ANNUAL RESEARCH REPORT 2008



VOLUME XIV

CAMS RESEARCH 2008

FACTS & FIGURES

- RO 1,673,230 Total Budget
- 51 Research Projects in Total
 - 29 Internal Grant Projects
 (9 awarded in 2008)
 - 9 Strategic Projects
 (3 awarded in 2008)
 - 3 Externally-Funded Projects (9 awarded in 2008)
- 62 Refereed Journal Publications



Annual Research Report 2008

Volume XIV

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Foreword

Since its start almost 25 years ago, the College of Agricultural and Marine Sciences (CAMS) has made enormous efforts to enhance its ability to conduct research to address the national development goals of Oman. Such efforts include investments in research infrastructure (laboratory and equipment), hiring and rewarding competent personnel, award of research grants, training of staff and maximize dissemination of research outcome by CAMS faculty and staff attending conferences and workshops. The College is committed to organize research under three broad themes, namely, i) Food Productivity, ii) Food Safety and Security and iii) Environmental Sustainability. The overall strategic goal of CAMS research activities is to increase the efficiency of agriculture; food systems; animal production; animal and human health; and marine sciences and fisheries.

Over the years CAMS faculty and staff have completed large number of projects dealing with current and future problems of Oman. In 2008, the CAMS total research budget was RO 1,673,230. As of 2008, CAMS faculty and staff have been the recipients of 13 research awards from HM research funds. Of which 4 have been completed and the rest are ongoing. These projects have special significance for different sectors of Omani economy. CAMS is also committed to transferring knowledge and skills to the broader community through its research and postgraduate programs. The College continues to maintain strong links with reputable local and international organizations and universities with the aim of maintaining high research quality and standards.

The postgraduate program in the College includes Masters and Doctoral programs. The Masters program, which started in 1997, continues to attract hardworking and enthusiastic students. The Masters program offers curricula in Animal and Veterinary Sciences, Crop Production, Crop Protection, Food Science and Nutrition, Marine Science and Fisheries, Natural Resource Economics, Soil and Water Management and Agricultural Engineering. The College had a total of 102 MS students in 2008 and total number of MS degrees awarded during the period 1999-2008 was 123 including 22 in 2008. The Doctoral program started in 2008 in four disciplines: Crop Sciences, Marine Sciences and Fisheries, Food Science and Nutrition and Soil and Water Management. The graduate students are involved in funded research projects. This strengthens the quality of their projects and provides them with the tools necessary to conduct practical research in their work areas.

We thank the Research and Postgraduate Studies committees of the College, CAMS administration, faculty, staff and students for making 2008 a very successful year in terms of research achievements. Our accomplishments in 2008 would not be possible without the support of the Deputy Vice Chancellor for Postgraduate Studies and Research and SQU administration, and for that we sincerely thank them.

Mushtaque Ahmed Asst Dean for Postgraduate Studies and Research

Research Committee (2008-2009)

Dr. Mushtaque Ahmed, *Chair* Prof. Humphrey Esechie Dr. Osman Gaafar Dr. Ali Khalfan Al-Wahaibi Dr. Majeed Al-Ani Dr. Michel Claereboudt Dr. Slim Zekri Prof. Anvar Kacimoy

The Year in Review

Introduction

The College of Agricultural and Marine Sciences' research goal is to work on research that will benefit the agricultural and fisheries community in the Sultanate of Oman. CAMS actively pursues basic and applied research that covers a broad range of disciplines in the areas of agriculture, food systems, animal production, animal and human health and marine sciences and fisheries.

The active participation of CAMS faculty, staff and students has contibuted to scientific and practical solutions for some of the problems facing the agricultural and fisheries sectors in Oman.

CAMS research achievements this year reflect its commitment to tackling problems of strategic importance to the Sultanate and to transferring knowledge and skills to the agricultural and fisheries community through its graduate programs.

Research Projects and Budgets

For the year 2008, the CAMS total research budget was RO 1,673,230 (Table 1).

Four internal grant projects were completed (Table 2), while 9 were awarded (Table 3) in 2008 (abstracts of internal grant research projects awarded in 2008 can be found on pages 44 to 54). There were also 16 continuing internal grant projects (Table 4).

Table 5 shows 3 strategic research projects which were awarded in 2008 (abstract of strategic research projects awarded in 2008 are on pages 56 to 60), while 6 were continuing (Table 6).

Three externally-funded research and development projects were awarded in 2008 and completed in the same year (Table 7). Two externally-funded research and development projects awarded from previous years and completed in 2008 are shown in Table 8.

Six other externally-funded research and development projects were awarded in 2008 (Table 9). Two continuing externally-funded research projects are shown in Table 10.

Table 1. Summary of research and development projects held by the College over 2004-2008.

Source of Fund	Number of Projects	Budget (RO)*	Total Budget (RO)
Internally-funded (SOU) projects			242.005
Completed in 2008	4	27,480	,
Awarded in 2008	9	74,530	
Continuing	16	139,995	
His Majesty's strategic research fund	_	_	866,800
Awarded in 2008	3	259 800	
Continuing	6	607,000	
Externally-funded projects			564.425
Awarded in 2008 and completed in the same year	3	8,340	,
Other projects completed in 2008	2	334,650	
Other projects awarded in 2008	6	188,985	
Continuing	2	32,450	
Total			1,673,230

*1 O.R. = 2.58 USD.

Table 2. Internally-funded research and development projects completed in 2008.

#	Title of Research	Principal Investigator	Year Granted	Amount (RO)
1	Mango rootstock evaluation, conservation and use in Sultanate of Oman	M. Deadman	2006	7,100
2	Physiological responses of date palm to various levels of water stress	R. Al-Yahyai	2006	4,480
3	Comparative studies of size-fractionated phyto-plankton primary productivity and bacterial biomass and production in Bandar Khayran Bay, Gulf of Oman and Masirah Island, Arabian Sea	A. Al Azri	2006	11,500
4	Design and construction of greenhouses for arid regions	Y. Al-Mulla	2006	4,400
To	tal			27,480

Table 3. Internally-funded research and development projects awarded in 2008.

#	Title of Research	Principal Investigator	Amount (RO)
1	Effect of thermal processing and enzyme supplementation on the nutritive value of local agricultural by-products as feed ingredients in chicken diets.	W. Al Marzooqi	11,500
2	Evaluation of Omani camel performance under intensive management for meat production and quality	O.M. Gaafar	12,000
3	Investigation on <i>Brucella melitensis</i> immunogenic domains	Y. ElTahir	12,000
4	Damage cost in dry Aflaj and live aflaj value for recreation	S. Zekri	8,900
5	The taxonomy and ecology of benthic elasmobranchs in the Gulf of Oman	A. Henderson	4,980
6	Antiatherogenic characteristics of consumption of fruit and vegetables grown in Oman	M. Al-Ani	11,000
7	Chemical and physical characterization of date pectin and its effect on date syrup quality	A.A. Al-Alawi	6,000
8	Production and quality assessment of a smoked tuna (<i>Thunus albacares</i>) product	N. Guizani	3,800
9	Performance evaluation of a solar tunnel dryer for drying of fishes and dates in Oman	M.A. Basunia	4,350
Total			74,530

#	Title of Research	Principal Investigator	Year Granted	Amount (RO)
1	The effect of Omanization policy on the efficiency of dairy and date farms in Oman	M. Mbaga	2007	11,350
2	Molecular characterization of phytoplasma associated with witches' broom, phyllody/ virescence diseases of sesame (<i>Sesamum</i> <i>indicum</i> L.) in Oman	A.J. Khan	2007	12,000
3	The role of harmful algal blooms (HAB's) in the coastal water of Oman with emphasis on the role of <i>N. scintillans</i> and <i>Trichodesmium sp.</i>	A. Al-Azri	2007	12,000
4	Biophysical dynamics of the upwelling ecosystems and surface currents along Oman	V.B.S. Yellepeddi	2007	12,000
5	Role of dietary and lifestyle risk factors on the prevalence of non-Hodkins lymphoma in Oman	A. Ali	2007	4,950
6	Application of water saving technologies in domestic water conservation in Oman	M. Ahmed	2007	4,900
7	Investigation of the prevalence of tick infes- tation and tick-borne haemoparasites of goats in the Sultanate of Oman	P. Bobade	2007	12,000
8	Reduction of post-harvest losses and improve- ment of fish handling systems in Oman	S. Al-Jufaili	2007	4,995
9	The effect of low levels of dietary cobalt on select parameters of the specific and non- specific immune responses of Omani goats	E. Johnson	2006	10,200
10	Bioavailability of iron in various types of meats in the Sultanate of Oman	I. Kadim	2006	10,000
11	Molecular investigation of lime Witches' Broom phytoplasma in Oman	N. Al-Saady	2006	10,200
12	Effect of manure amendment with varying C:N ratios on N mineralization in soil	S. Ismaily	2006	4,400
13	Economic and institutional aspects of Kingfish management	H. Kotagama	2005	5,000
14	Biodiversity and commu-nity structure of hard-substrate littoral communities in the Sultanate of Oman	M. Claereboudt	2005	10,500
15	Nausea and vomiting in pregnancy, maternal nutrition and pregnancy outcome	B. Al-Rasasi	2005	3,600
16	Development of salt and drought tolerant vegetable crops in Oman	A.J. Khan	2005	11,900
То	tal			139,995

Table 4. Continuing internally-funded research and developmentprojects.

His Majesty's Strategic Research Projects

In 2008, CAMS was awarded funding for three research projects in the sum of R.O. 259,800 through His Majesty's Strategic Research Fund. The projects include work on characterization, evaluation and conservation of indigenous animal genetic resources in the Sultanate of Oman; rejuvenating lime production in Oman; and stock assessment of Kingfish.

Table 5. His Majesty's strategic-funded research projects awarded in 2008.

#	Title	Principal Investigator	Amount (RO)
1	Characterization, evaluation and conservation of indigenous animal genetic resources in the Sultanate of Oman	0. Gaafar	80,000
2	Rejuvenating lime production in Oman: resolving current challenges	R. Al-Yahyai	100,000
3	Stock assessment of Kingfish	A. Govender	79,800
Total			259,800

Table 6. Continuing projects funded through His Majesty's strategic research fund from 2004-2008.

#	Title	Principal Investigator	Year Granted	Amount (RO)
1	Improving production of vegetable crops by develop-ment stress tolerant germ- plasm and farming systems research	F. Al Said	2004	74,800
2	Value-added marine raw materials and health	B. Soussi	2005	150,000
3	Postharvest technology to reduce losses and improve quality and supply of Omani local fresh food produce	L. Opara	2005	65,950
4	Management of salt-affected soils and water for sustainable agriculture	S. Al-Rawahy	2006	95,000
5	Conservation and utilization of plant genetic resources in Oman	H. Esechie	2007	139,300
6	Development of management strategies for pesticide resistance and pesticide residue problems in Omani agriculture	F. Talukder	2007	81,950
Total				607,000

Externally-Funded Research Projects

Externally-funded projects awarded and completed in 2008 are summarized in Table 7; other externally-funded projects awarded in previous years and completed in 2008 are summarized in Table 8. Other externally-funded research awarded in 2008 are summarized in Table 9. A total of 2 projects awarded from previous years were still on-going. The projects involved collaborations with United Arab Emirates University (UAEU), Ministry of Fisheries (MoF), Petroleum Development of Oman (PDO), Middle East Desalination Research Center (MEDRC), United Nations and Educational Scientific and Cultural Organization (UNESCO) and other private institutions.

Table 7. Externally-funded research and development projects awarded in 2008 and completed in the same year.

#	Title	Grantee	Agency	Amount (RO)
1	Wholesale fish market feasibility study	A. Palfreman	MoF	4,200
2	Code of practice for financing investment in small scale fisheries sector in Oman	A. Palfreman	Fishtech Mgt Consultants, Oman	2,940
3	Aquaculture regulatory financial study	S. Goddard	MoF	1,200
T	otal			8,340

Table 8. Other externally-funded research and development projects awarded from previous years and completed in 2008.

#	Title	Grantee	Agency	Year Granted	Amount (RO)
1	Mechanical profile control performance of elastomer seals	A. Kacimov (with College of Engg, SQU)	PDO	2005	325,000
2	Insecticide resistance in major agricultural insect pests in Oman: Monitoring and management strategies	F. Talukder	UNESCO	2006	9,650
т	otal				334,650

#	Title	Grantee	Agency	Amount (RO)
1	Characterization of camel milk protein isolates as nuraceutical & functional ingredients	A. Alawi	UAEU	40,000
2	Jabal Akhdar rose water production projects	M. Mbaga	MoF	12,385
3	Assessment of shark population movements, delineations and breeding grounds in the Sultanate of Oman	A. Henderson	MoF	100,000
4	Feasibility study to up-grade the effluent water treatment and water disposal system at the PDO MAF Terminal in Oman	M. Ahmed	PDO	16,320
5	Boron pre-treatment for seawater and brackish water desalination	M. Ahmed	MEDRC	5,740
6	Managed aquifer recharge of treated wastewater in Oman	S.A. Prathapar	Oman Wastewater Services Co., SAOC	14,540
Т	otal			188,985

Table 9. Other externally-funded research and development projects awarded in 2008.

Table 10. On-going externally-funded research and developmentprojects awarded from previous years.

#	Title	Grantee	Agency	Year Granted	Amount (RO)
1	Pesticide resistance and residue problems in Omani and UAE vegetable production. Phase II: Solution through rapid and molecular detection techniques & farmers awareness	F. Talukder	UAEU	2006	24,750
2	Assessment of PDO operated desalina- tion and sewage treatment plants	M. Ahmed	PDO	2007	7,700
т	otal				32,450

Other Significant Activities

University Research Day 2008

Some of the College's research projects were presented through oral and poster presentations. Abstracts of the projects presented can be found on pages 11 to 35.

