place and other methods and practices that must be introduced or implemented in the upcoming management framework by looking at characteristics of international aquaculture framework and what aspect need to be highlighted for a sustainable aquaculture industry.

A Study of Parasitic and Viral Infection of Imported Ornamental Fish: Implication for Biosecurity

Student Name : **Wafaa Ahmed Al Rawahi**
Supervisor : Dr. Gil Ha Yoon
Department : Marine Science and Fisheries

Keeping pastime and aquaculture industry of live freshwater fish are the main vectors for international trade of live fish. The transboundy movement of live fishes has been found to be associated with introduction of exotic parasitic and infectious viral agents. Worldwide a variety of parasites have been introduced through ornamental fish trade including various genera of monogenea, digenea, protozoa and metazoa. Viral agents have also been transmitted particularly in the latent stage of infection. Few studies have been conducted in the world regarding the parasitic and viral infections associated with ornamental fish trade and none conducted in Oman. Therefore, the goal of this study was to assess the biosecurity risks, parasitic and viral agents associated with importation of ornamental fish into Oman.

A survey was carried out to investigate the prevalence of gill ectoparasites and infectious viral agents of imported ornamental fishes. A sample of 81 imported goldfish were sampled from three pet shops (Al Hail, SABCO and Al araimi) in Muscat governorate and examined for ectoparasite infestation. The prevalence of ectoparasites from imported goldfish was compared with the prevalence of ectoparasite of examined Omani native freshwater fish (n=113) sampled from Wadi Daqeq in Sharqiyah Governorate. A group of imported ornamental fish species (n=136) that originally imported from Thailand, Singapore and Taiwan were sampled for virological examination. Ornamental fish species including Goldfish, Koi carp, Catfish, Pacu, Tiger barb, Sucker fish, Oscar, Golden gourami, Blue gourami and Silver carp were selected. Pooled samples of spleen, kidney and liver were tested for the presence of Koi Herpesvirus (KHV) and Iridovirus (IV) by following OIE PCR protocols.

The results obtained revealed overall ectoparasitic infestation of 97.53% in goldfish and 51.31% in Omani native freshwater fishes. It showed high prevalence of three genera of ectoparasite namely *Dactylogyrus sp.* (83.95%), digenean metacercaria (58.02%) and *Tricodina sp.* (11.11%) in the sampled goldfish. The former two parasitic genera were also prevalent with other monogenean *Gyrodactylus sp.* in native freshwater fish as (31.86%), (36.28%) and (7.08%) respectively. Based on the PCR test, 2 out of 25 pooled sample groups were positive for the presence of KHV. Sequence analysis of representative PCR products showed 100% genetic homology with the complete genome of cyprinid herpesvirus strain KHV-GZ11 (qi/647842001/KJ627438.1). The virus was detected in asymptomatic goldfish from Al araimi and Al Hail pet shops, originally imported from Thailand. The broad host range and pathogenicity of KHV highlights an emerging biosecurity risk. Moreover, new regulations on the importation of live aquatic animals should be studied and established including assessment of health certificate, establishment of quarantine practice and inspection of ornamental fish's consignments.

Farmer's Willingness to Pay for Tertiary Treated Wastewater in Barka, Oman

Student Name : **Samiha Hamed Hamood Al Harthi**
Supervisor : Dr. Slim Zekri
Department : Natural Resource Economics

Degradation of quality of groundwater is a challenge faced by the water resource sector. Treated Wastewater (TWW) is the water that is generated after removing contaminants from wastewater and household sewage, both runoff (effluents), domestic, commercial and institutional. Wastewater volumes in Oman are rising and continuously available due to growing urban populations. Every day at least 15 % of the production of TWW is dumped to the sea and this percentage is increasing.

The objectives of the research are to estimate the farmers willingness to pay (WTP) for treated wastewater and to identify the factors that affect the farmer WTP for treated wastewater. The method used to estimate the farm owners WTP is the Contingent valuation method. Barka was chosen as the study area because of its close proximity to the new A' Seeb Sewage Treatment Plant. Only 72 surveys were collected for the study due to several difficulties such as absence of right person to answer the survey in the farm.

The results indicated that a farmer WTP for TWW is significantly affected by the income and whether the farm is a commercial or hobby farm. Commercial farm owners will invest in their farm and cultivate if supply of water is ensured unlike the hobby farmers. The sign of other variables were as expected but they were not significant at 5% level. The average calculated WTP is 0.111 OR/m^3. The percentage of farmers willing to pay this price or higher is only 38%. Sixty two percent of the farmers are willing to pay this price or less. Haya water is selling TWW at 0.220 OR/m^3 which most of farmers didn't accept paying as it is not a profitable price. , The mean WTP is 0.128 and 0.87 OR for the hobby and commercial farmers respectively. That is indicating that hobby farmers are more willing to pay for TWW than commercial farmers.

It is clear that farm owners are in need of TWW to re-cultivate their farm, Haya water should find a way to provide these farms with this water in reasonable prices were they can benefit either as commercial or hobby farmers instead of dumping it to the sea.

Estimation of the Demand for Residential Water in Muscat Governorate

Student Name : **Rahma Salim Abdullah Al-Harthi**
Supervisor : Dr. Slim Zekri
Department : Natural Resource Economics

The increase in residential water demand is a challenging issue for the world and for Oman specifically as it is located in an arid region. Oman has continuously increased water supply through desalination to fill the rapid increases in water demand. However, no significant effort was done to manage the demand. The desalination is considered expensive option in solving the increase in water demand compared to water demand management. Thus, to manage the consumers demand, it is important to conduct a research to study the demand for water and the factors affecting its consumption. Therefore, this study estimates the water demand function in Muscat Governorate and identifies the main factors that affect water consumption.

The data used in the study was generated from a household survey conducted at Al-Seeb and Al-Qurum of Muscat Governorate counting 266 households. The dependent variable used in the analysis is the average monthly household water consumption and the independent variables are household income, number of residents, number of potted plants in the garden, presence of swimming pool, frequency of car washing, presence of modern irrigation system and the size of irrigated area in the garden.

Alternative econometric models were used to estimate the residential water demand. The econometric models used in the study are two stage least squire (2SLS) and lagged average price model. Results showed that the water users react to the lagged average price rather than the current average price.

The findings of the study are consistent with results reported in the literature. The price and income are significant variables in determining the demand for water. The other variables included in the model such as number of home residents, number of potted plants in the garden, presence of swimming pool and the frequency of car washing are significant variables in determining water demand in Muscat Governorate. The demand for water is price elastic. The price elasticity was estimated to be -2.1. This is expected, since part of the water users uses the water for outdoor purposes such as gardening, swimming and washing their own cars. Most of the consumers don't use the tap water for drinking; they tend to buy bottled water for drinking purposes. The income elasticity is estimated at 0.04 showing that the demand for water is income inelastic.

The findings indicate that managing demand for water in Muscat Governorate through economic instruments (eg: increase the price) is recommended, besides to increasing water supply through desalination.

Consumers' Preferences for Seafood in Oman

Student Name : **Jaynab Begum**
Supervisor : Dr. Shekar Bose
Department : Natural Resource Economics

Since conventional utility theory does not explain the behavioral factors and attitude behind consumers' preferences and purchasing decision, this thesis aims to determine the various socio economic and behavioral factors in determining the frequency of seafood consumption and the intention to consume seafood (in future) in Oman. It also researches how consumers in Oman perceive quality of seafood. Using a fusion of the Evoked Set and the Theory of Planned Behavior (TPB), the study was conducted through a survey using a questionnaire. A pilot study was steered before executing the survey amongst the students and staff (comprising of 10 participants) of the Sultan Qaboos University. A total of 906 respondents participated from the hypermarkets (Lulu and Sultan Centre), the Seeb fish market (souq) and the Sultan Qaboos University.

The econometric analysis is done using binary choice modeling along with descriptive statistics and inferential statistics. The study revealed that consumers perceived quality primarily as 'freshness' and 'appearance'. Moreover, factors such as nationality, education, household size, and income and habit persistence were significant factors in explaining the frequency of seafood consumption. The intention to consume seafood was significantly influenced by habit (previous consumption frequency), the present consumption frequency along with the attitude towards eating seafood.

The results suggest that the seafood industry could create segmentation in terms of seafood for Omanis and non-Omanis since there is a distinct difference in the preferences for the type of seafood among the two groups of respondents. Also, habit was found to be persistent from one time period to another. Respondents carried the preference for and frequency of seafood consumption from the past to the present and also hoped to continue the same pattern in the future. This could lead to habit formation where a diversion in the peoples' preference could be created by encouraging them to try different types of seafood rather than sticking to their favorite. This not only reduces pressure on the usual and general favorite species (e.g. Kingfish), but also creates diversification in peoples' preferences and brings other non-popular seafood species into limelight.

Respondents did not seem to be very much aware of the health benefits of seafood consumption. This is where the role of the Ministry of Health (MoH) and the Ministry of Agriculture and Fisheries (MoAF) comes into play in spreading knowledge, information and awareness about the various benefits of seafood consumption through educational and media related platforms. Quality of seafood needs to be restored and maintained by the use

of proper storage and transportation facilities, and also with the use of ice right from the time seafood is caught till they are consumed.

Lastly, traceability of seafood is becoming an increasing concern amongst consumers due to questionable quality of seafood being imported from other countries. Moreover, people are still skeptical about farmed/aquacultured fish in terms of their quality. Respondents suggested that seafood could be labeled as wild or farmed. All the more, this information would have some implications on the aquaculture industry which is still facing some skepticism in terms of product safety concerns.

Effects of Using Tertiary Treated Wastewater for Irrigation of Bread Wheat Crop

Student Name : **Moosa Said Nasser Saif Al Abri**
Supervisor : Dr. Hayder AbdelRahman
Department : Soils, Water and Agricultural Engineering

Many arid and semi-arid countries became increasingly scarce in water resource and planners were forced to consider any sources of water which might be used economically and effectively to promote further development. At the same time, with population expanding at a high rate, the need for increased food production is apparent. Many countries have included treated wastewater reuse as an important dimension of water resources planning. Some countries like Oman have a national policy to reuse all treated wastewater and have already made considerable progress towards this. It is generally accepted that treated wastewater use in agriculture is justified on agronomic and economic grounds but care must be taken to minimize adverse health and environmental impacts. The purpose of this study is to show results of a project done at SQU farm using treated wastewater to irrigate wheat crop by drip and furrow bed irrigation systems.