ABSTRACTS

Oral & Poster Presentations

University Research Day May 3, 2008

Oral Presentations

Management of Salt-Affected Soils and Water for Sustainable Agriculture (SP (AGP/SWAF (06 (01)

(SR/AGR/SWAE/06/01)

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The project started in May 2006 and is expected to be completed in May 2009. It is approaching half way of its targeted objectives. Some of the field crop trials conducted at the Agricultural Research Center at Rumais so far indicate that mulching with date palm shredded leaves for sorghum planted plots had the least salt concentration in soil in the rootzone, lower soil temperature and the highest crop yield as compared to plastic mulching and the control. Data from two other fields plots are still under statistical analysis. Sorghum harvested crop irrigated with 3-, 6- and 9 dS/m water was fed to Omani sheep for two months. Feed intake, body weight and digestibility of feed have been determined. The animals have been slaughtered and meat quality and animal health are being analysed. Preliminary results on tomato shows encouraging responses at the highest salt water concentration (9 dS/m) by producing good tomato crop very much comparable to low salinity (3dS/m) and medium salinity (6 dS/m). Trials are in progress to further explore the potential to grow tilapia on brackish water farms on the Al-Batinah plain at salinity of up to 20 parts per thousand to determine their suitability as an additional farm crop.

Socio-economic study of salinity management is well under way. Meetings with farmers for briefing them on the project objectives were made in Barka and Musan'aa. Farmers were then individually met at their farms, soil and water samples were collected for analysis and GPS readings were taken from each farm.

Development of Management Strategies for Pesticide Resistance and Pesticide Residue Problems in Omani Agriculture

(SR/AGR/CROP/07/02)

Farid A. Talukder, et al.

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Worldwide reports show that insects, fungi and weeds have become resistant to major pesticide classes. Currently, around 500 species of insect pest are resistant to 14 major pesticide classes; over 25 plant pathogens to 22 fungicides and fungicide groups, and around 291 weed biotypes exhibit resistance to 18 herbicide chemical families. During the last 32 years, Omani farmers have increased the amount of pesticides many folds for crop protection. The use of frequent and excessive amounts of pesticides to control major insect-pests, diseases and weeds has created serious problems including, pesticide resistance in target pests, toxic effects in beneficial organisms, birds & fish; and residues in crops, food, soil and water etc. Our research has been designed with following major objectives: to develop an invitro assay technique for pesticide resistance level determination in major agricultural pests; to develop a rapid pesticides residue bioassay technique for pesticide residue detection in crops; to develop a screening model for evaluating soil and groundwater contamination of pesticides use; to develop molecular markers for pesticide resistances in major insect-pests; and to increase awareness of pesticide resistance through farmer-participatory workshops. The outcome will help to develop a pesticide resistance index for the major insect-pests in Oman; and to determine residual levels in crops, soil and water.

Non-toxic Antimicrobial and Antifouling Compounds from Marine Organisms

S. Dobretsov

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Biofouling – undesirable attachment and growth of marine organisms on submerged surfaces – causes serious problems for the navies and marine industries around the world. Current antifouling technology is based on the application of toxic substances that can be harmful to the environment and humans. For this reason, there is a need for the development of "environmentally friendly" antifoulants. Only few non-toxic antifouling compounds have been isolated so far. In our investigation we isolated bioactive compounds from marine sponges, algae, soft corals and microbes and tested their antifouling potential. We were able to find some non-toxic antimicrobial and antifouling compounds from marine organisms and elucidate their structure. Results of this study suggest that marine organisms are promising sources of non-toxic antifouling compounds.

Glycemic Index of Foods: Relevance to Health and Management of Chronic Diseases in the Arab Gulf Region

Amanat Ali

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Changes in lifestyle and food consumption patterns during the past 3 decades in the Arabian Gulf countries have resulted in shifting of health problems from the survival issues to the diet and lifestyle related problems such as diabetes, heart diseases, hypertension, and obesity. According to the National Health Survey (2000), the prevalence of these non-communicable diseases is high in Oman. The glycemic Index (GI) of foods has shown its significance as a useful nutrition concept for classifying the carbohydrate rich foods based on their postprandial blood glucose responses, which relate to the rate at which these foods are digested. Low glycemic index foods have been shown to lower the risk of type 2 diabetes, reduce the rate of cardiovascular diseases, and certain types of cancers as well as can promote weight loss and help in controlling obesity. The chronic consumption of high glycemic index foods is thought to challenge the glucose homeostasis mechanisms and consequently may lead to insulin resistance and other related conditions. Despite inconsistencies in the existing data, sufficient positive findings have emerged to suggest that dietary glycemic index is of potential significance in the prevention and treatment of chronic diseases. Data bank of foodstuffs for their GI values is therefore important to make appropriate diet plans for both the diabetic and healthy people. We have evaluated the nutritional quality and glycemic index of some of the traditional Omani foods including different types of breads, dates and Omani halwa. These foods were found to have low to medium glycemic index values. The paper will discuss the significance of glycemic index in chronic diseases and the importance of developing a data bank of local/regional foods for their chemical composition and glycemic index (GI) values to make appropriate diet plans for both the normal population as well as for the people with physiologic abnormalities in the prevention and control of chronic diseases.

Effect of Drying Methods on Functionality of Garlic Powder (IG/AGR/BIOR/05/01)

M.S. Rahman¹, S.S. Sablani², A. Mothershaw¹, N. Guizani¹, G. Bengtsson³, Q. Al-Shamsi¹, H.I. Al-Sheibani¹, M.K. Al-Khuseibi¹, N.A. Al-Habsi¹, R.H. Al-Belushi¹, S. Al-Maskri¹, A. Al-Alawi¹, I. Al-Marhubi¹, I.S. Al-Amri⁴, M. H. Al-Riziqi¹

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Consumers' demand towards functional and health beneficial foods are increasing worldwide. Garlic has been used worldwide as a spice, food, and folk medicine. Functionality of garlic depends on how it is processed or preserved. Processing methods could destroy its functional components. The objective of this project was to investigate the effects of drying conditions and methods on structure and functionality of garlic powder. The formation of pores in garlic was examined during freeze-drying at different shelf temperatures (-5, -15, and -25°C). Apparent porosity increased with the decrease of moisture content showing varied curvatures depending on the shelf temperatures. Samples dried at -5°C showed significantly lower open pore porosity compared with the samples dried at -15 and -25°C, respectively, although all samples showed similar apparent (i.e. total) porosity. Pore-size distribution and scanning electron microscopy also supported these results. Moisture sorption (adsorption and desorption) isotherm of freeze-dried garlic powder was measured by static and dynamic isopiestic methods. The state diagram of freeze-dried garlic powder was developed using freezing curve, glass transition line, and maximalfreeze-concentration condition. State diagram developed could be used to identify the suitable processing conditions and food's stability during storage. The anti-microbial activity of a range of garlic products including dried garlic powder produced by different methods, commercial garlic products, and garlic oil was determined against a range of selected bacteria. Allicin, which is rapidly produced by the action of allinase on alliin when fresh tissue is crushed, is the main biologically active phytochemical of garlic. Air drying at 50°C, vacuum drying at 50 and 60°C, nitrogen atmosphere drying at 40°C gave lowest losses of allicin potential. In general the loss of allicin potential increased with increasing drying temperature, and drying below 50°C should be the best drying condition for the retention of allicin potential.

Water Markets in Aflaj Systems: Economic Efficiency and Institutions (IG/AGR/ECON/05/02)

Slim Zekri, Houcine Boughanmi, Hemesiri Kotagama

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The Aflaj small community managed irrigation systems date back to several centuries in Oman. They are monitored by a legally authorized person elected among the community of water right's owners. Farmers do own private water rights. The common water rights that are leased in the water market among farmers. Aflaj likely established the most ancient water market that has ever existed in the world. In the literature, several authors oppose the establishment of water rights and water markets. It is often argued that privatization of water services is not recommended in case of tiny proprieties and that water markets are not frequent because they are inefficient (Dellapena, 2001; Trawick, 2003). Since Omani water markets existed long-ago, the idea is to show that these water markets are able to balance supply and demand with very low transaction costs in an efficient way.

Records maintained by Aflaj managers about water prices and quantities auctioned weekly in 4 Aflaj during 994-2006 were collected in Samail region. Monthly Aflaj flow recorded by Ministry of Regional Municipalities and Water Resources are used to convert the water time-share auctioned into a volume in cubic meters. Additional surveys have been conducted for 2 Aflaj to collect farmer's income and social information. Several econometric linear and non-linear models were used to estimate the demand functions. A great difference in water prices was observed between the four Aflaj despite the similar weather, soil and socio-economic conditions. We believe that water price differences are mainly due to the high difference in water flow and to the absence of water transfer between Aflaj. Prices varied between 10 and 20 Baisas/m³ until the end of 1999, which means that there was no acute water scarcity. The maximum prices turned around 170 Baisas/m³ in 2003.

The statistic T-test was used to find whether seasonal water prices are different or not. For 5 years out of 6, the difference was statistically significant with an average difference of 8 Baisas/m³. Modeling water demand in the Aflaj areas revealed high elasticity values ranging between -

0.10 and -0.28. Irrigation prices in Aflaj have increased in response to supply decrease. Farmers have thus the capacity to adjust to water demand and supply via the market without the need for any government institution intervention, which shows the effectiveness of the market and its ability to manage water scarcity. The market is run transparently by the community itself. Water demand was further investigated using data gathered from the 2004-05 agricultural census and also from a survey done in 2 Aflaj in 2006. However the demand functions estimated were not statistically significant. The absence of yearly agricultural output prices- mainly dates prices/variety- is one important reason. The second reason is that farming is not meant only to produce agricultural products but to produce beauty and landscaping as well as a preservation of a family asset. We failed to capture these non- market benefits into our demand functions.

Poster Presentations

Chemical Composition and Glycemic Index of Three Different Varieties of Omani Dates (IG/AGR/FOOD/04/01)

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Date is a delicious fruit with sweet taste and fleshy mouthful. It represents an important constituent of everyday food basket of Omani people. Sugars make up a major component of date, which can be easily digested and metabolized after ingestion to provide a quick source of energy for body activities. Almost 60-70% of dates are consumed in the dried form. The present study was conducted to determine the chemical composition and glycemic index of 3 different varieties of sun-dried dates.

Representative samples of three varieties (Khalas, Khsab and Fardh) of sundried dates grown in three different regions (A'Dakhlia, A'Dhahira and Al-Batinah) of Oman were collected and analyzed for proximate chemical composition, dietary fiber contents and various sugar fractions according to the methods of AOAC (2000). The glycemic index of these dates was determined in ten healthy human volunteers (both males and females having an average age, height, weight, and body mass index of 22.7±0.8, 1.64±0.1,62.1±11.8 respectively) according to the method as described by Wolever et al. (1991) and FAO/WHO (1998). Pure glucose was used as a standard reference food.

Significant (P<0.05) differences were observed in the proximate chemical composition, dietary fiber contents, various sugar fractions and energy value of these dates. The moisture, ash, crude protein, total fat, and nitrogen free extract (NFE) values ranged between 18.77-23.71, 1.12-1.55, 1.28-1.89, 1.14-2.37, and 68.53-75.37 (g per 100g of date flesh on as such basis) respectively. The energy values ranged between 301 to 319 kcal/100g of date flesh. The dietary fiber content of the date samples ranged between 8.83 to 13.11 g/100g whereas the total sugar contents ranged between 52.17–59.96 g/100g. The glycemic index of different varieties of dates, collected from various regions of Oman (Khsab A'Dakhlia, Khsab A'Dhahira, Khsab Al-Batinah, Khalas A'Dakhlia, Khalas A'Dhahira, Khalas Al-Batinah, Fardh A'Dhahira and Fardh Batinah) and served with water, were 57.7, 52.3, 54.9, 50.9, 49.9, 55.6, 57.1, 47.6 and 50.9 respectively. The GI

values of these dates, when served with Arabian coffee, were 66.1, 55.9, 54.3, 52.9, 50.6, 63.0, 49.9, 44.8, and 54.3 respectively. Overall the variety Fardh showed significantly (P < 0.05) lower GI value (50.8) as compared to other two varieties Khsab (56.9) and Khalas (53.9). No significant differences were however observed between the glycemic index of dates served either with water or with Arabian coffee. The regional effects on the glycemic index of dates were non-significant (P < 0.05).

The present study indicated significant differences in the chemical composition of date varieties. Overall the varietal differences were significant. However, the regional differences did not significantly affect the GI value of dates. The results of this study will help in developing the appropriate dietary management strategies utilizing the concept of GI of foods for incorporating the dates in meal planning for normal and diabetic subjects to reduce the risk of chronic diseases.

Seasonal Variation of Phytoplankton Populations and Dissolved Organic Carbon (DOC) in the Coastal Waters of Oman

(IG/AGR/FISH/04/03)

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The Sultanate of Oman has an extensive coastline of 3615km, which includes the Gulf of Oman in the North and the Arabian Sea in the South. The oceanography of the coastal waters of Oman appears to be quite variable, complex, and poorly known. Biological characteristics of the ecosystem of the Gulf of Oman are mostly driven by the monsoonal winds (North East (NE) during winter and South West (SW) during summer). With the exception of few isolated studies, there have been no concerted efforts to examine the diversity and spatial-temporal variations of phytoplankton communities and their influence on the changes of DOC in the Gulf of Oman. To better understand the spatial and temporal variability of phytoplankton communities and their contributions to DOC, a study was conducted at three stations Fahal (F), Bandar Khairan (BK) and Offshore (OFF) in the coastal waters of the Gulf of Oman. The sampling strategy allowed us to follow spatial and temporal changes in phytoplankton community structure covering seasons that included the NE and SW monsoons. Hydrographic data, nutrients, chlorophyll a, DOC and phytoplankton samples were collected twice a month over the study period. Phytoplankton communities exhibited seasonal pattern characterized by three major groups: diatoms, dinoflagellates and cyanobacteria that appeared to be driven by the changes in hydrographic and chemical parameters. Highest phytoplankton abundance at station (F) $(5.3 \times 10^5 \text{ cells/L})$ was observed in August while the highest abundance at station (OFF) (5.8 x 10^4 cells/L) was observed in February. Phytoplankton assemblages were dominated by diatoms and dinoflagellates throughout the year at both stations. Diatoms maxima were observed in winter and autumn while dinoflagellates maxima observed in summer. Cyanobacteria were noticed in summer when nitrate concentrations became <1uM. DOC concentration showed a seasonal trend characterized with low concentration during winter and major peaks coinciding with high phytoplankton abundance. Our observations provide empirical evidence indicating that the diversity and spatial-temporal variations of phytoplankton communities succession contributed to changes in DOC concentrations in the coastal water of the Gulf of Oman.

Observations on the Fecundity and Gonadosomatic (GSI) of the Omani-Indian Oil Sardine Sardinella longiceps (Valenciennes 1847)

(IG/AGR/FISH/04/02)

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The Omani Indian oil sardine is considered among the most important fisheries in Oman. In this study we investigated the fecundity (F) and Gonadosomatic (GSI) of a total of 70 mature Indian oil sardines collected from the coastal region of Muscat. The fecundity of the fish ranged between 5500 and 60000 with an average of 19000. A significant linear regression was found between F and fish total length (TL); Fish weight (FW) and Gonad weight (GW). The regression equations were found to be: F = 2982.1TL - 28681; F = 927.02FW - 17214; and F = 15748GW - 3891.8. The results of the correlation regression were 0.966437; 0.796241; and 0.877952; respectively. The GSI analysis indicated that Omani Indian oil sardines show two major spawning peaks; March-April and during August.

Salinity and Pythium aphanidermatum-Induced Damping-off Disease of Greenhouse **Cucumbers** in Oman

(IG/AGR/PLNT/04/01)

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Salinity and disease are, respectively, the most important abiotic and biotic constraints to greenhouse crop production in Oman. Sea water intrusion following excessive groundwater extraction for agricultural production has led to a general increase in the salinity levels of irrigation water used across much of northern Oman. Surveys of the EC levels of irrigation water used in greenhouses across the region show that "hot spots" of high salinity occur within well-defined areas. According to published tolerances of cucumber to salinity, over 10% of farms with greenhouses in some areas have EC levels at which crop production becomes marginal due to consequent reduced yields. Based on anecdotal evidence, farms with high salinity levels suffer proportionately higher levels of damping-off disease caused by Pythium aphanidermatum. Detailed investigations have indicated that levels of salinity that compromise crop growth have no effect on the ability of P. aphanidermatum to grow in vitro or in vivo. In agar prepared with saline irrigation water, the pathogen grew as well as in agar prepared with distilled water, even when the salinity level exceeds that at which cucumber production is untenable. Similarly, in sand culture, *P. aphanidermatum* grew and colonized radish seeds even in the presence of highly saline water.

Preparation of Fish Silage under Omani Conditions as a Ruminant and Poultry Protein Supplement (IG/AGR/ANSC/05/01)

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Fish silage was prepared from ground Indian oil sardines (*Sardinella longiceps*) using organic and inorganic acid liquefaction method. For inorganic acids, 1.5 and 3.0 litres of 1:1 v formic and propionic acids combination were added to 100 kg ground sardines. Hydrochloric acid was used in various concentrations (2.0, 2.5, 3.0 and 3.5%). The acid was gradually added to the minced sardines in 10 kg plastic containers and thoroughly mixed using a rod fitted to a drilling machine. An antioxidant (ethoxyguin, 200 ppm) was added to the organic acids liquefaction but not with the HCL processing. The containers were then covered by plastic sheets to keep flies away and allow autolysis under ambient temperatures in the shade. The silage was stirred 3-4 times a day to maintain uniformity especially during the first two days. The pH was monitored daily and maintained below 4 by adding additional acid if required. Autolysis process takes place due to the natural presence of enzymes in the tissue and the acid accelerate it. The fish gradually converted to semi liquid product within two to three days.

The liquefied fish was dried before incorporation with other feed ingredients using wheat bran for ruminants and crushed corn for poultry to avoid high fiber rations for the latter. A 50:50, 60:40, 75:25 and 80:20 fish silage to wheat bran were experimented with aiming to determine the drying ratio which gives crude protein percentage similar to that of soybean. Mixing of wheat bran with the silage was carried out after complete fish liquefaction. The mixture was then spread on plastic sheets and dried under the direct sunlight. It was turned over daily to enable well drying. The co-dried silage was kept in bags under room temperature for future usage. Proximate analysis was carried out on the different mixtures.

The study revealed that the 3% from each type of acids was the optimum level under Omani conditions in which fish was preserved and denaturing of tissue was accelerated as pH level was maintained below 4. The fish silage/corn ratio of 85:15 was the most close to the soybean protein content for use in poultry rations. The fresh fish silage dry matter was 39.3% and it

contained 50.5% crude protein, 22% ether extract, 15.3 ash, 3.4 calcium and 3.1 phosphorus. The 75:25 silage:wheat bran contained 88.3 DM, 39 crude protein, 13.9 ether extract, 12 ash, 1.7 Ca and 1.7 Phosphorus.

This study indicated that fish silage may be successfully made under Omani conditions and it offers a cheap high protein supplement for feeding livestock and poultry. The HCL would be an acid of choice because of its availability and low cost compared to the organic acid (25% of the price).

Nutritional Aspects of Fish Silage and Fish Meal Compared with Soyabean Meal for Feeding Omani and Commercial Poultry Strains in the Sultanate of Oman

(IG/AGR/ANSC/05/03)

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The main objective of this study was to assess the nutritional value of fish silage and fish meal compared with soyabean meal for feeding Commercial and Omani poultry strains. Three protein source diets were evaluated using six replicates of eight birds per cage at 21 day of age for each strain. Cages were located in an environmentally controlled room maintained under conditions suitable for birds at this age with a photo-period of 23h in every 24h. Diets and water were offered on ad libitum basis. On the fourth day after the adaptation to the experimental diets, feed troughs were removed from every cage for 1 h and then reintroduced for 2 h. The ileal digesta samples were collected in small plastic beakers and frozen prior to being freeze-dried. Broiler birds showed distinctly higher digestbility coefficients of amino acids regardless the protein source than the Omani birds (P<0.001). The digestibility coefficients of amino acids of soyabean meal were considerably lower than those of fish silage or fish meal (P<0.001). The poor digestibilities of amino acids for soyabean meal is related to the presence of antinutritional factors such trypsin inhibitors. For broiler birds, the overall mean amino acid digestibility coefficients were: soybean meal (0.86); fish silage (0.90) and fish meal (0.74); whereas for Omani birds; the overall mean amino acid digestibility coefficients were: soybean meal (0.74); fish silage (0.82) and fish meal (0.63). The mean methionine and lysine digestibility coefficients for broiler birds were: soybean meal (methionine:0.93; lysine:0.88) and fish silage (methionine:0.94; lysine: 0.95). The mean methionine and lysine digestibility coefficients Omani birds were: soybean meal (methionine:0.81; lysine:0.79) and fish silage (methionine:0.91; lysine: 0.90). The results showed that fish silage has a great potenial to be used as protein supplements for poultry feeding partially replacing the soyabean meal.

Improving Production of Vegetable Crops by Development of Stress Tolerant Germplasm and Farming Systems Research (SR/AGR/PLNT/04/01)

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This was a multidisciplinary project designed to address strategic issues facing vegetable production. Following five areas remained focus of research: (1) Database on farming systems of Oman (one refereed papers); (2) International collaboration for germplasm acquisition and testing for local adaptations and quality characteristics with emphasis on tomato (four M.Sc thesis and one refereed papers); (3) Management of significant diseases of vegetable crops with emphasis on melons(one M.Sc, one PhD and five refereed papers); (4) Water use efficiency of several vegetable crops as compared to hey grass(one refereed papers); (5) Training of Omani students, staff, extension workers and farmers; and (6) Numerous conferences and workshop presentations.

There was a constant contact with the end users by working with Ministry of Agriculture and Fisheries (MAF) and farmers. We have succeeded in acquiring seeds/germplasm (>170 varieties) from Asian Vegetable Research and Development Center, Taiwan and University of California, Riverside through formal material transfer agreements (MTAs). That includes 54 accessions of tomato, 73 accessions of chilies and peppers, 12 types of heat tolerant beans and more than 30 melons. The experimental work was undertaken at 3 locations i.e. AES/SQU, Rumais/MAF and Barka/Farmer's field.

Overall, the project has been completed (pending some work till May 2008) according to the set milestones.

Prospects of Coral invertebrates from Arabian Peninsula of Oman: A Resource for Novel Bioactive Compounds (SR/AGR/FOOD/05/01)

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Natural products have been a prolific source of nutrition, and medicines for centuries and represent over 50% of all medication today. More than 100 species of corals have been found to inhabit the shallow waters of the Gulf of Oman. Several of these species are endemic to the Arabian Peninsula of Oman coasts. The coral reef fauna found in the southern parts of the Sultanate of Oman are estimated to be 130 species, these are associated with great biological diversity. The presence of high levels of sessile population among the coral reef fauna attracts scientist to investigate their chemical diversity essential for their existence. Discovery of potential marine bioactive compounds and understanding their mechanisms of action promises exploration of new frontiers of cell biology and function.

Within the integrated research program "Marine raw materials and health" supported by HM Sultan Qaboos Trust Funds for Strategic Research (B.Soussi:PI) We have carried on an expedition in the Gulf of Oman for sample collection of marine invertebrates. The invertebrate species investigated are those of soft corals, gorgoninans and zoanthids.

Bioassay guided fractionation using liquid-liquid partitioning followed by normal phase, silica gel and Polyamide chromatographies, combined with size exclusion and reverse phase chromatographic separations of various extracts have led to devise reproducible and efficient isolation schemes for the distinct organic fractions containing these bioactive chemicals.

During the current study, some bioactive compounds have been identified. These have been found to exhibit interesting biological properties, such as imunomodulatory, antibacterial, antiglycation and anti-leshaminial activities. Currently, we are performing high resolution 1D- and 2D-NMR spectroscopic and LC-MS-MS (Q-ToF) studies for structural identification of the isolated compounds.
Availability and Prices of Fresh Fruit and Vegetables in Supermarkets in Muscat, Oman (SR/AGR/BIOR/05/01)

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A major factor affecting the availability of local fresh produce in the market is the application of postharvest technology to reduce losses and maintain quality throughout the supply chain. Efforts to promote fruit and vegetable intake for public health must consider their availability and price. Recently, there has been a global concern on the rising cost of fruit and vegetables and other food products, but availability of relevant scientific data is limited.

Objective of the study was to investigate and document the prices and availability of fresh fruit and vegetables in supermarkets in Oman over an extended period of time.

A monthly survey of three major supermarkets in Muscat (Al Fair, Carrefour and Wholesale Centre) over three years (2005-2008) to record the availability and price of major fruit and vegetables which are both produced locally and imported.

Statistical analysis showed a significantly higher price of imported fresh produce compared with those produced locally. The price of fresh produce increased considerably between 2005 and 2007, with a higher increase for imported (e.g., tomato: 45.8% and banana: 32.38%) than local (tomato: 6.88% and banana: 21.68%) produce. Comparing the 2005 baseline data with 2007, the differences in price between locally grown and imported tomatoes and banana were 52.41% and 83.71%, respectively. Locally grown cucumber was available in the market during most times of the year. Physical assessment of produce samples and interviews with fresh produce handlers suggested that high incidence of physical damage due to inappropriate handling practices and packaging, and low quality produce due to lack of quality control and product segregation were the major factors accounting for the lower prices of locally grown produce.

Quality control is a minimum requirement to improve the price competitiveness of local produce in the domestic market. These findings will assist in designing future studies on quality improvement and postharvest management of local produce. They will also be beneficial in planning policy interventions to promote fruit and vegetable consumption among socio-economic groups in Oman.

Instrumental Texture and Sensory Evaluation of Formulated Fish Sausage

(SR/AGR/FOOD/02/01)

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Fish sausages with different formulations were developed from underutilized low grade fish species caught from the coastal regions of Oman. They were assessed for their quality attributes using sensory and instrumental methods. In a first series of experiment, the level of starch in the formulation was modified from 0 to 48% (w/w raw fish). Results showed that instrumental hardness highly correlated with sensory hardness (r = 0.656). Both sensory and instrumental hardness increased with an increase in starch content. No correlation was observed for adhesiveness, firmness, and brittleness (r = -0.145, 0.120 and 0.059 respectively), indicating that only hardness could be reasonably measured by instrumental method. Principal component analysis and factorial analysis were performed to find more in depth relationships between the attributes and formulated products. Overall, textural desirability was obtained with the formulation containing 8% starch. The addition of spices to the 8% formulation significantly (p < 0.05) improved consumer overall acceptability of the product.