The traditional surface irrigation system such as furrow remains the most common irrigation technique covering most of the agricultural area in Oman. The system has low water use efficiency and enhances soil erosion if not properly managed. The furrow system can be modified and improved to a level that can increase the efficiency and save much water.

The experiment was conducted in plots of loamy soil of 7.5 m^2 each during the season 2010/2011 in the Agricultural Experimental Station of Sultan Qaboos University in the Sultanate of Oman. Each plot had either a drip irrigation system or furrow bed of 60 cm width. The design was complete block design with three treatments 1) water source: freshwater and treated wastewater; 2) irrigation method: furrow bed and drip; 3) wheat varieties: V1 Wadi Qurayat 302 (W.Q.S 302) and V2 (Sinien) and three replications. Wheat was sown and all required parameters for soil and plants were measured. Plants were irrigated daily by drippers and once every three days by furrows bed based on crop evapotranspiration value.

From soil salinity data, it was found that both methods added some salts to the root zone with less salts in furrow bed method due to leaching process during irrigation. However, no a significant differences ($p<0.05$) were found between both irrigation methods. Plant growth was better with tertiary treated wastewater and almost in all growth parameters compared to freshwater, probably due to increased nutrients value. Wheat irrigated by drip system gave lower biological yield compared to furrow bed irrigation. Generally, all measured data collected from both irrigation methods didn't show any significant difference ($p<0.05$). Water productivity (Kg/m^3) data

gave higher results with furrow bed compared to drip method. Drip irrigation could be better in reducing evaporated water whereas furrow bed is favorite method in getting good yield with less expenses and high productivity.

The study concluded that both fresh and tertiary treated wastewater irrigation water gave high production of wheat yield. Although, tertiary treated wastewater could add some salts, it has some nutritional values compared to fresh water that increase the wheat production. Using modified furrow bed irrigation system as alternative technique for traditional furrow method showed good results compared to drip system in term of cost and yields. It gave insignificant difference in salt accumulated in the root zone. For plant parameters, there were almost similar values with insignificant difference between both irrigation methods. Water productivity was the best indicator for the efficiency of both methods. Furrow bed method gave better value than drip system in all irrigation water when initial water was subtracted. This finding could be a good indicator for replacing furrow with furrow bed method.

Hydropedology and Soil Evolution in Explaining the Hydrological Aspects of Recharge Dams in Arid Zone Environments

Student Name : **Said Mohd Nasser Al-Saqri**
Supervisor : Dr. Ali Al-Maktoumi
Department : Soils, Water and Agricultural Engineering

The Sultanate of Oman is an arid country where drought conditions prevail and water is precious. One of governmental efforts to augment water resources is by construction of recharge dams (e.g. Al-Khoud dam). Siltation is a common problem in many recharge dams around the world. Along with scaling-caking problem caused by siltation, a change in the hydrological properties (like reduction in infiltration) of the original soil porous media is common. Surface scraping is practiced to mitigate the scaling-caking problem along with improving the infiltration to some extent. In fact, scraping does not completely solve the problem of reduced hydraulic conductivity of the dam bed as fine soil particles may migrate into the deep subsurface layers which ultimately may alter the original alluvium characteristics. The main objectives of this study were: (i) to investigate the effects of anthropogenic activities on the subsurface soil physiochemical properties, and (ii) consequently, the impacts on hydraulic properties which are important for the augmentation of water resources of the underlying aquifers. To achieve the stated objectives, a number of field studies and laboratory experiments were conducted. A total of 33 soil pedons were excavated and described (15 inside; 18 outside the dam-12 of these in the recharge area downstream the dam). Physiochemical analyses include soil texture using Hydrometer method, measurements of total salts, soil pH and basic cations were also determined. Infiltration measurements were carried out using tension infiltrometers. In addition, several petrographic techniques like X-ray diffraction (XRD) and Scanned Electron Microscopy (SEM) were conducted to closer inspect the micromorphological and mineralogical composition of sub-soils in the study area. Major results of the study revealed that the sub-soil's physiochemical properties of the study area are changing due to human involvement in constructing the dam that result in changes in the hydropedological properties. Vertical variation in soil texture is evident in Al-Khoud dam recharge area which reduced hydraulic conductivity (e.g. Ks =0.01 cm/hr and 1.72 cm/hr for Pedons L and K inside the dam respectively) and hence, recharge into the underlying aquifers. Over time, and due to these changes, spilling of ponded water over the dam crest expected to occur more frequent and therefore, increases the potential hazards of flooding the downstream recharge area. In addition, pulses of finer particles might be sent to the soils of the recharge area where they may settle and even reduce the infiltration rate of these zones. Part of these finer particles may also migrate downward into the parent soil and cause clogging

of large pores and hence, reducing subsurface conductivity (Ks= 0.37 m/day). Formation of incipient calcic layers and hard pans were also discovered in the study area which in turn affected the hydraulic measurements. The infiltration rate downstream of the dam was relatively high (6 m/day) - and it was 3 times higher than the average value inside the reservoir (2.1 m/day), ranging between 0.01 m/day to 3.96 m/day, but less than at the upstream site of pedon AG (outside the dam). Understanding both the dynamics of the soil particles and water in a subsurface system is of paramount importance for water resources management. This study presents a hydropedological approach in understanding the subsurface system in the vicinity of Al-Khoud recharge dam in Oman and will assist in development of better managerial solutions and strategies in increasing dam efficiency.

International Collaborations

International Collaborations

Table 18. International collaborations in 2014.

No.	Organization	Type of Cooperation/ Contact Person	Contact Person/ Extent of Benefit
Dept of Animal and Veterinary Sciences			
1	University of Porto, Portugal	Collaborative research (HM project)/ Dr. Albano Fereira	Prof O.M. Gaafar/ Training Omanis and helping with DNA analyses
2	Al-Farabi Kazah National University Kazakhstan	Collaborative research (PhD student)	Prof I. T. Kadim/ Training a PhD student with meat quality characteristics
3	Univ of Kassel and Univ of Goettingen, Germany	Prof Dr Eva Schlecht	Prof O.M. Gaafar/ Animal husbandry in the tropics and subtropics
4	Univ of Kassel, Germany	Prof Dr Andreas Buerkert	Prof O.M. Gaafar/ Organic plant production and agroecosystems research in the tropics and subtropics
Dept of Crop Sciences			
5	University of California, Riverside	Asian Citrus Psyllid / Dr. Mark Hoddle	Dr. A. Al-Wahaibi
6	Plant Pests and Diseases Research Institute, Iran	WBDL vectors / Dr Alimorad Sarafrazi	Dr. A. Al-Wahaibi
7	Univ of New England, Australia	Dubas Bug / Dr. Lalit Kumar	Dr. A. Al-Wahaibi
8	Dept of Entomology, Univ of Kentucky, Lexington, USA	Dubas Bug / Dr. James D. Harwood	Dr. A. Al-Wahaibi
9	National Museum of Wales Cardiff, CF10 3NP, UK	Leafhoppers and planthoppers / Mike Wilson	Dr. A. Al-Wahaibi
10	Institute of Animal Ecology and Landscape Planning, Graz, Austria	Leafhoppers and planthoppers / Dr. Werner Holzinger	Dr. A. Al-Wahaibi

No.	Organization	Type of Cooperation/ Contact Person	Contact Person/ Extent of Benefit
11	Institute of Animal Ecology and Landscape Planning, Graz, Austria	Spider Ecology and Taxonomy/ Dr. Christian Komposch	Dr. A. Al-Wahaibi
12	Univ of Palermo, Italy	True Bugs/ Dr. Attilio Carapezza	Dr. A. Al-Wahaibi
13	Natural History Museum, London	Taxonomy of Micro-Lepidoptera/ Dr. David Agassiz	Dr. A. Al-Wahaibi
14	Univ of Innsbruk, Austria	Taxonomy of Widow Spiders/Dr. Barbara Thaler-Knoflach	Dr. A. Al-Wahaibi
15	Dept of Agriculture The University of Reading, UK	Supervision of Omani PhD students/ Dr. S.R. Gowen	Prof. M. Deadman
16	FABI, Univ of Pretoria, South Africa	Supervision of Omani PhD student/ Prof Mike Wingfield	Prof. M. Deadman
17	Environmental Studies Centre, Univ of Surrey, UK	Supervision of Omani PhD student/ Professor Steve Morse	Prof. M. Deadman
18	Univ of Louisiana, USA	Molecular identification of plant pathogenic fungi/ Prof. Cathie Aime	Prof. M. Deadman
19	Stellenbosch Univ, South Africa	Research / Prof. Linus Opara	Dr. R. Al-Yahyai
20	Stellenbosch Univ, South Africa	Research / Prof. Karen Theron	Dr. R. Al-Yahyai
21	Univ of Florida, USA	Research / Prof. Bruce Schaffer	Dr. R. Al-Yahyai
22	Univ of Agriculture, Faisalabad, Pakistan	Citrus and other fruit crops/Prof. Iqrar Khan	Dr. R. Al-Yahyai
23	UCD Sch of Agriculture, Food Sciences & Vet Med, Ireland	Postgraduate Research / Dr. Owen Doyle	Dr. R. Al-Yahyai/ Prof. M. Deadman
24	Lab. of Phytosanitary Biotech., Science & Tech. Park of Sicily, Italy	Tristeza virus / Dr. Grazia Licciardello	Dr. A.M. Al-Sadi
25	Science and Technology Park of Sicily, Italy	Tristeza virus / Antonino Catara	Dr. A.M. Al-Sadi

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26	Genomics Laboratory Weill Cornell Medical College in Qatar	WBDL l / Dr. Joel A. Malek	Dr. A.M. Al-Sadi
27	Instituto de Biologia Molecular y Celular de Plantas, Spain	Tristeza virus / Dr. Jesús A. Sánchez Navarro	Dr. A.M. Al-Sadi
28	Abu Dhabi Food Control Authority, UAE	Acid lime diseases / Rashid Al-Shariqi, Dir Gen	Dr. A.M. Al-Sadi
29	Nottingham University, UK	WBDL / Prof. Matthew Dickinson	Dr. A.M. Al-Sadi
30	John Innes Center, UK	WBDL, Prof. Saskia Hogenhout	Dr. A.M. Al-Sadi
31	Nova Scotia College of Agriculture, Canada	Precision Agriculture/ Dr. Q. Zaman, Chair Precision Agriculture	Dr. M. Khan
32	Univ of Agriculture Faisalabad, Pakistan	Production Horticulture/ Dr J. Jaskani, IHS, Director, Citrus Lab	Dr. M. Khan
33	Ministry of Agriculture, Qatar	Dr. N. Hussain	Dr. M. Khan
Dept of Food Science and Nutrition			
34	Univ of Tunis II- Ecole Supérieure des Industries Alimentaires, Tunisia	Collaborative research/ Dr Salwa Bornaz	Prof N. Guizani
35	Dept of Pharmacology Univ of New South Wales, Australia	Collaborative research/ Prof Gilles J Guillemin	Dr M. Essa
36	Washington State Univ, USA	Collaborating in research and publishing books/ Dr Mushtaq A. Memon	Dr M. Essa
37	National Institute of Health, USA	Collaborating in research and publishing books/ Dr Mohammed Akbar	Dr M. Essa
38	Nagasaki International Univ, Japan	Collaborating in research/ Prof Yukihiro Shoyama	Dr M. Essa
39	Developmental Neuroscience NYSIBR, USA	Collaborative research/ Dr Ted Brown/Abha Chauhan	Dr M. Essa

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40	National Institute of Health, USA	Research collaboration, Book editing/ B.J. Song, NIAA, NIH	Dr. M. Essa
41	Rx Bio Sciences Ltd, USA	Research collaboration, Grants submission/ Dr. Qazi Hamid	Dr. M. Essa
42	Univ of North Carolina, USA	Research collaboration/ Dr. Annamalai Prakasam	Dr. M. Essa
43	Karunya Univ, India	Research collaboration/ Dr.Kalidass Subramaniam	Dr. M. Essa
44	Dept of Nutritional Sciences, Univ of Toronto	Scientific collaboration/ Emeritus Prof A.V. Rao and Prof Nancy Kreiger	Dr A. Ali
45	Dept of Pharmacology, Univ of Sargodha, Pakistan	Scientific research collaboration/ Prof M. S. Akhtar	Dr A. Ali
46	Indonesia Center for Agricultural Post Harvest Research and Development, Indonesia	Research collaboration/ Dr. Heny Herawati	Prof. M.S. Rahman
47	Bogor Agricultural Univ, Indonesia	Research collaboration/ Dr. Feri Kusnandar	Prof. M.S. Rahman
48	La Rochelle University, France	Research collaboration/ Prof. K. Allaf	Prof. M.S. Rahman
49	National Technical University of Athens, Greece	Research collaboration/ Prof. M.K. Krokida	Prof. M.S. Rahman
50	Bihar Agricultural University	Dr. M. W. Siddiqui/ Published Book	Prof. M.S. Rahman
51	The Univ of Queensland, Australia	Prof. Bhesh Bhandari/ Research collaboration	Prof. M.S. Rahman
52	Pibulsongkram Rajabhat Univ, Thailand	Dr. Khongsak Srikaeo/ Research collaboration	Prof. M.S. Rahman
53	Bangladesh University of Engineering and technology	Collaborative research and Book Project/ Dr. M. S. Khan	Prof. M.S. Rahman
54	Kuwait Institute for Scientific Research, Kuwait	Book project/ Dr. Jasim Ahmed	Prof. M.S. Rahman

No.	Organization	Type of Cooperation/ Contact Person	Contact Person/ Extent of Benefit
55	University College Cork, Ireland	Book project/ Prof. Yrjo H. Roos	Prof. M.S. Rahman
56	Department of Pharmaceutical Sciences, Nova South-eastern Univ, Fort Lauderdale, Florida, USA	Research collaboration/ Prof Ricahrd Deth	Dr M. Waly
57	Department of Preventive Medicine, College of Medicine, Northwestern Univ, USA	Research collaboration/ Prof Lifang Hou	Dr M. Waly
58	College of Food Science and Engineering, Ocean Univ of China	PhD student co-supervsion/ Dr. Qing-Juan Tang	Dr M. Waly
59	Department of Food Science and Nutrition, Univ of Reading, London, UK	PhD Student co-supervsion/ Dr. Vimal Karani	Dr M. Waly
Dept of Marine Science and Fisheries			
60	University of Maryland, Center for Environ-mental Science, Horn Point Laboratory	To study nutrient uptake and phytoplankton ecology/ Prof Patricia Glibert	Dr A. Al Azri
61	Bigelow Lab in Maine, USA	Scientific research on Arabian sea project/Impact of global warming on phytoplankton blooms/ Dr Joaquim Goes and Helga Gomes	Dr A. Al Azri
62	Rosentiel School of Marine and Atmospheric Science, USA	Joint project - study interaction of phytoplankton and zooplankton in upwelling region/ Prof Sharon Smith	Dr A. Al Azri
63	International Islamic University of Malaysia (IIUM)	Joint Research	Dr S. Al Barwani
64	University of British Columbia	Re-construct catches of fishes in Oman from 1950 to the present time/ Prof Daniel Pauly	Dr A. Govender

No.	Organization	Type of Cooperation/ Contact Person	Contact Person/ Extent of Benefit
65	Florida Museum of Natural History	Taxonomy/ Gustav Paulay	Dr M.R. Claereboudt/ Acquisition of taxonomic expertise, identification of specimen
66	Univ of Vienna, Dept. of Paleontology	Taxonomy of bryozoans and biodiversity/ Andrei Ostrovsky	Dr M.R. Claereboudt/ Identification of bryozoans
67	Dusseldorf University, Germany	Knowledge transfer/ Prof. Peter Proksch	Dr S. Dobretsov/ Several manuscripts were published/ Identification of natural products
68	Roskilde University, Denmark	Visits exchange, knowledge transfer/ Prof Benni Hansen	Dr S. Dobretsov/ 1 MSc and 1 PhD students working at MSF Dept. There are perspective of the future publications
69	Smithsonian Marine Station, USA	Visits exchange, knowledge transfer/ Prof Valerie J Paul	Dr S. Dobretsov/ Several joint publications were published
70	Carl-von-Ossietzky-Univ Oldenburg, Germany	Visits exchange, knowledge transfer/ Prof Peter Schupp	Dr S. Dobretsov/ 1 joint PhD student working at MSF Dept. There are perspective of the future publications
71	King Abdullah University of Science and Technology *(*KAUST*), Saudi* Arabia	Visits exchange, knowledge transfer/ Dr Chris Voolstra	Dr S. Dobretsov/ 1 joint publication
72	Second Univ of Naples, Italy	Visits exchange, knowledge transfer/ Prof. Mario de Stafono	Dr S. Dobretsov/ There are perspective of the future publications
73	California Univ, USA	Analysis of mesoscale eddies of the Arabian Sea/ Dr Nik Nezlin	Dr S. Piontkovski/ Series of joint papers

No.	Organization	Type of Cooperation/ Contact Person	Contact Person/ Extent of Benefit
74	NOAA/Climate Lab., USA	Assembly of historical data/ Syd Levitus & Alex Mishon	Dr S. Piontkovski/ Assembly of the Arabian Sea database
75	Institute of Biology of the Southern Seas, Ukraine	Taxonomy of zooplankton/ Dr Alexandra Gubanova	Dr S. Piontkovski/ Series of joint papers
76	Univ of Western Australia, Australia	Modeling of physical dynamics in the Sea of Oman/Drs. Greg Ivey and Michael Meuleners	Dr. S. Piontkovski/ New proposal for TRC funding
77	Qatar Univ, Qatar	Algal blooms development/ Abdulrahman AlMuftah	Dr S.Piontkovski/ New proposal for Qatar Research Fund
78	IFREMER La Reunion (France) + Chelonia La Reunion	Investigating loggerhead turtles connectivity between Oman and La Reunion Dr Jerome Bourjea (IFREMER) Dr Mayeuil Dallau (Chelonia)	Dr L. Carassou/ Exchange of expertise/ Joint papers planned
Dept of Natural Resource Economics			
79	Environmental Management Centre for Environmental Policy Imperial College London, London SW7 1NA, U.K.	TRC project "Monitoring Groundwater using Energy Water Smart Meters and Precision Irrigation" / Dr. Kaveh Madani	Dr. S. Zekri Development of a dynamic hydro-economic model
80	World Trade Organization	Enhancing food security though WTO multilateral trading system and market oriented food policies	Dr. H. Boughanmi WTO Chair
Dept of Soils, Water and Agricultural Engineering			
81	(IAEA), Vienna	International Workshop on Isotope Hydrology for better understanding of water resources	Dr. A. Al-Maktoumi

No.	Organization	Type of Cooperation/ Contact Person	Contact Person/ Extent of Benefit
82	Institute for the Development of Water Resources [Jaroslav Cerni Institute (JCI)] in Belgrade, Serbia	Development of groundwater resources, produced water treatment and use and water-saving irrigation techniques	Dr. H. Abdel Rahman Dr. A. Al-Maktoumi
83	Rottenberg, Univ of Applied Sciences, Germany	Guest lecturer	Dr. A. Al-Busaidi
84	Stillwater, Oklahoma, USA	Reviewed the agricultural egineering structure and advised on preparations for ABET accreditation/ Prof. David R. Thompson	Dr. A. Al-Busaidi
85	National Research Institute for Rural Engineering, Water, & Forestry (Tunisia), Univ of Jordan (Jordan) and Univ of Florida , USA	Meetings on USAID funded project	Dr. A. Al-Busaidi
86	Rhodes Univ, South Africa	Collaborative research/ Dr Roman Tandlich	Dr M. Ahmed
87	Univ of Highlands & Islands, UK	PhD Supervision/ Prof Martin Price	Dr M. Ahmed
88	Curtin Univ of Engineering & Technology, Australia	PhD Supervision/ Prof. Hari Vuthaluru	Dr. M. Ahmed
89	Univ of Kassel, Germany	Joint workshop on Oman mountains: environment & agriculture/ Research proposal review/ Prof. Andreas Buerkert	Dr. M. Ahmed
90	National Research Foundation Singapore The Institution of Engineering & Technology, UK	Book proposal review	Dr. M. Ahmed
91	IASTED, Canada	Member, International Program Committee (IPC), Africa EWRM 2014	Dr. M. Ahmed