Thermal Transitions of King Fish Muscle (SR/AGR/FOOD/05/01)

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Kingfish (Scomberomorus commerson) is in high demand in Oman and in the international markets owing to its sensory and nutritional attributes. In addition, the fish has some health benefits due to its high content of polyunsaturated fatty acids, mainly the ω -3 fatty acids. The fish is normally preserved at very low temperatures, i.e frozen storage. In order to maximize storage stability of active compounds such as ω -3 fatty acid the knowledge of glass transition temperature and other properties (water sorption and freezing) are important. Thermal transitions of whole fish muscles were measured by Differential Scanning Calorimetry (DSC). Initial freezing points were measured by cooling curve method and modeled as a function of solids content. The muscle showed structural changes as a function of temperature. However, it was difficult to justify that the transition was a glass transition of whole or fat-free fish muscles. The heat flow curves obtained from DSC showed 3 characteristic transitions for whole king fish muscle: one base line shift and two endothermic peaks. The increasing moisture had very little influence on the base line shift. The two endothermic transitions were due to the melting of the fat. The end point of freezing and corresponding solids content was estimated to be – 17.4 $^{\circ}\text{C}$ and 68.8% respectively. The unfreezable water was estimated as 36.7%. The data obtained could be useful in the efficient design of freezing process and also in the evaluation of chemical and biochemical stability of fat and free fatty acids in fish muscle.

An Apple a Day! Do Antioxidant Contents Differ in Peel and Flesh of Fruit Fractions?

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We quantified the differences in vitamin C, total carotenoids, and total chlorophyll (Chla+b) content in the flesh and skin of four apple cultivars, varying in skin color from green (Granny Smith) to deep red (Red Delicious). Mean vitamin C content was significantly higher (51.45%; p<0.05) in fruit skin than the flesh, exceeding 76% for Red Delicious apple. Among the four apple cultivars studied, the average vitamin C content in fruit flesh ranged from 0.86 mg/100gFW (Golden Delicious) to 2.10 mg/100g FW (Granny Smith), while the vitamin content in the skin ranged from 1.56 mg/100 gfresh weight (Golden Delicious) to 4.23 mg/100gFW (Royal Gala). Based on colorimetric attributes of fruit skin color on the CIELAB scale, skin redness (a*) was the best predictor of flesh vitamin C content (R2=0.9984), while skin yellowness (b*) was the best predictor of skin vitamin C content (R2=0.9726).Both mean contents of lycopene and total carotenoids were also significantly higher in fruit skin than flesh, being 60.00% for lycopene and 74.84% for total carotenoids. Although the differences in both flesh lycopene and total carotenoid contents were moderately negligible among the cultivars, the lycopene content of Royal Gala fruit skin and total carotenoids content of Granny Smith skin were significantly higher than other cultivars. Skin total chla+b content were significantly higher in Granny Smith and least in Red Delicious apples. The implications of these findings on dietary planning will be discussed.

Antioxidative Effect of Light Muscle Press Juice from Hamour (SR/AGR/FOOD/05/01)

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Reactive Oxygen Species (ROS) can cause oxidative stress which is in turn linked to various diseases. Studies have shown that antioxidant rich food can reduce the generation of ROS and hence reduce the risk of diseases associated with oxidative stress. Increasing intake of dietary antioxidants may help to maintain an adequate antioxidant status. Currently, there is no "total antioxidants" as nutritional index available for food labeling because of lack of standard quantization methods. We have recently developed a cellular model using human monocytes, to assess the effect of PJ from Herring and known antioxidants, G.Gunnarsson et. al 2006). Hamour (*Epinephalus Chlorostigma*) light muscle press juice (PJ) is used assayed here for antioxidant capacity on the generation of ROS from the monocyte system along with in vitro analysis.

Fresh whole Hamour was obtained from the warm ocean current of Oman. The light muscle was manually dissected from the whole fish minced and extracted. The PJ was subjected to ultra filtration using 1000 Da membrane for the LMW (Light Molecular Weight) fraction, and 3500 Da for the HMW (High Molecular Weight) fraction. In-vitro methods have been optimized to evaluate antioxidant activity in fish muscle. Oxygen Radical Absorbance Capacity (ORAC) assay at 600 nm has been used here for the determination of Total Antioxidants Capacity. ROS were excreted from the Monocytes upon stimulation with phorbol myristate acetate (PMA) and were detected as isoluminol-enhanced chemiluminescence (CL). Ion exchange chromatography coupled with UV-vis detection technique was used for the exposure of trace minerals. Protein content was analyzed by Lowry's SDS Method. Other compositions of PJ were analyzed with post column HPLC.

Both ORAC and CL data show an antioxidant profile of the PJ from Hamour. This effect was, however, more pronounced in the HMW fractions.

It is concluded that the PJ from Hamour reduces the generation of ROS in the human monocyte model owing to its antioxidant capacity. The mechanisms of action remain to be elucidated.

Reference:

Gunnarsson G., Undeland I., Sannaveerappa T., Sandberg A. S., Lindgård A., Mattsson-Hultén L. and Soussi B. Inhibitory effect of known antioxidants and of press juice from herring (Clupea harengus) light muscle on the generation of free radicals in human monocytes. *J Agric Food Chem* 54(21), 8212-8221, 2006.

Value-Added Marine Raw Materials and Health

(SR/AGR/FOOD/05/01)

Prof. Bassam Soussi, PI

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This project aims to establish an integrated research program in value-added seafood/marine raw materials for health. Quality, safety, human nutrition issues are addressed as well as the evaluation of novel candidate substances and their mechanisms of action.

The beneficial health effects from a fish-rich diet indicated in epidemiological studies point out the involvement of omega-3 free fatty acids (n-3 PUFA). However, the mechanisms remain unknown and aqueous compounds in the fish might possibly also be involved. Utilizing marine bioactive compounds for value added food or functional foods can raise the status of the fish industry, but more knowledge is needed on mechanisms of action and oxidative stabilization. We aim at (i) developing new natural antioxidative strategies for marine bioactive substances and (ii) further evaluating the role of marine antioxidants in vivo.

The effects of dietary oils on the n-3 PUFA content of two species of farmed and marine fish will be examined. The fish produced with increased n-3 PUFA concentrations along with marine fish will be studied in animal models and clinical trials with human volunteers in Oman. Quality issues will be addressed by innovative post-harvest handling, packaging and storage conditions to improve the quality of fresh and frozen fish.

An extra dimension will be provided by studying algae and a variety of marine invertebrate organisms from Omani habitats. Extraction, processing and identification of compounds will be carried out.

This multidisciplinary research project will be performed at Sultan Qaboos University involving the Colleges of Agriculture and Marine Sciences and Medicine and Health Sciences and the Ministry of Agriculture and Fisheries. A strong and established international collaboration will facilitate technology transfer and sharing of scientific results and expertise. The project links medical sciences, food science and nutrition with seafood/ marine biotechnology. Parts of the work will be conducted in collaboration with the industry, locally and abroad. The project at large aims at studying bioactive compounds in marine raw materials from molecule to man with focus on health. Traditional and new tools for measurements will be used. In vivo studies will be based on mouse/rat models combined with state-of-the-art whole body high resolution MRS/MRI investigations.

Impact

- Identification of additional bioactive components in fish and other marine species for functional foods and nutraceuticals will create business opportunities.
- Production of high quality safe seafood will contribute to better health and well being.
- Illumination of the mechanisms behind the role of fish consumption in disease prevention will lead to better dietary recommendations.

Significant Research Outcomes

Significant Research Outcomes

Effects of Pomegranate Juice Consumption on Health of Healthy University Student Volunteers

M.R. Al-Ani, L.U. Opara, S.S. Al-Kindi, F.A. Al-Said

In a preliminary study performed in summer of 2008, fourteen healthy female students from SQU campus took part in the study. All participants were in good health as determined by medical history questionnaire, physical examination, and laboratory blood tests. Before starting the experiment, overnight fasting blood samples were collected for analysis. Subjects were then given 200 milliliter of Jabal Al-Akhdar pomegranate juice per day for four weeks, except weekends. By the end of this period, blood samples were also collected. Analysis of blood included platelet aggregation, C-Reactive protein, lipid profile (triglycerides, total cholesterol, HDL, LDL, and VLDL), lycopene, β -carotene, vitamin C, total antioxidant status, and blood pressure. Results showed consistent maintenance of normal blood pressure, with a reduction in the level of blood cholesterol and triglycerides but increasing the level of HDL.

Vitamin C Content and Antimicrobial Properties of Pomegranate Fruit (*Punica granatum* L.) Sold in Oman

M.R. Al-Ani and L.U. Opara

Pomegranate (Punica granatum L.) is one of the oldest edible fruit that has long history as a medicinal fruit and have been used extensively in the folk of many cultures. All parts of the pomegranate tree and fruit have been used to ameliorate an array of common diseases. The objectives of this study were to determine the vitamin C content and test the antimicrobial properties of fresh and dried fractions of fruit peel and arils of locally grown and imported pomegranate sold in Oman. We found a significant variation in vitamin C content among the five types and sources of pomegranate studied, ranging from 52.8 to 72.0 mg/100g fresh weight (FW) for arils and 76.8 to 118.4 mg/100gFW for peels. Irrespective of the type or source of pomegranate, vitamin C content in the peel was significantly higher than the aril, with differences ranging from 24.4% to 97.0% depending on cultivar. Fruit fractions, particularly locally grown fruit, showed antimicrobial effects (inhibition zone) on Staphylococcus aureus and Pseudomonas aeruginosa but not Escherichia coli. Sun drying of fruit peel significantly ($p \le 0.05$) enhanced vitamin C retention and antimicrobial effects in comparison with oven drying presumably due to lower rate of moisture removal associated with low temperature drying over longer duration in comparison with short-time hightemperature oven drying.

Coral Reef Communities

M. Claereboudt

A simulation study of coral dispersal suggest a very low level of connectivity accross reefs located on either side of Ras-alHadd. In addition, even between reefs located in the same region (gulf of Oman, Arabian Sea), connectivity is relatively low on average. Most reef community appears to be mainly self-seeding. Although this result confirm a general trend in recruitment, larval dispersal models in various part of the world, this is the first indication that such mechanism takes place in the Gulf of Oman. This findings has consequences for conservation, biodiversity and biogeography studies and possibly for fisheries. It implies that micro management strategies could work for some invertebrates and fish species.

Two special problems studies showed the importance of controlling incident light on turtle nesting beaches and on the negative impact of car and truck tracks on the same beaches. Both disturbances have highly significant effect on the survival of hatchling turtles. These papers were submitted to the college for "Best Special-Problem" award. They were carried out by Haitham Al-Furqani and Ammar Al-Omiri.

Bioactive Compounds from Marine Microorganisms

S.V. Dobretsov

With the help of Prof. Peter Proksch we were able to isolate and identify an antifouling compound from the soft coral *Sinularia* sp. inhabiting Bandar Khiran. This compound appeared to be hydroxytritriacontanoic acid with chemical formula $(C_{33}H_{66}O_3)$. This is the central core finding in the Ms. Aisha Wahaibi MSc thesis. Additionally, about 300 strains of bacteria were isolated from Omani waters and their ability to produce amylases (enzymes that cleave long chain sugars). Several potent strains were identified and their properties have been investigated.

Review of the Current Situation of Aquaculture in the Sultanate of Oman – with Particular Reference to Food Safety and the Environment *S. Goddard*

This project was undertaken in May/June 2008 under a service contract between the Ministry of Fisheries Wealth/FAO/SQU. Three specialists were involved in the study; Dr Stephen Goddard was selected as the national aquaculture expert, Dr N. Anadvally, FAO, as consultant on fish quality and safety and Dr Sunil Siriwardena, FAO, as a consultant on the environmental impacts of aquaculture. The work commenced with a review of existing aquaculture regulations and visits to the national offices and laboratories involved in regulatory and development work in aquaculture. Visits were also made to fish farms. The study focussed on the issues of consumer safety of aquaculture products and the impacts of fish farms on the environment. A 52-page report, based on the findings and including recommendations, was prepared by the Fisheries and Aquaculture Department, FAO, Rome and submitted to the Ministry of Fisheries Wealth. Sultanate of Oman.

Physiological Responses of Date Palm to Various Levels of Water Stress

R. Al-Yahyai

Date palm (Phoenix dactylifera) is primarily cultivated in arid and semi-arid regions that are characterized by high evapotranspiration, low and sporadic rainfall and dependency on irrigation for crop cultivation. Frequent drought periods influence growth, yield and fruit quality of fruit crops in these regions. The effects of sub-optimal irrigation on the yield and fruit quality attributes of dates were investigated. Physico-chemical quality attributes of date palm (cv. Khalas) grown in northern Oman showed variable response to reduced frequency and amount of irrigation water applied during fruit development. Bunch weight, fruit weight, Fruit juice content, titratable acidity, and reducing sugars were reduced in the fruits of the least irrigated date palms, whereas, total soluble solid contents (°Brix), percentage of dry matter, and pectin were increased. No significant differences were observed in tannins, pH, and ash content. Yield and eating quality of dates were directly related to the amount of irrigation water received during fruit development.

Wholesale Fish Market for Oman

A. Palfreman

This study was completed in collaboration with Ministry of Fisheries It identified several weaknesses in Wealth officials. the fish marketing and distribution system in Oman, such as poor management of fish markets, food quality failures, small numbers of buyers and sellers at some remote markets, weak box management, selling of fish in other, often unhygienic and in the full glare of the sun, Gulf markets, under distress conditions and information failures. It noted that most significant fishing nations have central wholesale fish markets to support internal distribution as well as exports. It recommended that Oman should have such a market, based in or near Muscat, and prepared a pre-feasibility study. The recommendations were accepted by the Cabinet and proposals for its construction are now under consideration by the Government.

Code of Practice for Financing Investment in the Small-Scale Fisheries Sector

A. Palfreman

The study reviewed the current status of credit finance for investment in the small-scale fisheries sector. It assessed the extent to which the financing system in Oman meets the development and management needs of the sector. It concluded that Oman has a wellfunctioning finance sector, and that investment finance is available from various sources, especially, but by no means only, the Oman Development Bank. However, the current credit regime sometimes fails to take into account the special characteristics of the sector, such as the seasonal fluctuations in fish availability as well as the capacity of small vessels to put to sea at certain times of the year. The system does not help young Omanis with limited collateral to invest in the sector. The credit arrangements do little to meet the development needs of the sector, namely the policy requirement to expand operations into larger vessels capable of operating further offshore for longer periods. The study prepared a draft code of practice and made some recommendations on improvements to the credit system, notably suggesting a greater degree of partnership between the State and private sector financial institutions.