No.	Organization	Type of Cooperation/ Contact Person	Contact Person/ Extent of Benefit
92	International Centre for Biosaline Agriculture, Dubai	Jointly edited the book 'Environmental Cost and Face of Agriculture in the Gulf Cooperation Council Countries', Springer/ Dr S. Shahid	Dr. M. Ahmed
93	Univ of Sydney, Australia	Holding of a mini-symposium, Water-Plant-Energy-Food Nexus in Two Arid Tropical Regions: Australian and Omani Experience	Dr. M. Ahmed
94	Univ of Nebraska, USA	Collaborative research/MAR Prof. Vitaly Zlotnik	Dr A. Al-Maktoumi
95	California Institute of Technology, USA	Collaborative research/ Radar probing of groundwater in hyper-arid environments/ Prof Jean Philippe Avouac	Dr A. Al-Maktoumi
96	Univ of Jordan	Collaborative research/MAR funded by USAID-FABRI	Dr A. Al-Maktoumi
97	Hassan II Institute of Agronomy and Veternery Medicine	Collaborative research/ Radar probing of groundwater in hyper-arid environments/ funded by USAID-FABRI	Dr A. Al-Maktoumi
98	Taipei Economic & Cultural Office (TECO), Muscat, Oman and National Chiayi University (NCYC), Taiwan	Potential collaboration in high-tech greenhouse cultivation with NFT techniques for growing Orchids and vegetables/ Mr. Liao, Representative of TECO, Muscat and Prof. Yen, NCYC, Taiwan	Dr. A. Al-Ismaili Dr. H. Jayasuriya

Publications in 2014

Publications in 2014

Table 19. Summary of total publications in 2014.

Refereed Journals	109
Book	1
Edited Books	5
Book Chapters	57
Conference Presentations	165
Papers = 63 (31 in proceedings); Abstracts = 62; Posters = 24; Invited as Speaker = 16	
Technical Reports	15
Others	
Newspaper Articles (SQU = 7 ; Local =16); Net interview = 1	24
Total	**376**

Refereed Journals

1. Al-Kalbani, M. S., Price, M. F., Abahussain, A. A., Ahmed, M., & O'Higgins, T. (2014). Vulnerability assessment of environmental and climate change impacts on water resources in Al Jabal Al Akhdar, Sultanate of Oman. *Water Policy, 6*, 3118-3135. DOI: 3110.3390/w6103118.
2. Al-Riyami, B., El-Tahir, M., Al-Maskari, S., Johnson, E. H., & Saleh, J. A. (2014). Acute effects of exogenous hormone on postprandial acylation stimulating protein levels in ovariectomized rats after a fat load. *Journal of Nutrition and Metabolism. Volume 2014, Article ID 510916, 7*, 1-7.
3. Al-Abri, A. S., Mahgoub, O., Kadim, I.T., Al-Marzooqi, W, Goddard, S., and Al-Farsi, M. (2014). Use of fish silage as a protein source for feeding Omani sheep. 1. Processing and evaluation of nutritive value of fish silage. *Journal of Applied Animal Research, 10/2014; 42(4). DOI: 10.1080/09712119.2013.875909*
4. Al-Adawi, A. O., Barnes, I., Khan, I. A., Deadman, M. L., Wingfield, B. D., & Wingfield, M. J. (2014). Clonal structure of Ceratocystis manginecans populations from mango wilt disease in Oman and Pakistan. *Australasian Plant Pathology, 43*, 393-402.

5. Al-Adawi, S., Braidy, N., Essa, M. M., Al-Azri, F., Hussain, S., Al-Sibani, N., Al-Khabouri, J., Al-Asmi, A., & Al-Mashani, A. (2014). Cognitive profiles in patients with multi-infarct dementia: an Omani study. *Dementia and Geriatric Cognitive Disorders Extra. 07/2014, 2014*(4), 271-282.
6. Alahakoon, P. M. K., Jayasuriya, H. P. W., Zekri, S., & Al-Busaidi, H. (2014). Comparative study of ET based and soil moisture based irrigation for Al Batinah Region in Oman. *J. Acta Horticulture, ISHS Acta Horticulturae 1054 (online) ISBN - 978-94-62610-45-3*.
7. Al-Attabi, Z., D'Arcy, B., & Deeth, H. C. (2014). Volatile sulfur compounds in pasteurised and UHT milk during storage. *Dairy Science & Technology*, 1-13.
8. Al-Azri, A. R., Piontkovski, S., Al-Hashmi, K. A., Goes, J. I., Gomes, H. R., & Glibert, P. (2014). Mesoscale and nutrient conditions associated with the massive 2008 *Cochlodinium polykrikoides* bloom in the Sea of Oman/Arabian Gulf. *Estuaries and Coasts, 37*, 325-338.
9. Al-Busaidi, A. & Ahmed, M. (2014). Sustainable reuse of treated wastewater for agriculture. *International Journal of Environment and Water, 3*(5), 66-73. (ISSN 20523408).
10. Al-Busaidi, H. A. & Al-Mulla, Y. A. (2014). Crop water requirement inside conventional versus seawater greenhouses. *Acta Hort. (ISHS) 1054*, 73-79.
11. Al-Fori, M., Dobretsov, S., Myint, M. T. Z., & Dutta, J. (2014). Antifouling properties of zinc oxide nanorod coatings. *Biofouling, 30*, 871-882.
12. Al-Hashmi, K., Goes, J., Claereboudt, M., Piontkovski, S. A., Al-Azri, A., & Smith, S. (2014). Variability of dinoflagellate and diatoms in the surface waters of Muscat, Sea of Oman: comparison between enclosed and open ecosystem. *International Journal of Oceans and Oceanography, 8*(2), 137-152.
13. Ali, A., Al-Saady, N. A., Waly, M. I., Bhatt, N., Al-Subhi, A. M., & Khan, A. K. (2014). Evaluation of indigenous Omani legumes for their nutritional quality phytochemical composition and antioxidant properties. *International Journal of Postharvest Technology and Innovation, 3*, 333-346.
14. Ali, B. H., Al-Salam, S., Al- Za'abi, M., Al Balushi, K. A., Ramkumar, A., Waly, M. I., Yasin, J., Adham, S. A., & Nemmar, A. (2014). Does swimming exercise affect experimental chronic kidney disease in rats treated with gum acacia? *PLoS One, 9*(7), e102528. doi:102510.101371/journal.pone.0102528. eCollection 0102014. PubMed PMID: 25048380.
15. Ali, B. H., Al-Salam, S., Za'abi, M. A., Al Balushi, K. A., Al Mahruqi, A. S., Beegam, S., Al-Lawatia, I., Waly, M. I., & Nemmar, A. (2014). Renoprotective effects of Gamma Aminobutyric Acid (GABA) on cisplatin-induced acute renal injury in rats. *Basic Clin Pharmacol*

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16. Ali, B. H., Alza'abi, M., Ramkumar, A., Al-Lawati, I., Waly, M. I., Beegam, S., Nemmar, A., Brand, S., & Schupp, N. (2014). The effect of activated charcoal on adenine-induced chronic renal failure in rats. *Food and Chemical Toxicology, 65*, 321-328. [Published by Elsevier, impact factor 323.301].
17. Ali, B. H., Madanagopal, T. T., Ramkumar, A., Boudaka, A., Tageldin, M. H., & Nemmar, A. (2014). Some physiological and histological aspects of gastrointestinal tract in a mouse model of chronic renal failure. *Journal of Pharmacological and Toxicological Methods, 69*, 162-166.
18. Ali, B. H., Ramkumar, A., Madanagopal, T. T., Waly, M. I., Tageldin, M., Al-Abri, S., Fahim, M., & Nemmar, A. (2014). Motor and behavioral changes in mice with cisplatin-induced acute renal failure. *Physiological Research 63*(1), 35-45. Published by Academy of Sciences of the Czech Republic, Prague.
19. Al-Ismaily, S. S., Al-Yahyai, R. A., & Al-Rawahy, S. A. (2014). Mixed fertilizer can improve fruit yield and quality of field-grown tomatoes irrigated with saline water. *Journal of Plant Nutrition, 37*(12), 1981-1996. DOI: 1910.1080/01904167.01902014.01920364.
20. Al-Maamari, I. T., Al-Sadi, A. M., & Al-Saady, N. A. (2014). Assessment of genetic diversity in Fenugreek (*Trigonella foenum-graecum*) in Oman. *International Journal of Agriculture and Biology, 16*, 813-818.
21. Al-Maktoumi, A., Al-Ismaily, S., Kacimov, A., Al-Busaidi, H., Al-Saqri, S., & Al-Haddabi, M. (2014). Soil substrate as a cascade of capillary barriers for conserving water in a desert environment: lessons learned from arid nature. *Journal of Arid Land, 6*(6), 690-703.
22. Al-Maskri, A., Hameed, M., Ashraf, M., Khan, M. M., Fatima, S., Nawaz, T., & Batool, R. (2014). Structural features of some wheat (*Triticum* spp.) landraces/cultivars under drought and salt stress. *Arid Land Research and Management, 28*, 355-370.
23. Al-Mulla, Y. A., Huggins, D. R., & Stöckle, C. O. (2014). Modeling the emergence of winter wheat in response to soil temperature, water potential and planting depth. *Transactions of the ASABE, 57*(3), 761-775.
24. Al-Qamashoui, B., Mahgoub, O., Kadim, I. T., & Schlecht, E. (2014). Towards conservation of Omani local chicken: phenotypic characteristics, management practices and performance traits. *Asian Australian Journal of Animal Science, 27*, 767-777.
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26. Al-Rawahi, A. S., Edwards, G., Al-Sibani, M., Al-Thani, G., Al-Harrasi, A. S., & Rahman, M. S. (2014). Phenolic constituents of pomegranate peels

(*Punica granatum* L.) cultivated in Oman. *European Journal of Medicinal Plants, 4*(3), 315-331.

27. Al-Saady, N. A., Nadaf, S. K., Al-Subhi, A. M., Al-Hinai, S. A., Al-Farsi, S. M., Al-Habsi, K. M., H.A., E., & Siddique, K. H. M. (2014). Multicrop legume germplasm collection in Oman. *International Journal of Agriculture and Biology, 16*, 231-241.
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36. Al-Yahyai, R., Al-Subhi, A., Al-Sabahi, J., Al-Said, F., Al-Wahaibi, K., & Al-Sadi, A. M. (2014). Chemical composition of acid lime leaves infected with *Candidatus Phytoplasma aurantifolia*. *Agricultural Sciences 5*(1), 66-70.

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39. Aryamanesh, N., Zeng, Y., Byrne, O., Hardie, D. C., Al-Subhi, A. M., Khan, T., Siddique, K. H., & Yan, G. (2014). Identification of genome regions controlling cotyledon, pod wall/seed coat and pod wall resistance to pea weevil through QTL mapping. *Theoretical and Applied Genetics, 127*, 489-497.
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41. Belwal, R., Belwal, S., & Al-Jabri, O. (2014). Training needs assessment of fishermen in Oman through concept mapping technique. *European Journal of Training and Development, 38*(7), 673-688.
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CONFERENCE PRESENTATIONS

Papers Presented

1. Ahmed, M. & Al-Maktoumi, A. (2014). *Feasibility of Managed Aquifer Recharge (MAR) using excess treated wastewater in Oman*. Paper presented at the Symposium on Disposal of Large Volumes of Water: Challenges and Opportunities for Arid Environments in MAR Practices, Water Research Centre (WRC), Sultan Qaboos University (Cultural Center) Oman, 16 June.
2. Al Gheilani, H., Al Alawi, A., Al Naamani, M., Al Masroori, H., & Yoon, G. H. (2014). *The evaluation of consumer's preference between cultured and wild orange spotted grouper, Epinephelus coioides*. Paper presented at the 1st National Conference on Agriculture & Fisheries Research, Oman, 17-18 March.
3. Al Gheilani, H., Al Alawi, A., Al Naamani, M., Al Masroori, H., & Yoon, G. H. (2014). *Preference results of blind taste test between cultured and wild orange spotted grouper, Epinephelus coioides*. Paper presented at the International Conference on Seafood Safety, Quality and Traceability Systems, 3-5 March.
4. Al Harrasi, A., Al Bawiqi, B., Al Naamani, M., Al Masroori, H., & Yoon, G. H. (2014). *The attitude of consumers against newly tasted fish Tilapia, Oreochromis niloticus in Oman*. Paper presented at the 1st National Conference on Agriculture & Fisheries Research, 17-18 March.
5. Al Harrasi, A., Al Bawiqi, B., Al Naamani, M., Al Masroori, H., & Yoon, G. H. (2014). *Quality evaluation and consumer acceptance of Tilapia, Oreochromis niloticus*. Paper presented at the International Conference on Seafood Safety, Quality and Traceability Systems, Muscat, Oman, 3-5 March.
6. Al Kaabi, H., Al Kindi, U. K., & Yoon, G. H. (2014). *Presence of unexpected bacteria in Omani abalone, Haliotis mariae*. Paper presented at the 1st National Conference on Agriculture & Fisheries Research, Oman, 17-18 March.
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9. Al-Barwani, S. (2014). *Condition index of the Brown Mussel Perna perna along the Arabian Sea of the coast of Oman*. Paper presented at the 2nd International Environment and Health Conference 2014, Malaysia, 27-28 August.
10. Al-Ismaili, A. M. (2014). *Irrigation water production via a system of solar stills-cum-greenhouse evaporative cooler*. Paper presented at the 12th International Congress on Mechanization and Energy in Agriculture, Cappadocia, Turkey, 03-09 September.
11. Al-Ismaily, S. S., Al-Maktoumi, A., Kacimov, A., Al-Saqri, S. M., & Al-Busaidi, H. A. (2014). *Effects of anthropogenic interventions on the entisols of Al-Khoud Dam Area in a dry region of Oman*. Paper presented at the 20th World Congress of Soil Science. "Soils Embrace Life and Universe", Jeju, Korea, 08-13 June.
12. Al-Naamani, L. & Dobretsov, S. (2014). *Bioactive compounds from Omani fish waste*. Paper presented at the 1st National Conference on Agriculture & Fisheries Research, Oman, 17-18 March.
13. Al-Sadi, A. M. (2014). *Diversity in plant pathogens associated with crops of economic Importance in Oman*. Paper presented at the 11th Arab Congress of Plant Protection, Amman, Jordan, 8-11 November. Arab Journal of Plant Protection 32: E55-56.
14. Al-Subhi, L. K. (2014). *Prevalence of physicallyactive and sedentary adolescents in ten eastern mediterranean countries and its relation with age, gender and BMI*. Paper presented at the 2nd International Conference on Nutrition and Growth (N&G2014), Barcelona, Spain, 30 January to 01 February 2014.
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16. Dobretsov, S., Al-Fori, M., Myint, M., & Dutta, J. (2014). *Control of harmful algal blooms by zinc oxide nanorod coatings by sunlight*. Paper presented at the International Conference on Harmful Algal Blooms (HABs) and Desalination, Oman, 16-17 April.
17. Gallardo, W. (2014). *Aquaculture development and environmental issues*. Paper presented at the Mini-Symposium on Aquaculture Development in Oman, SQU, 14 December.
18. Gallardo, W. (2014). *Integrated multi-trophic aquaculture (IMTA): its potential application in the Sultanate of Oman*. Paper presented at the 1st National Conference on Agriculture and Fisheries Research, Muscat, Oman, 17-18 March.
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pumping in Oman. Paper presented at the 12th Precision Agriculture Conference, Sacramento, CA, USA, 21-23 July.

20. Jayasuriya, H. (2014). *GIS mapping of soil compaction and moisture distribution for precision tillage and irrigation maangement*. Paper presented at the 12th Precision Agriculture Conference, Sacramento, CA, USA, 21-23 July.
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47. Al-Mulla, Y. A., Al-Busaidi, H., & Al-Belushi, M. (2014). *Soilless culture in controlled environment: mechanisms of recovering crop production of the salt affected lands due to seawater intrusion. In*: Proceedings of the American Society of Agricultural and Biological Engineers (ASABE) Annual International Meetin. Paper number 141913540, Montreal, Quebec, Canada. 13-16 July.
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50. Essa, M. M., Subash, S., Al-Asmi, A., Al-Adawi, S., Vaishnav, R., Al-Jabri, A., Awlad-Thani, K., Al-Buraiki, Z., & Al-Senawi, H. (2014). *Chronic dietary supplementation of 4% figs modifiy the status of membrane bound enzymes and oxidative stress in mouse-tg2576 model. In*: Proceedings of the Transactions of American Society for Neurochemistry (ASN) 2014, PS09-03, Long Beach, California, USA. 8-12 March.
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Conference on Precision Agriculture, Sacramento, California, USA. 21-23 July.

54. Kacimov, A., Al-Ismaily, S., Al-Maktoumi, A., Al-Busaidi, H., & Al-Saqri, S. (2014). *Cascade of proppant-sandwiched silt blocks as a double-continuum: from discovery to mathematical modeling. In*: Proceedings of the 15th Annual Conference of the International Association for Mathematical Geosciences. Mathematics of Planet Earth, E. Pardo-Iguzquiza, C.Guardiola-Albert, J. Heredia, L. Moreno-Murino, J. Duran and J.A. Vargas-Guzman (Eds). Lecture Notes in Earth System Sciences, 193-196.
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60. Manickavasagan, A., Al-Yahyai, R., & Al-Sadi, A. M. (2014). *Computer vision techniques for quality assessment of dates. In*: Proceedings of the International Research Conference on Engineering, Science and Management 2014 (IRCESM 2014) (Non -refereed proceedings). pp199-201, Dubai, UAE. 4-5 June 2014.

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Abstracts

1. Ahmed, M. (2014). *Brine disposal from inland desalination plants in Oman: problems and opportunities*. Abstract. In: Book of Abstracts. International Conference on Desalination, Environment and Marine Outfall Systems, SQU, Muscat, Oman, 13-16 April.
2. Ahmed, M. (2014). *Storing treated wastewater underground in arid countries: a case study from Oman*. Abstract. In: Proceedings of Section of Earth System Sciences. Indian Science Congress. p 65-66, Jammu, India, 3-7 February.
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4. Al-Abadi, S. Y., Al-Sadi, A. M., & Al-Yahyai., R. A. (2014). *Analysis of diversity in Candidatus phytoplasma aurantifolia in Oman, UAE and Iran*. Abstract. In: Book of Abstracts. 1st National Conference on Agriculture & Fisheries Research, Sultan Qaboos University, Muscat, Oman, 17-18 March.
5. Al-Alawi, A. (2014). *Seaweed in Oman – A new source of income*. Abstract. International Conference on Seafood Safety, Quality and Traceability Systems, Muscat, Oman, 3-5 March.
6. Al-Haddabi, M., Vuthaluru, H., Ahmed, M., & Znad, H. (2014). *Use of ceramic membrane technology for sustainable management of oil production water*. Abstract. In: Book of Abstracts. International

Conference on Desalination, Environment and Marine Outfall Systems, p 16, SQU, Muscat, Oman, 13-16 April.

7. Al-Hashmi, I. H., Dorvlo, A., & Piontkovski, S. A. (2014). *Time series analysis of physical-biological coupling as a tool in monitoring invasions in Omani waters*. Abstract. International Conference Management of Ballast Water and Other Factors, Muscat, Oman, 17-19 February.
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11. Al-Jabri, S. & Ahmed, M. (2014). *Prospects of desalination in agriculture in Oman*. Abstract. Book of Abstracts. International Conference on Desalination, Environment and Marine Outfall Systems, p. 22, SQU, Muscat, Oman, 13-16 April.
12. Al-Maamari, I. T., Al-Sadi, A. M., Al-Saady, N. A., & Khan, M. M. (2014). *Morphological characterization and diversity of (Trigonella foenum-graecum) in Oman*. Abstract. In: Book of Abstracts. 1st National Conference on Agriculture & Fisheries Research, Muscat, Oman, 17-18 March.
13. Al-Maktoumi, A., Al-Ismaily, S., Kacimov, A., Al-Busaidi, H., Al-Saqri, S., & Al-Haddabi, M. (2014). *An engineering cascade of capillary barriers for irrigation water management in arid zone farming: inspiration by nature*. Abstract. 1st National Conference on Agriculture and Fisheries Research (Research for Development), Muscat, Oman, 17-18 March.
14. Al-Mulla, Y.A. 2014. Current CEA structures and their aptness to GCC environment. Abstract. In: Book of Abstracts, National Conference on Agriculture & Fisheries (Research for Development). 17-18 March, Muscat, Oman.
15. Al-Mulla, Y. A., Al-Habsi, R., Al-Belushi, M., Al-Busaidi, H., Charabi, Y., & Al-Khamisi, S. (2014). *Hydrothermal time simulation model for better wheat cultivation in arid climate: innovative approach towards*

better water management and food security. Abstract. Third Symposium of Sultan Qaboos Academic Chairs, Japan, 2-3 October.