Comparative Studies of Size-Fractionated Phytoplankton Primary Productivy and Bacterial Biomass and Production in Bandar Khayran Bay, Gulf of Oman and Masirah Island Arabian Sea

A. Al-Azri, K. Al-Hashmi, S. Al-Khusaibi

Phytoplankton are known to play a significant role in the marine primary productivity. However their response to environmental changes in term of carbon flow may vary depending on the ecosystem. A rather puzzling feature of phytoplankton groups is the coexistence of diverse phytoplankton groups with differing degrees of abundance and growth.

This project investigates how the carbon and energy flow in marine environments that go through the seasonality of monsoon winds over the period of three years. The project results have proven their significance in understanding the spatial-temporal variability of the Gulf of Oman and Arabian Sea. For instance seasonality of water temperature and nutrients have shown the high concentrations of nutrients and lower temperature at Masira station compared to Gulf of Oman which could be attributed to the south west monsoon upwelling. From the hydrography data, we were able to detect the extended period of the South west monsoon which is yet to be compared to chemical and biological data. Taxonomical and sizefractionated phytoplankton showed for the first time the annual distribution of different groups of phytoplankton (pico-nanno and microplankton) in the Arabian Sea and the Gulf of Oman.

Mango Rootstock Evaluation, Conservation and Use in the Sultanate of Oman

M.L. Deadman

Mango wilt disease has become the most important constraint to fruit production in Oman since the lime witches broom disease epidemic was identified in Oman in the 1970's. The disease has regional and international implications were it to spread beyond Oman. The causal pathogen was identified as a new species (*Ceratocystis manginecans*), distinct from a second new species described from the project (*Ceratocystis omanensis*) that is also implicated in disease aetiology. The epidemiology of the disease has been described and includes the involvement of a bark beetle (*Hypocryphalus mangiferae*) as vector for the pathogen. The extent of mango tree losses have been quantified and the epidemic quench point has been estimated at about 60% loss. Exotic mango germplasm has been imported (under phytosanitary license) for ongoing evaluation for resistance to the disease. A national strategy has been established for the rehabilitation of mango in Oman. Substantive collaborations have been maintained with the Ministry of Agriculture, University of Pretoria, South Africa, University of Florida, USA, University of Agriculture, Faisalabad, Pakistan, Department of Agriculture, Bhutan, Ministry of Agriculture, Nepal, and FAO.

Insecticide Resistance in Major Agricultural Insect-Pests in Oman: Monitoring and Management Strategies *F. Talukder*

One hundred crop producing farms representing differences in size, location and organizational structure were surveyed from 5 major crop growing regions in the Sultanate i.e. Batinah, Dakhliva, Dhahirah, Sharqiyah and Dhofar. The surveyed farms were growing different vegetables, fruits and secondary crops as a part of mixed cropping practices. All surveyed farms use different degrees of chemical insect-pest management as crop protection tools. Among the major insect-pests, the whitefly, leaf minor and heliothis as major vegetable pests; bark beetle, fruitfly & mites as major fruit pests; and whitefly, leaf minor & leafhoppers were recorded as major secondary crop pests. It was found that all Omani farms prefer to use chemical pesticides as a part of the crop protection. Over 40 different insecticides, 25 fungicides and 4 herbicides were recoded in the surveyed farms. In case of insecticides, Salut, Malathion, Omite, Dimecron, Diazinon and Dursban were recorded as most popular insecticides used by Omani farmers. Among the fungicides, the most commonly used fungicides were the Dithane, Ridomil, Carbendazim, Derosal and copper sulphate used by Omani farmers. On the contrary, most of the Omani farms preferred not to use chemical weed control practices. The majority crop producing farms monitored their crops regularly for the presence of insect, diseases and weeds. However, a certain ratio of farms uses routine application of pesticides, irrespective of the presence of insect-pest.

Summary of Internal Grant Projects Awarded in 2008

Effect of Thermal Processing and Enzyme Supplementation on the Nutritive Value of Local Agricultural by-Products as Feed Ingredients in Chickens Diets

W. Al-Marzooqi, P.I.

Dept of Animal & Veterinary Sciences College of Agricultural & Marine Sciences Sultan Qaboos University

Duration: 3 years

Budget: 11,500

Summary

A major constraint of poultry production in Oman is the high cost of feeds. One way to overcome this problem is by using unconventional local cheap feed resources. Generally there is a lack of information on the nutritive value of unconventional local feed ingredients available in Oman. This study aims to investigate the effect of processing and enzyme supplementation on the nutritive value of mango seeds kernel, date pits and Meskit pods on ileal nutrient digestbilities. performance and carcass and meat quality characteristics in broiler chickens. These aims will be achieved through three phases. The first phase will determine the chemical composition and anti-nutritional levels in mango seeds kernel, date pits and Meskit pods before and after processing. The second phase is designed to determine the nutrient digestibility coefficients of amino acids, crude fiber and energy in raw and processed mango seeds kernel, date pits and Meskit pods in a set of digestibility trials. In phase three, a growth study will be conducted to test the effect of processing and exogenous enzymes on the nutritional value of local agricultural by products. The dietary treatments, involve 3 levels of inculsion (5 %, 10% and 15%) for each of 3 local by products (mango seed kernel, date pits and Meskit pods) partially substituting corn; 3 processing (raw, process 1, and process 2); 2 enzyme treatments (with enzyme and without enzyme) and will be evaluated in comparisons to the basal diet (with and without enzyme). There will be six replicates for each dietary treatment, and each replicate cage will contain five birds. Daily feed intake, body weight gain feed conversion ratio will be measured. At the end of the growth study, 12

birds per treatments will be randomly selected and slaughtered to evaluate carcass and meat quality traits as well as measuring ileal viscosity. This project will provide information on the nutritive values of potential local feed ingredient which may reduce feeding cost of poultry and consequently increase farmer's revenue in the Sultanate of Oman.

Evaluation of Omani Camel Performance under Intensive Management for Meat Production and Quality

O. Gaafar, P.I.

Dept of Animal & Veterinary Sciences College of Agricultural & Marine Sciences Sultan Qaboos University

Duration: 3 years

Budget: 12,000

Summary

This study aims to evaluate the potential of the Omani camel for meat production under feedlot systems. The meat production abilities of the camel will be studied in animals maintained under intensive management. Yearling camels will be purchased and transported from Dhofar region and housed at the AES. For comparative investigation, the performance of camels will be evaluated under both intensive and poor managemental conditions. Growth rate, feed conversion, carcass and meat quality will be analyzed in animals fed varying qualities of feed ranging from a high plane of nutrition to poor quality roughage. Health parameters including haematological and serum biochemistry values will be determined for camels under high and low planes of nutritoin as a baseline for assessing the physiological status of camels in health and disease. Immuno histochemistry and enzyme kits will be used to study the changes in the digestive physiology of the camel under various nutritional levels. Collaboration include the Dept of Animal Wealth, Ministry of Agriculture and Fisheries, Oman National livestock Developemtn Co. and Omani local camel herders.

Investigation on *Brucella melitensis* Immunogenic Domains

Y. El Tahir, P.I.

Dept of Animal & Veterinary Sciences College of Agricultural & Marine Sciences Sultan Qaboos University

Duration: 3 years

Budget: 12,000

Summary

The present work is aimed at establishing the prevalence of Brucella. melitensis in goats and camels in Oman, and investigation on competitive tests for detection of the organism. Random blood samples would be collected from goats and camels. The slaughter house will also provide blood and tissue samples. The database will be searched for characteristic immunodominant domains and specific immunogenetic regions that could be targeted. The biotinylated synthetic Bp26 or Omp31 proteins -specific peptides would be used together with enzyme-immunodominant assay (ELISA). Commercial kits and reference sera will be used. The outcome will contribute to cost-effective standardization of Brucella testing and increase the sensitivity and reliability of rapid screening tests. Collaboration includes the Department of Animal Wealth, Ministry of Agriculture and Fisheries, mainly Dr. Adam Mohammad Adam Brucella Researcher at Salalah Veterinary hospital, Oman National Livestock Development Co., Muscat Municipality and local camel herders.

Damage Cost in Dry Aflaj and Live Aflaj Value for Recreation

S. Zekri, P.I.

Dept of Natural Resource Economics College of Agricultural & Marine Sciences Sultan Qaboos University

Duration: 3 years

Budget: 8,900

Summary

The current research proposal aims to determine the economic value of aflaj other than the direct agricultural value. The damage cost caused due to falaj dry up has never been estimated. The damage cost is much higher than the simple damage of production losses. The second objective of this project is to determine the value of aflaj for recreationists. The estimation of the damage cost to dry aflaj and the value of recreation in the case of active aflaj is a powerful argument to increase expenditure and develop serious hydrological projects aimed to protect aflaj from drying up. The damage Cost Method will be used to estimate the social and environmental costs in dried aflaj. This method is useful when measuring the resource cost brought on by an environmental change. The travel cost method (TCM) is intended to place a value on non-market environmental goods by using consumption behavior in related markets. Used as a proxy for price, consumption costs will include travel costs, entry fees, on-site expenditure and outlay on capital equipment necessary for consumption. The final purpose of the research project is to help decision makers understand the benefits of protecting aflaj as a system and compare such benefits to the costs of protection and necessary investments. Besides, protection of aflaj should be undertaken by farmers themselves, thus proposing entrance fees, when possible, will considerably improve the maintenance of the aflaj given the incentive to farmers in doing so by increasing the number of visitors and thus income from non agricultural products.

The Taxonomy and Ecology of *Benthic Elasmobranchs* in the Gulf of Oman

A. Henderson, P.I.

Dept of Marine Science & Fisheries College of Agricultural & Marine Sciences Sultan Qaboos University

Duration: 3 years

Budget: 4,980

Summary

Much confusion exists over the identity of a number of ray and guitarfish species inhabiting Oman's waters. This has obvious ramifications for the management and sustainable exploitation of these stocks. The proposed project will examine the taxonomic characteristics of rays and guitarfish inhabiting the shallow shelf waters of the Gulf of Oman, and thereby determine their true identity. Specimens will be procured from fish landing sites as well as through an at-sea sampling campaign. Additionally, coastal surveys will be used to identify key nursery grounds for the species in question. The results of the study will complement those of a previous MAF study which focused on the shark species in Omani waters, and will be employed in a general management plan for the Oman elasmobranch fishery. It is envisaged that certain ray and guitarfish species will be confirmed as species complexes; the actual species will be delineated and described, and fisheries relevant biological characteristics will also be reported.

Antiatherogenic Characteristics of Consumption of Fruit and Vegetables Grown in Oman

M. Al-Ani, P.I.

Dept of Food Science & Nutrition College of Agricultural & Marine Sciences Sultan Qaboos University

Duration: 3 years

Budget: 11,000

Summary

Coronary heart disease is the major contributor of morbidity and mortality in the world. The national health survey conducted in 1999 in Oman (published in 2000) suggested that risk factors for cardiovascular disease are high and that coronary heart disease (CHD) may be considered as the leading cause of death in the Sultanate, which may be attributed in part to dietary habit and practices. Antioxidant nutrients are believed to slow the progression of coronary heart disease because of their ability to inhibit damaging oxidative process. Among the antioxidant-rich foods, tomato occupies a top position because of its high lycopene content. Pomegranate was also shown to possess potent antioxidative capabilities against lipoprotein oxidation and platelet aggregation. Human and animal studies on both products proved to be as cardioprotectors, but no research has been conducted in this regard on fruit and vegetables grown in Oman, since nutrient contents would vary with regional, seasonal, and ecological factors.

The aim of the study presented herein was to investigate the role of consumption of certain fruit and vegetables grown in Oman such as pomegranate and tomato in the prevention of coronary heart disease. Prior to the study, clearance from the University ethic committee is to be granted. The first phase of the experimentation will be analyzing pomegranate juice (PJ) and tomatoes grown in Oman for their nutrient composition, with concentration on the antioxidant content such as vitamin C, β -carotene, lycopene, and total antioxidants, beside the proximate analysis. Such fruit and vegetables are to be given to human volunteers. Forty eight healthy non-smokers of both genders recruited from SQU campus by mean of advertisement are to take part in the study. All participants are to be in good health which will be determined

by medical history questionnaire, physical examination, and results of laboratory tests. During the study, subjects are to continue their habitual diets. Before starting the major experiment, participants are to stay only on their habitual basic diet for two weeks, and by the end of this initial period, 15 ml of overnight fasting blood samples are to be collected in citrated tubes for analysis. Subjects are then to be randomized into two equal groups. Each individual in the first group is to take 250 ml of pomegranate juice per day for four weeks, and those in the second group to consume 100 gm of fresh tomato per day for the same period. By the end of this period, blood samples are to be collected again. By the end of this stage, volunteers are to be left again for two weeks on their basic diets as a washout period, and then blood to be collected again. In the last four week of the study, all subjects are to take both pomegranate juice and fresh tomatoes daily, and then withdraw blood samples. Analysis of blood will include platelet aggregation, lipid profile (triacylglycerol, total cholesterol, HDL, LDL, VLDL), lycopene, β-carotene, vitamin C, and total antioxidant status. In conclusion: the present study will lead to a better understanding of the interaction between fruit and vegetables consumption and the protection against coronary heart disease, and whether Omani grown produce have different properties.