16. Al-Naamani, L. & Dobretsov, S. (2014). *Bioactive compounds from Omani fish waste* Abstract. 1st National Conference on Agriculture and Fisheries Research, Muscat, Oman, 17-18 March.
17. Al-Sadi, A. M., Al-Yahyai, R. A., Al-Abadi, S., Al-Moqbali, H., & Al-Mahmooli, I. H. (2014). *Analysis of diversity in acid lime and Candidatus phytoplasma aurantifolia, the cause of witches' broom disease of acid lime*. Abstract. In: Proceedings of the 14th International Congress of the Mediterranean Phytopathological Union, Istanbul, Turkey, 25-29 August.
18. Al-Said, F. A., Khan, M. M., & Al-Mahruki, Y. (2014). *Effect of indiginuos Omani Cucumber rootstock on yield and quality of greenhouse cucumbers cv. Rima F1*. Abstract. In: Book of Abstracts. 1st National Conference on Agriculture & Fisheries Research, SQU, Oman, 17-18 March.
19. Al-Shihi, A., Al-Sadi, A. M., & Deadman, M. L. (2014). *Screening of tomato inbred lines against different begomoviruses in Oman*. Abstract. In: Book of Abstracts. 1st National Conference on Agriculture & Fisheries Research, Muscat, Oman, 17-18 March.
20. Al-Subhi, A., Al-Yahyai, R., Al-Sabahi, J., Said, F. A., Al-Wahaibi, K., & Al-Sadi, A. M. (2014). *A pilot study on the variation in leaves chemical composition of phytoplasma-susceptible and tolerant Citrus species*. Abstract. In: Book of Abstracts. 1st National Conference on Agriculture & Fisheries Research, Sultan Qaboos University, Muscat, Oman, 17-18 March.
21. Al-Subhi, L. K., Bose, S., & Al Ani, M. F. (2014). *Physically active and sedentary adolescents in ten eastern Mediterranean countries and its relation with age, gender and BMI*. Abstract. 2nd International Conference on Nutrition and Growth, Barcelona, Spain, 30 Jan – 1 Feb.
22. Al-Yahyai, R. (2014). *Oman mountains as fruit baskets: dream or reality*. Abstract. Symposium on Oman Mountains: Environment and Agriculture College of Agricultural & Marine Sciences, Sultan Qaboos University, Muscat, Oman, 21 December. pp 10-11.
23. Al-Yahyai, R. (2014). *Optimizing water utilization for improved horticultural crop production in Oman*. Abstract. Mini-Symposium on Water-Plant-Energy-Food Nexus in Two Arid Tropical Regions: Australian & Omani Experience, Sultan Qaboos University, Muscat, Oman, 4 March. p. 8.
24. Al-Yahyai, R. & Al-Hashmi, K. (2014). *Agroecology of traditional date palm farms in Oman*. Abstract. The 2nd Symposium of the Arab-American Frontiers of Science, Engineering and Medicine, Muscat, Oman, 13-15 December. p. 49.

25. Al-Yahyai, R. & Al-Hashmi, K. (2014). *Agroecology of traditional date palm plantations in Oman*. Abstract. The 5th International Date Palm Conference, Abu Dhabi, UAE, 16-18 March.
26. Al-Yahyai, R., Al-Said, F. A., & Opara, U. L. (2014). *Status and prospects for pomegranates research in Oman and South Africa*. Abstract. In: Book of Abstracts. 1st National Conference on Agriculture & Fisheries Research, Sultan Qaboos University, Muscat, Oman, 17-18 March.
27. Ammara, U. & Al-Sadi, A. M. (2014). *Transgenic tomatoes expressing Repsyn130 protein offer resistance against TYLCV-OM*. Abstract. In: Book of Abstracts. 1st National Conference on Agriculture & Fisheries Research, Muscat, Oman, 17-18 March.
28. Balal, R. M., Khan, M. M., Shahid, M. A., Abbas, T., Aquel, M. A., Javid, M. M., & Mattson, N. (2014). *Foliar spray of phyto-extracts supplemented with silicon: an efficacious strategy to extenuate the salinity-induced deleterious effects in pea (Pisum sativum L.)*. Abstract. Annual Conference, American Society For Horticultural Science, 2014, USA.
29. Balasuriya, V., Kodithuwakku, S., & Weerahewa, J. (2014). *An assessment of the potential of supermarkets as a means of channeling premium quality dried fish.* . Abstract. In: Proceedings of the 8th Annual Research Forum of the Sri Lankan Agricultural Economics Association, HARTI, Colombo, 12-13 December.
30. Bose, S. (2014). *A rational nexus in fisheries systems: research role, status and priorities*. Abstract. 1st National Conference on Agriculture and Fisheries Research, 17-18 March.
31. Bose, S., Al Balushi, A. H., Al Marzouqi, A. S., Al Haddabi, A. S., & Al Balushi, R. E. (2014). *Socio-economic and regulatory aspects of the lobster fishery in Oman: a preliminary analysis*. Abstract. International Institute of Fisheries Economics and Trade (IIFET) Conference, Queensland University of Technology, Brisbane, Australia, 7-11 July.
32. Dobretsov, S. (2014). *Marine biofilms associated with antifouling coatings: our friends or enemies?* Abstract. 17th International Congress on Marine Corrosion and Fouling, Singapore, 6-10 July.
33. Dobretsov, S. & Al Jaafari, S. (2014). *Biofouling on fishermen boats in the Sultanate of Oman*. Abstract. 1st National Conference on Agriculture and Fisheries Research., Muscat, Oman, 17-18 March.
34. Dobretsov, S., Al-Fori, M., Myint, M., & Dutta, J. (2014). *Control of harmful algal blooms by zinc oxide nanorod coatings by sunlight*. Abstract. International Conference on Harmful Algal Blooms (HABs) and Desalination, Muscat, Oman, 16-17 April.
35. Essa, M. M. (2014). *Date palm fruits from Oman attenuates cognitive and behavioral defects and reduces inflammation in a transgenic mice model of Alzheimer's disease*. Abstract. ICHNFS 2014: XII

International Conference on Human Nutrition and Food Sciences. Published as Proceedings available in WASET website, Geneva, Switzerland, 22-23 December.
https://www.waset.org/abstracts/19583);
https://www.waset.org/conference/2014/12/istanbul/ICHNFS/program?forceTentative=1.

36. Essa, M. M., Subash, S., Awlad-Thani, K., Al-Adawi, S., Al-Asmi, A., Samuoi, M., Vaishnav, R., & Al-Senawi, H. (2014). *Chronic date palm fruits supplementation therapy reduces oxidative stress in transgenic (Tg2576) mouse model of Alzheimer's disease*. Abstract. FASEB Journal, Proceedings of EB 2014. 1025.18.
37. Guizani, N., Suresh, S., & Rahman, M. S. (2014). *Polyphenol contents and thermal characteristics of freeze-dried date-pits powder*. Abstract. International Conference of Agricultural Engineering. AgEng 2014, Zurich, 6-10 July. Paper C0296.
38. Jayasuriya, H., Zekri, S., Zaier, R., Al-Busaidi, H., Hamza, N., & Teirab, A. (2014). *Evaluation of a sensor-based precision irrigation system for efficiency and to monitor and control groundwater over-pumping in Oman*. Abstract. 12th International Conference on Precision Irrigation. The International Society of Precision Agriculture, Sacramento, USA, 20-23 July.
39. Jayaweera, V. W., Kodithuwakku, K. A. S. S., Kobayashi, T., & Weerahewa, J. (2014). *Market oientation of small and medium scale rural farmers in Saga Prefecture, Japan*. Abstract. In: Proceedings of the 1st Faculty of Agriculture Undergraduate Research Symposium, Faculty of Agriculture, University of Peradeniya, Peradeniya, Sri Lanka, 23 December.
40. Johnson, E. H., Al-Busaidi, R., & Al-Habsi, K. M. (2014). *Vitamin B12 deficiency in Omani goats: a likely cause of increased susceptibility to infectious diseases*. Abstract. In Proceedings of the1st National Conference on Agricultural and Fisheries Research (Research for Development), Oman, 17-18 March.
41. Jonoski, A., Ebrahim, G. Y., Al-Maktoumi, A., & Ahmed, M. (2014). *Model-based optimization of Managed Aquifer Recharge in the lower Samail catchment, Oman*. Abstract. HIC 2014 - 11th international Conference on Hydroinformatics, New York, USA, 17-21 August.
42. Kacimov, A. R., Obnosov, Y. V., & Or, D. (2014). *Juxtaposition of evaporation, gravity and Darcian resistance in seepage through a silt block adjacent to a coarse sand compartment: solutions based on theory of holomorphic functions and computer algebra*. CP26. Abstracts of the 2014 SIAM Annual Meeting. p 30, Chicago, USA, 7-11 June.
43. Kalbus, E., Zekri, S., & Karimi, A. (2014). *Can smart irrigation technologies reverse saltwater intrusion in an arid area coastal*

aquifer? Abstract. Meeting of the German Association for Hydrogeology Bayreuth, Germany, 28-31 May.