Chemical and Physical Characterization of Date Pectin and its Effect on Date Syrup Quality

A. Al-Alawi, P.I.

Dept of Food Science & Nutrition College of Agricultural & Marine Sciences Sultan Qaboos University

Duration: 3 years

Budget: 6,000

Summary

Date is rich with many compounds that can be utilized to produce value added products. One of these compounds is pectin. Pectin is produced commercially as a by product of other products mainly because it exists in small quantities. The same principle is applied to dates. Although the percentage is very low, pectin has very big influence on quality of date syrup which is considered as one of the most products of dates. This influence comes preliminarily from the fact that pectin can exist in many forms and sizes depending on the maturation stages. Therefore, good understanding of the changes and their time will effectively provide dates processors with good knowledge to control the quality of the date syrup between batches. Furthermore, pectin some how considered as unwanted component in date syrup, so if the processors can alter the extraction conditions to target only sugars on the date and save pectin, then that pectin can be used as a valued by-product. The objective of this investigation is to study the changes of date pectin during maturation of four different varieties and relate that to the quality of date syrup and also possibility of commercially extracting pectin from date syrup as a by-product will be investigated.

Production and Quality Assessment of a Smoked Tuna (*Thunnus albacares*) Product

N. Guizani, P.I.

Dept of Food Science & Nutrition College of Agricultural & Marine Sciences Sultan Qaboos University

Duration: 3 years

Budget: 3,800

Summary

Tuna and tuna-like species are important fish species in Oman and in the world. Tuna is currently processed as canned food in factory or sliced and exported for sashimi or sold as raw meat in local markets at usually low prices. In order to expand sales and achieve organic growth , it is necessary for the Oman Fish industry to develop new fish products. The objective of this study is to develop quality smoked tuna and to assess the different processing conditions (brine concentration, time/temperature schedules of smoking and drying) on final product quality. The criteria defined to assess the quality of the smoked product are: chemical (moisture, ash, protein, fat and fatty acids oprofile), sensorial (flavor, color, texture and overall acceptability) and microbial (aerobic plate count, coliform and enterococci counts, and histamine producing bacteria). Storage stability of the product will be assessed in order to determine the shelf life of the final products as a function of different storage conditions. The output of this project will be transferred and scaled up to industrial level for the development of quality products for export and the local market.

Performance Evaluation of a Solar Tunnel Dryer for Drying of Fishes and Dates in Oman

M.A. Basunia, P.I.

Dept of Food Science & Nutrition College of Agricultural & Marine Sciences Sultan Qaboos University

Duration: 3 years

Budget: 4,350

Summary

In many countries of the world, the use of solar tunnel dryers in drying agricultural products like vegetables, fruits, coffee and other crops has shown to be practical and economical. Solar dryers considerably reduce the drying time compared to open air natural sun drying. Their small holding capacity is a major limitation for commercialization. Moreover the moisture removal rate is inadequate and the required moisture removal could only be achieved with forced ventilation using fans (Basunia and Abe, 2001b, 2001c; Lutz et al, 1987). A successful new solar tunnel drier was designed and developed at the University of Hohenheim, Germany, to meet the drying requirements of small farmer cooperatives (Esper et al. 1994). This new dryer design eliminated the dependence on grid electricity since the power consumption of the fan could be supplied by batteries or solar PV panels. A solar tunnel dryer, adapting the Hohenheim design and scaled down to fit the Omani environmental conditions and requirements, will be constructed at the Sultan Qaboos University using locally available materials. The performance of the dryer will be evaluated in order to find its suitability in drying dates and fishes as these products drying using solar energy have greater potentiality in Oman.

Summary of Strategic Research Projects Awarded in 2008

Rejuvenating Lime and Mango Production in Oman: Resolving Current Challenges

R.Al-Yahyai, P.I.

Dept of Crop Sciences College of Agricultural & Marine Sciences Sultan Qaboos University

Duration: 3 years

Budget: 100,000

Summary

Production of two major tree fruit crops in Oman, i.e. lime (Citrus aurantifolia) and mango (Mangifera indica), has been significantly reduced in recent years. The reduction in yield has been attributed to a combination of abiotic and biotic factors that adversely affected tree growth and productivity. Loss of area cultivated with lime trees was 50% of that in 1990, mainly due to Witches' Broom Disease of Lime (WBDL). Furthermore, a recent outbreak of Mango Sudden Decline (MSD) has devastated over 60% of mango trees in northern Batinah coast of Oman. The cultivated area in Oman was reduced to less than 30% of what it was in 1990. Reduction in mango production attributed to MSD in Oman was estimated to be 23% of all trees in Oman in 2002. These diseases that originated in the Sultanate have the potential to devastate lime and mango production throughout the entire regions of western Asia and North Africa thus affrecting fruit imports to Oman as well. In Oman, these problems have been worsened by increasingly stressful abiotic conditions caused by drought, salinity, soil infertility and heat which ultimately led to the decline of fruit production in the country. The compound adverse effects of biotic and abiotic stresses on tree fruit yield have resulted loss of tree fruit acreage and profitability and reduced income from largely traditional farming systems. The unsustainable tree fruit production has eventually led to abandonment of many farms, to conversion of fruit farms to forage farms, or to complete change of the land use into housing and commercial projects. While the causes of some of these problems have been identified, practical solutions to them have not been tested and these challenges remain many years later. Through national and international collaboration, methodological experimentation in the laboratory and

field testing of efficient management strategies, this research will tackle solution-oriented aspects of WBDL and MSD in Oman. The researchers aim to eventually provide practical solutions to tree fruit growers, thus enabling them to continue production from diseased trees while new, long-term solutions through resistant cultivars are being gradually evaluated and introduced.

The proposed project will address two major issues that face the largest grown tree fruit crops (i.e. lime & mangoes) in Oman:

- (1) WBDL through continued breeding and hybridization of new *Citrus* resistant clones, establishment of field trials for evaluating hybridized and exotic cultivars of *Citrus*, particularly lime, and optimizing fruit production through management of diseased trees;
- (2) MSD through continuous monitoring of the status of the disease in regions in Oman where the disease has not yet been reported, investigating epidemiology of the disease and host-vector relationship and continued screening for disease-tolerance of imported poly-embryonic cultivars for use as rootstocks and mono-embryonic cultivars for use as scions, and investigating the use of various chemical, physical & biological measures to limit the spread of disease to new areas.

Stock Assessment of Kingfish

A. Govender, P.I.

Dept of Marine Science & Fisheries College of Agricultural & Marine Sciences Sultan Qaboos University

Duration: 3 years

Budget: 79,800

Summary

In this study we propose to study the effects of a closed season on the age distribution of kingfish (*Scomberormorus commerson*) before and after the said closed season. We hope to achieve this objective by sampling the catch in a cost-effective way (in terms of manpower and purchasing of samples). The latter is the crux of the study –age determinations and preparation of otoliths requires highly skilled and experienced readers. We believe this study will reduce the cost of sampling kingfish (and other species, giving the multi-species nature of the Omani fishery).

Characterization, Evaluation and Conservation of Indigenous Animal Genetic Resources in the Sultanate of Oman

O. Gaafar, P.I.

Dept of Animal & Veterinary Sciences College of Agricultural & Marine Sciences Sultan Qaboos University

Duration: 3 years

Budget: 80,000

Summary

The importance of animal biodiversity was recognized by the United Nations Convention on Biological Diversity for the integrity and sustainability of the biosphere and human society. The diversity of species, strains and breeds is the basis for the development of highly productive livestock populations. It also allows animals to thrive in the face of harsh climatic conditions. pests or diseases. Conservation of indigenous genetic resources is vital for the development of new and improvement of existing animal species. Oman has noticeable biodiversity in local animals that are adapted to the unique and diverse topographic and climatic conditions of the Sultanate. There is currently a decline in global biodiversity which threatens genetic diversity, the raw materials for food and other by-products. As in many developing countries, the Sultanate of Oman has introduced several modern animal species (bred and selected in other countries) into the research programs and released to farmers. This involves the replacement of the generally viable lower yielding breeds with introduced ones.

It is also recognized that indigenous animal breeds have emerged in Oman by selection for survival since their introduction long ago, most probably from Western Asia. Little work has been carried out to identify or conserve these breed which are well adapted to Omani conditions. A parallel effort is needed to evaluate the reproductive and production performance of local livestock to complement the genetic improvement work. At present, native Omani breeding males are selected on the basis of subjective evaluation of physical appearance and visual observation of the testes and no semen collection and evaluation is performed before animals are used for breeding purposes. Accurate and reliable information on genetic distances within and among Omani breeds and about the contributions of the respective breeds to the total diversity is required in order to make the most optimal use of breeding programs.

The animal genetic resources available to farmers and biotechnicians have been radically reduced this century by the advance of high input, intensive farming systems that tend to rely on developing a small number of productive breeds or strains, leading to the extinction of many well-adapted genetic resources. Indigenous knowledge and cultural diversity is also lost with this erosion of farm genetic resources.

To ensure that valuable genetic resources and indigenous knowledge are preserved this project aims to survey, identify. indigenous characterize and conserve breeds that are useful by incorporating molecular approaches. economically This will accelerate the utilization of Omani livestock in the development of new breeds and or improve the productivity of the currently available ones. This proposal also aims to provide analytical and objective analysis for the genetic diversity within Omani breeds as a rational basis for conservation and improvement. Additionally, efforts will be made to evaluate the reproductive efficiency of Omani breeding animals and establish a semen bank for future genetic improvement programs. Performance of local breeds of Omani chicken and cattle will be evaluated.

Graduate Program

Graduate Program

The Masters program, in its 12^{th} year continues to attract hardworking and enthusiastic students.

The program offers curricula in Animal and Veterinary Sciences, Crop Production, Crop Protection, Food Science and Nutrition, Marine Science and Fisheries, Natural Resource Economics, and Soil and Water Management and Agricultural Engineering.

The College had a total of 102 postgraduate students; 22 graduated in the year 2008 (including 2, who were awarded a graduate diploma).

Graduate students are involved in funded research projects as part of the masters' requirements. This strengthens the quality of their projects and provides them with the tools necessary to conduct practical research in their work areas.

Various abstracts of the thesis work done by the graduate students are presented in pages 64 to 96.

Thesis Abstracts of Students Graduated in 2008

Abstract

Mycoplasma gallisepticum (Mg) is an etiologic agent of chronic respiratory disease (CRD) in poultry. The disease is characterized by respiratory distress, sneezing, sinusitis, and conjunctivitis. In the present study, 551 sera (local = 327, exotic = 224) and 226 egg-yolk samples (local = 111, exotic =115) were collected from broilers and layers respectively. The samples were tested for the presence of antibodies using an antigen specific MqELISA (Enzyme Linked Immunosorbant Assay) and the results were compared to a routinely MaSPA (Serum Plate Agglutination) test. The results used demonstrated that 27.2% of sera and 50.9% of egg volk samples were found to have specific antibodies for Mq. Further analysis revealed that the local breed had a higher percentage of seropositive broilers and positive egg-volk samples in layers. The highest percentage of seropositive chickens was recorded in the local broilers (34.8%) when compared to exotic broilers (1.8%). Similarly, the results of egg-yolk samples demonstrated that the local layers had a higher number of positive samples (21.6%) than the exotic layers (3.2%). There was a significant difference (p<0.05) in seropositivity between broilers and layers of local and of exotic breeds. Based on the results of the MgELISA and the MgSPA tests, it was determined that the MgSPA test gave 6.3% false positives and 1.4% false negative results. When the same sera were tested with an antigen specific MsELISA test, it was found that 61.3% of the false positive samples were due to infection with Mycoplasma synoviae (Ms) which indicates that most cross-reactions seem to be caused by infections with Ms.
Title	:	Serological Response of Goats to an Inactivated Foot and Mouth Disease Vaccine
Student Name	:	Julanda Hamed Humoud Al-Maawali
Supervisor	:	Prof. Eugene H. Johnson
Department	:	Animal & Veterinary Sciences

Goats are the main source of meat in Oman as their meat is the most preferred by the local population. Infectious diseases such as Foot and Mouth disease (FMD) constitute a major impediment to animal production and are considered to be an important limiting factor in the maintenance of livestock such as goats. FMD is considered to be endemic in all regions of Oman. In order to control and prevent disease outbreaks a trivalent killed vaccine containing types O, A and Asia1 FMD virus is used for vaccination in the Sultanate.

To ascertain the effectiveness of FMD vaccine the present study highlights the serological response of 4 breeds of goats to FMD vaccine containing FMD virus types O, A and Asia1. Twenty goats from four breeds, (Jabal Akhdar, Sharqia, Shami and Crossbreed between Shami and Sharqia) four months of age of both sexes which had not been previously vaccinated against FMD were selected and maintained together. All animals were screened for antibodies against types Asia 1, A and O monisia. Thereafter, each animal was vaccinated with 1 ml of the inactivated FMD vaccine. A dose of 1 ml contained 5.08 PD₅₀, 4.28 PD₅₀, 4.95 PD₅₀ of O, A and Asia1 FMDV antigens respectively. Blood samples were collected from each goat on days 7, 14, 21, 28, 60, 90, 120, 150, 180, 210, 240 and 270 post vaccination. A liquid phase blocking ELISA was performed. The assay is based on the specific blocking of a defined amount of FMDV antigen by antibodies in the test sample during the liquid phase.

The results of the study demonstrated that the FMD vaccine, presently used in Oman for goats does not give adequate protection for 6 months as indicated by the manufacturer. Also the antibody response against FMDV type A was the least protective of the three serotypes. An acceptable level of protection for all three types was only for 4 months. The genetic background of the animals appears to have an effect on the serological response. A significantly better

response was observed in Jabal Akhdar goats in comparison to the other 3 groups against type O, A and Asia1. The reasons for these apparent breed differences need further investigation. Furthermore, alternative FMD vaccine and vaccination strategy need to be explored for Omani goats.

Title	:	Demonstration of Sustainable Crop Growth Using Production Water Purified with Solar-Membrane Distillation: Assessment of Effects on Soil and Plant Tissue
Student Name	:	Ismail bin Saif bin Yahya Al-Rashdi
Supervisor	:	Dr. Ahmed Al-Maskri
Department	:	Crop Sciences

Leftover water from the oil fields is one of the biggest problems facing many oil-producing countries. The oil-tainted salty water (Production water) is produced from the oil field when the oil is brought up from the well. This huge quantity of contaminated water, which can be four times the volume of the produced oil, can create an environmental problem. To tackle this issue, a new technique, known as Solar Dew Membrane Technology was developed. It consists of membrane distillation which uses solar energy as the driving force to purify the production water. The objective of this study was to test the possibility of using solar membrane distillation technology (Solar Dew) to purify the produced water and evaluate the effect of treated water on soil and plant tissues. An experiment was run at the Nimr site, in southern Oman, with reedbed outlet salty water and using the membrane desalination system, which depends on the solar energy. The solar dew produced water was tested on two crops. Due to the lower than expected fresh water production capacity of the solar membrane distillation system (i.e. 0.75L/m³d vs. $1.5L/m^3d$, the field testing of crops was limited to date pam (Phoenix dactulifera) and Tahiti lime (Citrus latifolia) trees. Samples of water, soil and plants were analyzed for presence of heavy metals. Plant tissue analysis indicated that there was no build up of heavy metals, while analysis of soil indicated a slight buildup of salts. This was attributed to the use of sewage-treatment-plant (STP) water prior to irrigation with Solar Dew water. The salt content of the treated water varied from low (11 mg/L) to acceptable (122 mg/L). It was demonstrated that crop growth could be achieved using reed-bedoutlet production water treated with Solar Dew membrane technology.

Title	:	Evaluation of Muskmelon Production Systems and Cultivars Grown in Oman for Export to Japanese Market
Student Name	:	Akino Ohashi
Supervisor	:	Dr. Iqrar Khan
Department	:	Crop Sciences

Muskmelon is a highly valued fruit in Japan. In addition to local greenhouse production of melon in Japan, there is substantial import to meet local demand. Oman has emerged as an exporter of vegetables to Japan with the introduction of snap beans as a lead crop. Muskmelon appears to be another candidate crop for export from Oman. Owing to strict quality standards followed in Japan, it was found necessary to investigate quality, especially sweetness, of Omani melon to meet Japanese market requirements. Three experiments were undertaken viz. evaluation of 32 Japanese cultivars grown in Oman under Omani methods; evaluation of Omani cultivars grown by Japanese methods in Spring; and evaluation of Omani cultivars grown by Japanese methods in Fall.

From the experiment of evaluation of 32 Japanese cultivars in Spring 2005, the top eight cultivars Andersen, Smash melon, Aristo seika, Rockstar, Lewis, Picaso Melon, Bonus 2gou and Monami red showed the highest quality which having TSS 10% and more, thus they can be considered for future testing. Comparing 32 Japanese cultivars with a local control, average TSS percentage did not show significant differences (P<0.05). Average fruit weight and length of 32 cultivars were lighter and shorter than the control. This is probably because the number of fruits per plant in 32 cultivars was higher than that of the control. The results indicate that Japanese high quality melon is not primarily due to cultivar characteristics but rather to other factors.

In the experiments of Spring and Fall 2006, one cultivar, Sunrise, was used and cultivated by applying some Japanese cultivation methods, that is, topping bud, trimming branches, guiding leaves

and branches, planning fruit setting position, and thinning fruit. TSS 13% was not obtained by all treatments. Since fruit setting position must have risen higher than the planned position due to damage by fruit fly in spring 2006, different results were obtained from experiments in Spring and Fall 2006. Compared with the control which was cultivated by Omani cultivation methods, melon grown by some of the Japanese methods had less TSS percentage, width, and circle ratio, and higher weight and length than those of the control in Spring 2006, however, none of them showed significant differences in Fall 2006. TSS percentage had significant interaction with fruit weight, length, width and number of fruits per plant in Spring and Fall 2006. However, fruit set position interaction with TSS percentage, and fruit weight, length and width showed different results in Spring and Fall. This study is at early stage. Further studies including the other Japanese practices, that is, making a ridge in the field and precise irrigation and fertilization are needed in combination with the effect of fruit set position.

Title	:	Evaluation of Warm Season Turfgrasses under Four Irrigation Levels in Oman
Student Name	:	Abdullah Mohd Hasan Al Shehhi
Supervisor	:	Dr. Iqrar Khan
Department	:	Crop Sciences

Turfgrasses play a very important role in enhancing quality of life in modern urban living. Water quantity is the most important challenge worldwide in establishing and maintaining quality turf. The present study was aimed to test the performance of three warm season turfgrasses under four water levels in Oman. Research was conducted at the Agriculture Experiment Station (AES) of Sultan Qaboos University (SQU), for 12 weeks from December 2006 till March 2007. Pits (48) measuring 1m length x 1m width x 0.6 m depth were planted with four replications of Common Bermuda grass (Cynodon dactylon), Tifway Bermuda grass (Cynodon dactylon x transvaalensis) and Seashore Paspalum grass (Paspalum vaginatum) in complete randomized design (CRD). Irrigation was done daily with 15 L / plot during the first 4 weeks (establishment period) and four irrigation levels (5, 10, and 15, 20 L /plot) were maintained in the following 8 weeks (treatment period). Physical parameters (canopy temperatures, ambient temperature, leaf area, shoot production and relative water content) were measured once in two week as well as the visual quality (shoot color, shoot density and shoot uniformity) was assessed. However Chlorophyll analysis was done in the end of the study. Repeated measure analysis was applied to the physical data whereas chi-square was applied for the visual quality parameters. It was found that temperature has significant effect on performance of turfgrasses. Canopy temperature was higher than ambient temperature in the three turfgrasses but it has different level in each variety. Common Bermuda and Tifway Bermuda have lower relative water content than Seashore Paspalum.

Title	:	Postharvest Characteristics and Quality Attributes of Selected Exotic Banana Genotypes in Oman
Student Name	:	Abdullah Said Al-Hosni
Supervisor	:	Dr. Rashid Al Yahyai
Department	:	Crop Sciences

Banana (Musa Spp.) is the 2nd most important fruit crop in Oman after date palm in terms of area and production. Due to emergence of serious diseases around the world, banana cultivation is threatened in many countries including Oman. Seven genotypes (diploids, triploids and tetraploid hybrids) of Musa Spp. were introduced from the International Network for the Improvement of Banana and Plantain 'INIBAP', a program under the Bioversity International, for evaluation under the growing conditions of Oman. These exotic varieties that included 'SH 3436-9', 'FHIA-21', 'FHIA-03', 'FHIA-18', 'SH 3640', 'FHIA-25' and 'FHIA-23' were evaluated for preharvest and characteristics. studv. postharvest In this postharvest physicochemical, morphological and physiological characteristics of the introduced exotic banana varieties were studied and compared with the locally grown 'Williams' variety at Sohar Research Farm, in Al-Batinah Region of the Sultanate of Oman.

The introduced genotypes showed variations in the measured postharvest characteristics. 'FHIA-25' excelled in bunch weight, number of hands and number of fingers followed by 'FHIA-18'. However, 'SH 3640' had poor performance regarding these characteristics. The varieties 'FHIA-25', 'FHIA-18', 'FHIA-21' and 'FHIA-03' yielded higher than 'Williams'. With regards to physical properties of the varieties, 'FHIA-21' and 'FHIA-18' had the hardest texture, whereas, the soft texture of 'FHIA-25' fruits led to rapid softening during storage. 'FHIA-21', 'SH 3436-9', 'FHIA-18', 'FHIA-03' and 'Williams' had the highest TSS level. All the evaluated banana varieties gave a pH less than 5 except 'FHIA-23'. 'SH 3436' and 'SH 3640' had higher (TSS/ Acid ratio) compared to the varieties.

Among the studied varieties, pulp weight was highest in 'FHIA-21' and lowest in 'FHIA-23'. 'FHIA-23' had highest edible portion. 'FHIA-03' and 'FHIA-18' had the thickest peel, whereas 'SH 3640' and 'FHIA-23' showed the thinnest pulp. 'FHIA-21' had the minimum pulp moisture content and the highest peel moisture content. Pulp dry matter content was highest in 'FHIA-21', while the variation in peel dry matter was limited. As the positive correlation showed, the very firm pulp texture of 'FHIA-21' contributed to the relatively long shelf life. While, 'SH 3640' and 'FHIA-25' presented a short postharvesting period. 'FHIA-23', 'FHIA-03' and 'Williams' had a green life more than two weeks compared with the others.

Each variety presented positive and some negative characteristics as well. 'FHIA-18' and 'FHIA-03' showed excellent bunch and finger characteristics but highly susceptible to finger drop. In contrast, 'SH 3640' had an average bunch and fingers characteristics but had the highest TSS/ Acid. Among all studied varieties, 'SH 3436-9' was the most similar to 'Williams' variety in terms of bunch weight, overall yield and fruit characteristics. 'FHIA-03' and 'FHIA-18' showed similarities in terms of bunch and finger characteristics. Thus, based on desired characteristics and qualities, it is recommended to introduce 'FHIA-18', 'FHIA-03' and 'FHIA-21' in Oman, especially in view of the steady expansion of some serious pests and diseases in neighboring countries.

Title	:	Evaluation of Exotic Tomato Germplasm for Adaptation in Oman
Student Name	:	Khaled Abdulaziz Yousuf Al-Farsi
Supervisor	:	Dr. Iqrar Khan
Department	:	Crop Sciences

Tomato is the major vegetable crop grown in Oman. The production is entirely dependent on imported hybrids and these are not met by any regulatory mechanism leading to exploitation of farmers. The production is restricted to mild winter months of the year while most summer remains untapped due to lack of heat tolerant cultivars. There is a need to develop indigenous breeding program for evaluation and release of exotic germplasm (hybrid and pure lines) as well as to develop local hybrids. Fifty four genotype of tomato were acquired from AVRDC, Taiwan and evaluated for their adaptation in Oman. They were categorized as fresh market tomato, cherry tomato, and high ß-carotene tomato. The experiments were conducted in two Sultan Oaboos University, Al-Khoud, locations. and in the Agricultural Research Center, Barka. Field evaluation was conducted through two seasons 2004-2005, and 2005-2006. Also, to evaluate the heat tolerant accessions, two experiments were conducted in both locations during summer 2006. The experimental design was CRD with five replications. Data were collected on fruit number, fruit size, fruit shape, total yield and TSS. Biochemical compositions of the accessions were analysis (moisture percentage, ash percentage, crude protein percentage, crude fiber percentage, crude fat percentage, nitrogen free extract percentage and lycopene content). Results showed significant variation for yield, fruit number, fruit shape and TSS within varieties and locations. For fresh market CLN2545A, CLN2498E, CLN2498D, PT4664B, CLN2001A, and CL5915 showed promising results in relation to yield and fruit number over years and locations. Most of the accessions had TSS between 4 to 6.5%. In high ß-carotene tomato, the high yielding and large fruited accessions were CLN2366A, CLN2071C and CLN2366B. Fruit size was varied between accessions. The TSS ratio in this category ranged from 4 to 6%. For cherry tomato, the variation in yield and fruit number was observed within varieties and locations. CHT1050C, CHT1050SB, CHT1050SG and CHT1050SA were the highest yielding accessions within this category. The TSS of cherry tomato ranged between 6 to 8.5%. For heat tolerant accessions, results indicated that these lines have a limit of heat tolerant below 44°C because accessions died when temperature exceed than this temperature. The accessions varied significantly (P<0.05) in their chemical compositions. The lycopene content was varied between the accessions. The highest lycopene value was observed for the fresh market heat tolerant accession BL1173 (90.37 mg/kg tissue). Results of the evaluation experiments showed adaptation of some accession to the local condition.

Title	:	Morphological and Genetic Diversity of Cucumber Landraces in Oman
Student Name	:	Muthir Saleh Said Salem Al-Rawahy
Supervisor	:	Dr. Fahad Al-Said
Department	:	Crop Sciences

Oman has several accessions of cucumber but there is no information about their diversity. The aim of this study was to investigate their morphological and genetic diversity. Twenty-four accessions of Omani cucumber were collected from four regions; Sharqiya, Dakhilia, Batinah and Muscat. The experiment was conducted at Directorate General of Agriculture and Livestock Research Rumais from November 2006 to March 2007 in open field. Data on thirteen quantitative plant characteristics were recorded. In addition, sixteen qualitative characters were also recorded for the study. Shannon-Weaver diversity index analysis was used for understanding the diversity among the accessions either combined or region wise. Multivariate Analysis namely Principal Components Analysis and Cluster Analysis was employed for studying the relationship among accessions. The results of analysis of diversity index (H) for agronomic, fruit and seed characters for all regions combined or four regions individually showed that Omani cucumber accessions have high diversity (H) for characters Per se. The genetic diversity indices for the agronomic characters ranged from 0.63 for Muscat to 0.73 for Sharqiya region and the average for all regions combined was 0.73. While the indices for fruit and seed characters ranged from 0.59 for Muscat to 0.73 for Dakhilia and the average for all regions combined was 0.70. These results were confirmed with Principal Components Analysis, Cluster Analysis and Genetic Similarity clearly revealed that there were no comparable differences between the accessions in terms of morphological quantitative characters. The genetic similarity for all regions combined ranged from 0.63 to 0.92. These results suggested that the assessment of overall genetic diversity of Oman cucumber accessions indicated to be similar despite that they were collected from different regions of Oman.