44. Karimi, A., Zekri, S., Madani, K., & Kalbus, E. (2014). *An agent-based modeling approach to integrated groundwater management in Oman*. Abstract. 11th Annual Meeting of the International Water Resource Economics Consortium (IWREC), Washington DC, USA, 7-9 September.
45. Khan, M. M., Al-Kabi, F., Al-Said, F. A., & Al-Busaidi, A. (2014). *Effect of Municipal treated sludge compost on cucumber (Cucumis sativus L.) plant growth and yield.* Abstract. In: Proceedings of the International Agriculture Congress. p 59-60, Malaysia, 25-27 November.
46. Kodithuwakku, S., Boughanmi, H., & Weerahewa, J. (2014). *An assessment of trade potential between GCC and South Asia: findings from a gravity model*. Abstract. In: Proceedings. Business & Management Review. Nov 2014. 5(3):125.
47. Muthukrishnan, T., Abed, R., & Dobretsov, S. (2014). *Microbial fouling on commercial biocidal fouling control coatings*. Abstract. 17th International Congress on Marine Corrosion and Fouling, Singapore, 6-10 July.
48. Ngqwala, P., Tandlich, R., Al Adawi, S., & Ahmed, M. (2014). *Development of a low-cost system for greywater treatment for onsite use in subsistence agriculture*. Program and Abstracts. 1st National Conference on Agriculture & Fisheries Research, p 153, Muscat, Sultanate of Oman, 17-18 March.
49. Oukil, A. & Zekri, S. (2014). *A three-stage analytical framework for the evaluation of farming efficiency.* Abstract. 12th International Conference on Data Envelopment Analysis, 14-17 April.
50. Piontkovski, S. A., & Chiffings, T. (2014). *Does climate change favors invasive species in Omani waters?* Abstract. International Conference Management of Ballast Water and Other Factors, Muscat, Oman, 17-19 February.
51. Singh, V., Guizani, N., Al-Zakwani, I. M., Al-Shamsi, Q., Al-Alawi, A., & Rahman, M. S. (2014). *Sensory texture of Date fruits as a function of physico-chemical properties and its relationship with instrumental texture profile analysis.* Abstract. In: Proceedings of the 2014 International Conference of Food Properties (CFP 2014), Kuala Lumpur, Malaysia, 24-26 January.
52. Subash, S., Essa, M. M., Al-Adawi, S., Al-Asmi, R., Vaishnav, R., & Guillemin, G. J. (2014). *Nine months of dietary supplementation of omani fruits improves the memory anxiety and learning skills in AD transgenic mice*. Abstract. FASEB Journal, Proceedings of EB 2014. 845.1.
53. Subash, S., Braidy, N., Essa, M. M., Al-Adawi, S., Al-Asmi, A., Vaishnav, R., & Guillemin, G. J. (2014). *Pomegranate ameliorates*

Alzheimer's disease-type neurodegeneration in tg 2576 mouse model. Abstract. FASEB Journal, Proceedings of EB 2014. 846.1

54. Subash, S., Essa, M. M., Al-Buraiki, Z., Al-Asmi, A., Al-Adawi, S., Vaishnav, R., Lakhtatika, R., Al-Senawi, H., Awlad-Thani, K., Al-Jabri, A., & Samuoi, M. (2014). *Effect of dietary supplementation of pomegranate fruit grown in Oman on the memory, anxiety and learning skills in a transgenic mice model of Alzheimer's disease*. Abstract. FASEB Journal, Proceedings of EB 2014. 728.10.
55. Subash, S., Essa, M. M., Awlad-Thani, K., Al-Adawi, S., Al-Asmi, A., Vaishnav, R., & Guillemin, G. J. (2014). *Memory deficits and learning skills improved in transgenic mouse model of Alzheimer's disease after date-rich diet supplementation*. Abstract. FASEB Journal, Proceedings of EB 2014. 845.4.
56. Subash, S., Essa, M. M., Guillemin, G. J., Al-Adawi, S., Al-Asmi, A., & Vaishnav, R. (2014). *Dietary supplementation of pomegranate reduces the brain oxidative stress in transgenic tg2576 mouse model of Alzheimer disease*. Abstract. FASEB Journal, Proceedings of EB 2014. 1025.5
57. Tandlich, N. R., Ahmed, M., & Al-Adawi, S. (2014). *Simple and low-cost greywater treatment system for home gardening*. Abstract. SQU Day, SQU, Oman, 4 May.
58. Waly, M. (2014). *Low intake of dietary antioxidants is associated with oxidative stress in Omani adults newly diagnosed with type 2 diabetes*. Abstract. FASEB Journal April 2014 28:829.16.
59. Waly, M. (2014). *Low serum levels of trace elements (iron, zinc and copper) is associated with increasing number of pregnancies among Omani women: a case-control study*. Abstract. (1042.10). FASEB Journal April 2014 28:1042.10.
60. Yoon, G. H., & Al-Masroori, H. (2014). *From fishy to fish: an opportunity to extend aquaculture prospects in water limited areas*. Abstract . Symposium on Disposal of Large Volumes of Water: Challenges and opportunities for Arid Environments in MAR Practices, Msucat, Oman, 15-16 June.
61. Zekri, S., Karimi, A., & Madani, K. (2014). *Groundwater policing for a sustainable food supply in Oman*. Abstract. International Association of Hydro-geologists IAH, the Moroccan Chapter - 41st IAH International Congress "Groundwater: Challenges and Strategies", Marrakech, Morocco, 15-19 September.
62. Zekri, S., Karimi, A., & Madani, K. (2014). *The value of cooperation in coastal aquifer management: lessons for Oman*. Abstract. IEEE SMC. IEEE International Conference on Systems, Man, and Cybernetics, San Diego, CA, USA, 5-8 October.

Posters

1. Al Gheilani, H., Al Alawi, A., Al Naamani, M., Al Masroori, H., & Yoon, G. H. (2014). *The evaluation of consumer's preference between cultured and wild orange spotted grouper, Epinephelus coioides.* Poster. 1st National Conference on Agriculture & Fisheries Research, Muscat, Oman, 17-18 March.
2. Al Harrasi, A., Al Bawiqi, B., Al Naamani, M., Al Masroori, H., & Yoon, G. H. (2014). *The attitude of consumers against newly tasted fish Tilapia, Oreochromis niloticus in Oman.* Poster. 1st National Conference on Agriculture & Fisheries Research, Muscat, Oman, 17-18 March.
3. Al-Azri, A. (2014). *Impact of low oxygen layers on phytoplankton composition and fish kill.* Poster presented at the Low Oxygen Environments in Marine, Estuarine and Fresh Waters Conference, Liege, Belgium, 05-09 May.
4. Al-Busaidi, A. (2014). *Saline-treated sludge for better plant growth and water productivity.* Poster. 3rd International Salinity Forum, Riverside, California, USA, 16-18 June.
5. Al-Busaidi, A. & Yamada, S. (2014). *Possibility of using sea salts as nutrients in hydroponic systems.* Poster. 3rd International Salinity Forum, Riverside, California, USA, 16-18 June.
6. Al-Busaidi, A., Goddard, S., Al-Rawahy, S., & Ahmed, M. (2014). *Maximizing the outcome of saline agriculture by integrating fish culture with field crops.* Poster. 3rd Symposium of Sultan Qaboos Academic Chairs "Managing Water Resources for Sustainable Development", Tokyo, Japan, 02-03 October.
7. Al-Fori, M., Myint, M. T. Z., Dobretsov, S., & Dutta, J. (2014). *Zinc oxide nano-rod coatings for the prevention of marine micro- and macro-fouling.* Poster. 17th International Congress on Marine Corrosion and Fouling., Singapore, 6-10 July.
8. Al-Ismaily, S. S., & Al-Maktoumi, A. K. (2014). *Understanding soils: inspiring the new generation towards agricultural and environmental sustainability in Oman.* Poster. The 20th World Congress of Soil Science. Soils Embrace Lfe and Universe, Jeju, Korea, 8-13 June.
9. Al-Ismaily, S. S., & Al-Shuaili, M. (2014). *Effect of manure amendments with varying C:N ratios on N mineralization in an Omani soil.* Poster. 1st National Conference on Agriculture and Fisheries Research (Research for Development), Organized jointly by: TRC-MAF-CAMS, SQU, Muscat, Oman, 24-26 March.
10. Al-Maktoumi, A., Al-Ismaily, S., Al-Busaidi, H., Al-Saqri, S., & Al-Haddabi, M. (2014). *Efficient irrigation-water usage in arid environment: a cascade of capillary barriers in the soil substrate.* Poster. 3rd HM Chairs Symposium in Water Resources Management for Sustainability, Tokyo, Japan, 2-3 October.

11. Al-Maktoumi, A., Al-Ismaily, S., Kacimov, A., Al-Busaidi, H., Al-Saqri, S., & Al-Haddabi, M. (2014). *An engineering cascade of capillary barriers for irrigation water management in arid zone farming: inspiration by nature*. Poster. 1st National Conference on Agriculture and Fisheries research (Research for Development), Muscat, Oman, 17-18 March.
12. Al-Maskri, A., Khan, M. M., & Al-Manthri, O. (2014). *Effect of irrigating graywater on barley (Hordeum vulgare L.) cv. Batini production in Oman*. Poster. In: Book of Abstracts, p 61. International Agriculture Congress 2014, Malaysia, 25-27.
13. Al-Mulla, Y. A., Al-Habsi, R., Al-Belushi, M., Al-busaidi, H., Charabi, Y., & Al-Khamisi, S. (2014). *Hydrothermal time simulation model for better wheat cultivation in arid climate: innovative approach towards better water management and food security*. Poster. Third Symposium of Sultan Qaboos Academic Chairs, Japan, 2-3 October.
14. Al-Nahdi, Z. M., Al-Alawi, A., Al-Marhubi, I., & Rahman, M. S. (2014). *Optimization of the extraction conditions of K-Carrageenan extracted from Hypnea bryoides*. Poster. International Conference on Seafood Safety, Quality and Traceability Systems, Muscat, Oman, 3-5 March.
15. Arif, C., Roder, C. M., Barbrook, A., Howe, C. J., La Jeunesse, T., Dobretsov, S., Burt, J., & Voolstra, C. R. (2014). *Molecular diversity of reef-building coral symbionts around the Arabian Peninsula*. Poster. ISME15, Seoul, South Korea, 24-29 August.
16. Bose, S., Al Balushi, A. H., Al Marzouqi, A. S., Al Haddabi, A. S., & Al Balushi, R. E. (2014). *Socio-economic and regulatory aspects of the lobster fishery in Oman: a preliminary analysis*. Poster. International Institute of Fisheries Economics and Trade (IIFET) Conference, Queensland University of Technology, Brisbane, Australia, 7-11 July.
17. Dev, S. R. S., Ghnimi, S., & Manickavasagan, A. (2014). *Microwave assisted solar vapor absorption systems for sustainable cold chain in Oman - a feasibility analysis*. Poster. 2014 NABEC Conference, Kemptville, ON, Canada, 27-30 July.
18. Dobretsov, S., & Al Jaafari, S. (2014). *Biofouling on fishermen boats in the Sultanate of Oman*. Poster. 1st National Conference on Agriculture & Fisheries Research, Muscat, Oman, 17-18 March.
19. Guizani, N. (2014). *Polyphenol contents and thermal characteristics of freeze-dried date-pits powder*. Poster. International Conference of Food Engineering - AgEng 2014, Zurich, Switzerland, 06-10 July 2014.
20. Manickavasagan, A., Teena, M. A., Ravikanth, L., & Jayas, D. S. (2014). *Detection of fungal infected dates using NIR-Hyperspectral imaging (Paper ID: 1899173)*. Poster. ASABE and CSBE | SCGAB Annual International Meeting, Montreal, Quebec, Canada, 13-16 July.
21. Rahman, M. S. (2014). *Characterization of red seaweed extracts treated by water, acid and alkaline solutions*. Poster. 47th Annual AIFST

(Australian Institute of Food Science and Technology) Convention, Melbourne convention and Exhibition Centre, Melbourne, Victoria, Australia, 22-25 June 2014.

22. Rahman, M. S. (2014). *Stability of Vitamin C in fresh and freeze-dried capsicum stored at different temperatures*. Poster. 47th Annual AIFST (Australian Institute of Food Science and Technology) Convention, Melbourne convention and Exhibition Centre, Melbourne, Victoria, Australia, 22-25 June 2014.
23. Sankar, D., Ali, A., & Sambandam, G. (2014). *Sesame oil Exhibits Synergistic Effect with Anti-Diabetic Medication and Affects Glucose and Lipid Metabolism in Type-2 Diabetic Patients*. Poster. 9th Congress of the Asian-Pacific Society of Atherosclerosis and Vascular Diseases (APSAVD) & 16th Diabetes and Cardiovascular Risk Factors - East Meets West (EMW) Symposium, Hong Kong Convention & Exhibition Centre, Hong Kong., 25-28 September.
24. Watanabe, T., Watanabe, T., Yamazaki, A., Pfeiffer, M., Garbe-Schönberg, D., & Claereboudt., M. R. (2014). *High-resolution isotopic records in Oman corals: Indian monsoon climate reconstruction*. Poster. Eleventh Annual Meeting of the Asia Oceania Geoscience Society, Sapporo, Japan, 28 July - 1 August.

Invited as Speaker

1. Ahmed, M. (2014). *Brine disposal from inland desalination plants*. Keynote Speaker, 2nd International Training Workshop, Conference and Exhibition on Desalination, Regional Perspectives for Cooperation, Tehran, IR Iran, 20-22 October.
2. Ahmed, M. (2014). *Storing treated wastewater underground and its use for growing crops: a case study from Oman*. Invited Speaker. ICBA Meeting on Wastewater Reuse in Agriculture, Dubai, 14-16 January.
3. Ahmed, M. (2014). *Storing treated wastewater underground in arid countries: a case study from Oman*. Invited Speaker. Indian Science Congress, Jammu, India, 3-7 February.
4. Ahmed, M. (2014). *Water management in oil and gas*. Invited Speaker. Organized by IQPC (International Quality & Productivity Centre), Abu Dhabi, 9-10 June.
5. Ahmed, M. (2014). *Water resources in Al Jabal Al Akhdar: current status & trends*. Invited as Speaker. Symposium on Oman Mountains: Environment & Agriculture. Sultan Qaboos University-University of Kassel, 21 December.
6. Ali, A. (2014). *Bioactive components of whole grains and their impact on human health*. Invited as Speaker. International Conference on Nutritional Therapies Against Lifestyle Related Disorders, National

Institute of Food Science and Technology, University of Agriculture, Faisalabad, Pakistan, 29-30 May.

7. Ali, A. (2014). *Diet, obesity and risk of cancer*. Invited as Speaker. International Conference & Expo 2014. Recent Development in Human Nutrition, Pearl Continental Hotel, Lahore, Pakistan. www.nap.org.pk/ichn, 19-20 March.
8. Ali, A. (2014). *Dietary and lifestyle factors and risk of cancer*. Invited as Speaker. Annual Scientific Meeting of the Nutrition Society of Sri Lanka, Applying Nutritional Science to Healthy Living-Preventing Non-Communicable Diseases, Taj Hotel, Colombo, Sri Lanka, 25-26 January.
9. Ali, A. (2014). *Health benefits of consuming whole grains*. Invited as Speaker. Annual Scientific Meeting of the Nutrition Society of Sri Lanka, Applying Nutritional Science to Healthy Living-Preventing Non-Communicable Diseases, Taj Hotel, Colombo, Sri Lanka, 25-26 January.
10. Al-Yahyai, R. (2014). *Optimizing water utilization for improved horticultural crop production in Oman*. Invited as Speaker. Mini-Symposium on Water-Plant-Energy-Food Nexus in Two Arid Tropical Regions: Australian & Omani Experience, Sultan Qaboos University, Muscat, Oman, 4 March.
11. Bose, S. (2014). *A rational nexus in fisheries systems: research role, status and priorities*. Invited as Keynote Speaker at the 1st National Conference on Agriculture and Fisheries Research, Muscat, Oman, 17-18 March.
12. Dobretsov, S. (2014). *Marine biofilms associated with antifouling coatings: our friends or enemies?* Invited speaker at the 17th International Congress on Marine Fouling and Corrosion, Singapore, 06-10 July.
13. Jayasuriya, H. (2014). *Innovative farming technologies and research to meet challenges of agricultural production*. Invited Speaker. Thai Society for Agricultural Engineering (TSAE) 2014 - International Conference on Agriculture and Engineering, Phra Nakhon, Si Ayutthaya, Thailand, 2-4 April.
14. Kadim, I. T. (2014). *Determination of chemical contaminants of meat and meat products*. Invited as Speaker. Food Safety Week Conference, Al-Bustan Palace, A Ritz Carlton Hotel, Sultanate of Oman, 21-23 April.
15. Rahman, M. S. (2014). *Novel and emerging technology in food and biomaterial processing*. Invited Speaker at the 2nd International Conference on Agriculture and Ago-industry 2014 (iccai 2014), Mae Fah Luang University, Chiang Rai, Thailand, 20-21 November.
16. Zekri, S. (2014). *Economic and social aspects of the use of treated wastewater in Oman*. Invited as Guest Speaker. Conference on The Use of Treated Wastewater in Agricultural Production in the Arab

World: Current Status and Future Prospective, Dubai, UAE, 14-16 January.

TECHNICAL REPORTS

1. Ahmed, M. et al. (2014). *Characterization and treatment of textile industry effluents and nanotechnology*. Final Report. SQU Project: Industrial Innovation Center & Caledonian College of Engineering.
2. Ahmed, M. et al. (2014). *Feasibility of Managed Aquifer Recharge*. Final Report. SQU project: SR/AGR/SWAE/09/01.
3. Ahmed, M., Baawain, M., Choudri, B. S., Yoon, G. H., Al-Busaidi, A., Al-Adawi, S., Marikar, F., & et al. (2014). *Wastewater treatment and reuse at A'Saffa poultry farm at Thamrait*. Final Report. SQU Project: CR/DVC/CESAR/12/01.
4. Al Subhi, L. K. (2014). *Established the "Omani Code of Ethics for the profession of Dietetics, Nutritionist, and Diet Technicians" in collaboration with the Department of Nutrition*. Approved by the Legal Department Ministry of Health (MoH) on 20 April 2014.
5. Al-Haddabi, M., & Ahmed, M. (2014). *Performance evaluation of hybrid adsorption-ceramic membrane microfiltration approach for produced water treatment*. Final Report. CR/AGR/SWAE/13/03.
6. Al-Maktoumi, A. (2014). *Soil analysis for Al-Kamil Date Palm Farm*. Technical Report for a consultancy work. Contracted by the Institute for the Development of Water Resources, Jaroslav Černi", Belgrade, Serbia.
7. Al-Maktoumi, A. (2014). *The efficiency of household water filters in various regions*. Final Report. Project funded by the TRC through FURAP project (FRP/SQU/13/01).
8. Al-Sadi, A. M. (2014). *Potential sources of plant pathogenic fungi and bacteria into farms in Oman* Final report. HM Strategic Project. SR/AGR/CROP/10/01.
9. Bose, S. (2014). *Development of monitoring and control program for the Lobster fishery in the Sultanate of Oman*. Report. Ministry of Agriculture and Fisheries, Oman.
10. Bose, S., & Al-Jabri, O. (2014). *The role of small and medium enterprises (SMEs) and agricultural cooperatives in promoting sustainable agriculture for rural development and food security*. Report. The Research Council (TRC), Oman.
11. Dobretsov, S. (2014). *Bioactive compounds from Oman marine organisms*. Project Final Report. SQU Internal Grant No. IG/AGR/FISH/12/01. Date completed: 31 December 2014. 14pp.
12. Essa, M. M. (2014). *Finding Novel biomarkers for early detection of autism in Omani children*. Research Final Report. May 2014. Internal Grant (IG/AGR/FOOD/11/02).

13. Kadim, I. (2014). *Identification of camel meat quality parameters using proteomics*. Research Final Report. 31 December 2014. Internal Grant (IG/AGR/ANVS/12/01).
14. Piontkovski, S. (2014). *Numerical modeling of ocean circulation to investigate the regional marine environment and climate around Sultanate of Oman*. Project Final Report. The Research Council Grant No. RC/AGR/FISH/12/01.
15. Piontkovski, S. (2014). *Oceanographical regime shift in the Sea of Oman*. Project Final Report. The Research Council Grant No. RC/AGR/FISH/10/0.

OTHERS

Newspaper Articles

Published in SQU publication

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