Title	:	Effect of Column Sizes and Media on Yield and Fruit Quality of Strawberry Under Hydroponics Vertical System
Student Name	:	Fatma Shamurid Al-Raisi
Supervisor	:	Dr. Fahad Al-Said
Department	:	Crop Sciences

The investigations on the response of strawberry cultivar, Camarosa to four media viz. Perlite + Peat moss (1:1), Perlite + Peat moss (3:1), Perlite + Local Peat (1:1) and Perlite + Local Peat (3:1) and three column sizes with 6, 7 and 8 pots were undertaken under vertical hydroponics system in non-cool shadehouse conditions during winter 2005-06 (November 2005 to April, 2006) at Agriculture Research Center, Rumais of the Directorate of Agriculture and Livestock Research, Ministry of Agriculture. The response of strawberry was assessed in respect of four biomass indices (fresh and dry weights of shoot and root), three yield (fruit number, fruit yield and average fruit weight) and three fruit quality attributes (fruit juice pH, acidity percentage and total soluble solids of the fruits) as well as ionic concentrations of nine elements viz., N, P, K, Ca, Mg, Mn, Zn, Cu and Fe. The results indicated that of these 19 characters, the effects of column types was significant in respect of 11 characters (Fresh and dry shoot and root weights, total number and weight of fruits/pot, fruit juice pH, N, P, K and Fe whereas the effect of media was significant with respect to 5 characters (Fresh shoot and root weights, dry root weight, Mn and Fe while the effect of interaction was significant only with respect to 2 characters (Fresh shoot weight and fruit juice pH).

Among the column types, columns with 6-pots performed significantly batter than those with 7 and 8-pots respectively, in terms of biomass, yield and fruit quality attributes studied.

Among the growth media the mixture of perlite and peat moss irrespective their ratios showed significant superiority to the mixture of perlite and local peat in terms of biomass characters but not in yield characters. Hence, it was concluded that vertical hydroponics system could be used for cultivation of strawberry in 6-pots colums with peat moss or local peat. However, it is suggested to use local Omani peat (date peat) than other substrate as it is cheaper and easily available. Thus the results of the investigations demonstrated that strawberries could be produced under non-cool shadehouse conditions in Oman with fruit yields 8 to 10 kg/m² comparable to yield levels obtained elsewhere in the world.

Title	:	Molecular Characterization of <i>Begomovirus</i> Associated with Tomato in Northern Oman
Student Name	:	Abdulrahman Mohd Obeid Al Matrushi
Supervisor	:	Dr. Akhtar Jamal Khan
Department	:	Crop Sciences

Tomato yellow leaf curl virus (TYLCV) is a major tomato pathogen in Oman. It belongs to whitefly-transmitted genus, begomovirus in the family *geminiviredae*. However, little is known about its epidemiology, molecular characterization, strains, natural hosts and transmission to tomato varieties. Disease incidence was recorded as high as 100% in non protected tomato fields, whereas disease ranged between 1 -20% in Agryl protected fields. Typical symptoms of upward curling and vellowing of the leaves were observed on tomato leaves and chlorosis of the intervein and the margin of the leaves of peppers. The symptoms on common beans were observed to be yellowing of the leaves. Total nucleic acid isolated from symptomatic and asymptomatic samples was used as a template to amplify core CP, satellite DNA (DNA- β) by polymerase chain reaction (PCR) using primers, FD-CP-382/RD-CP-1038, and Sat01/Sat02, respectively and full length genome by rolling cycle amplification. The PCR amplifications yielded core CP gene ranging 620 - 720 bp from 53 symptomatic samples collected from different regions and ~1300 bp satellite DNA in 37 out of 53 samples tested. The complete DNA sequence (2765 nucleotides) of the monopartite genome of TYLCV isolated from Wylaiat of Liwa was determined. The circular genomic DNA containing six open reading frames (ORFs), of which two (V1 and V2) are located on the virion-sense strand and four (C1, C2, C3 and C4) on the complementary-sense strand. The ORFs are comparable to those of other whitefly-transmitted begomoviruses with a monopartite genome. Sequence comparisons of core CP gene (V1) of Omani isolates with each other and with that of other begomoviruses showed that all Omani isolates are related to each other and closer to the isolate of China. The sequence comparison of full genome with other begomoviruses showed more than 91% similarity with TYLCV from Iran (TYLCV-IR). The natural hosts of the TYLCV strains of Oman were determined by ELISA to be tomato, pepper, common bean, squash and cucumber. The vareital test shows that CLN2545B, CLN2948E, CLN2264G, CLN2264J and CLN2498D are tolerant to TYLCV. These varietes should be retested in another study to confirm the result and to be recommended for farmers.

Title	:	Screening of Local and Exotic Cucumber Rootstocks for Natural Resistance Against Damping-Off and Wilt Diseases
Student Name	:	Qais Saif Al-Ma'awali
Supervisor	:	Dr. Akhtar Jamal Khan
Department	:	Crop Sciences

Damping-off and wilt diseases affect most greenhouse cucumber crops at seedling and mature growth stages. Despite many of the chemical and cultural methods used for disease management in Oman, the diseases still cause significant losses to farmers. The aim of this study was to characterize different local and exotic rootstocks for resistance/tolerance to Pythium aphanidermatum infection. Assessment of 28 rootstocks for resistance/tolerance to Puthium infection and uniformity of seed germination and viability were observed *in vitro* and in the greenhouse. Rootstocks showing low levels of infection were selected for greenhouse evaluation. Compatibility tests were used to determine the suitability of cucurbits as rootstocks for cucumber. Influence of compatible rootstocks on cucumber scion growth and vield was assessed under greenhouse conditions.

Out of the 28 cucurbit species tested in the lab oratory, no infection was observed in pumpkin lines (Titan, Hercules and local pumpkin), Indian ridge gourd and Omani sponge gourd. Hercules pumpkin and Salalah cucumber showed optimum results for seed viability and germination uniformity; Indian bitter gourd and squash had the lowest seed viability and uniformity. Under greenhouse conditions, Hercules pumpkin and Peth Alpha and Salalah cucumber showed highest seed viability and germination uniformity; Magda squash had the lowest seed viability and uniformity. Rootstock varieties (Titan, Hercules and Magda squash) showed zero infection in greenhouses up to 45 days after transplanting. However, Zena and Peth Alpha cucumbers, which were used as control, showed damping-off and wilt symptoms in greenhouses.

Omani sponge gourd and Salalah cucumber had the lowest compatibility with commercial Zena cucumber (36% and 40%respectively); Magda squash (80%), Hercules (88%) and Titan pumpkin (96%) had the highest compatibilities. Titan pumpkin rootstock significantly increased growth of Zena cucumber which reached a height of 244.8cm after 140 days, whereas the maximum plant height in the Zena control (non-grafted) was 186.8cm. Titan and Hercules pumpkin rootstocks significantly improved vegetative growth of cucumber (number of leaves) and flowering (number of female flowers). Over 2 seasons (winter and summer) Titan 0.72 and 1.63cm and Hercules 0.60 and 1.56cm pumpkin rootstocks had significantly larger stem diameters than the Zena control 0.597 and 1.22cm. Titan and Hercules rootstocks significantly increased fruit number and weight compared to the control, with fruit weight and number increased by 5.70 - 5.47kg and 24 - 21 fruits per plant for Titan and 3.49kg - 7.17kg and 12 - 30 fruits per plant for Hercules, respectively. However, Zena grafted on Zena produced significantly less yield compared to the non-grafted Zena control. Titan and Hercules pumpkin, Salalah cucumber, Magda squash, Omani sponge gourd and Indian ridge gourd-2 rootstocks significantly increased fruit length, and improved fruit diameter and total soluble solid. The effects of the Hercules rootstock on fruit quality was greater than for Titan, where fruit length, diameter and TSS were increased by 1.5cm - 4.1cm, 0.18 - 0.66cm and 0.29 - 0.5% for Hercules and 0.7cm -3.4cm, 0.14cm - 0.4cm and 0.09 - 0.46% for Titan, respectively.

From 28 cucurbits lines were tested, only pumpkin lines (Titan and Hercules) had no wilt and damping-off infection in *in vivo* and in the greenhouse until the end of the season. They showed good results for seed viability and germination uniformity *in vitro* and under greenhouse conditions. They showed the highest compatibilities with cucumber scions and improved vegetative growth of Zena cucumber scion. In addition, they increased total yield up to 4 tones per greenhouse with longer fruit length, wider fruit diameter and higher total soluble solid (TSS) of Zena cucumber scions.

Title	:	Effects of Maturity and Storage on Major Antioxidant Contents and Nutritive Value of Greenhouse Grown Tomato Cultivars in Oman
Student Name	:	Nadiya Mohammed Nasser Al Rahbi
Supervisor	:	Dr. Majeed Al Ani
Department	:	Food Science and Nutrition

Tomato (Lycopersicum esculentum) is one of the most widely grown and consumed crop in Oman and the world. It is an important source of dietary nutrients and antioxidants, especially lycopene and vitamin C. However, little is known about the antioxidant contents of tomatoes commonly consumed in Oman. The aim of the present study was to evaluate the effect of fruit maturity, storage conditions, and natural variation of fruit size on the physico-chemical properties, proximate composition, and antioxidant components of three commercial tomato cultivars commonly in Oman grown (Lycopersicum esculentum cv. 'Monika', 'Isabella' and 'Cherry'). Significant ($P \le 0.05$) differences were observed in the chemical composition (moisture, ash, fibre, protein, and fat), physico-chemical characteristics (pH and total soluble solids) and antioxidant contents (lycopene and ascorbic acid) among the three cultivars during maturation. 'Cherry' tomato was found to contain the highest amount of fiber, ash, fat, protein and total soluble sugar compared to 'Monika' and 'Isabella'. Irrespective of cultivar, the fruit lycopene content increased rapidly during maturation; however, vitamin C content fluctuated during maturation. Among the tomato cultivars studied, 'Isabella' contained the highest amount of lycopene and vitamin C at the last stage of maturation (dark red colour), compared with 'Cherry' and 'Monika', respectively.

Storage temperature and duration affected the antioxidant components and nutritive value of tomatoes; however, the magnitude of these effects depended on cultivar. Over seven day's storage duration at different temperatures, cold storage enhanced the retention of lycopene and vitamin C contents in fruit better than elevated storage temperatures. The effect of natural variation in fruit size on lycopene and vitamin C contents was investigated and found to be significant but did not follow a consistent pattern. In general, 'Isabella' fruit with large size had higher lycopene and lower vitamin C contents than very small size fruit. Large and very small sized 'Cherry' tomatoes had similar antioxidant contents which were significantly different from the contents of medium and small size fruit.

Regression analysis was used to develop prediction models for lycopene and total ascorbic acid (TAA) contents of tomato fruit based on non-destructive measurement of fruit external colour indices using a portable chromameter. Overall, colorimetric index a*/b* gave a better prediction of lycopene content for 'Cherry' (y=14.7e^{0.9835x}; $R^{2}=0.9573$), 'Isabella' (y=26.258x²+41.4x+20.856; R²=0.9784), and 'Monika' (y=41.328x²+22.912x+7.2698; R²=0.9617) than vitamin C content of 'Cherry' ($y=-6.8408x^2+7.6425x+41.411$; R²=0.8881), 'Isabella' (v=-0.4094x²+8.2362x+43.955; R²=0. 0.8827), and 'Monika' (y=-14.042x²+8.624x+48.483; R²=0. 0.5287). These prediction models represent new useful tools assessing the antioxidant components of these tomato cultivars during postharvest handling and nutritional planning for dietary intervention. The lycopene and vitamin C contents of tomatoes were used to demonstrate the effects of fruit maturity level, size and storage condition on the amount of fruit needed to meet the Dietary Reference Intake (DRI) of an adult. Animal models and human intervention studies are needed to assess the bioavailability of nutrients of tomato cultivars required for developing dietary guidelines in health and diseases.

Title	:	Texture Profile Analysis and Moisture Isotherm of Gelatin Gel Extracted from Grouper Skin and Commercial Bovine and Porcine Gelatin Gels
Student Name	:	Abdullah Issa Saif Al-Mahrouqi
Supervisor	:	Dr. Mohd Shafiur Rahman
Department	:	Food Science and Nutrition

Moisture sorption isotherm and mechanical characteristics of gelatin gels extracted from grouper skin, and commercial bovine and porcine. The gelatin yield obtained from grouper fish skin was 26.4% as expressed in grams of dry gelatin per 100 g of dry solids in skin. The gelling and water sorption properties of gelatin extracted from grouper skin were measured and compared with gelatin from porcine). mammalian sources (bovine and The mechanical characteristics (hardness, firmness, toughness, and modulus) of 10% gels of gelatin from fish skin, determined from one cycle compression, were significantly lower compared to the other sources of gelatin gels. Bovine and porcine gels did not show any significant difference in their mechanical characteristics. In one cycle, 80% compression was used in order to fracture the samples. A compression of 40% was used in two compression-decompression cycles in ordered to avoid gel fracture. Hardness of fish and mammalian gelatin increased significantly as the concentrations of gels increased. The hardness of bovine gelatin gel was highest (harder) followed by porcine then fish gelatin gels. Cohesiveness of 20% bovine and 10% fish skin gelatin gels were the highest and lowest, respectively and in the cases of other samples at different concentrations there were no significant differences. Adhesiveness of bovine gelatin gels decreased significantly as the concentration of gels was increased. Adhesiveness of porcine gels showed no significant differences for different concentrations. The fish skin gelatin gels at 10% concentration showed significantly lower adhesive properties compared to the 20 and 30% concentrations. Fish skin gelatin gels at 10% showed the lowest springiness value compared to all other samples. In the cases of other samples there were no significant differences in the springiness of different types of gels with varying concentration. In the case of bovine and fish gels at 10%, resilience was significantly increased compared to the 20 and 30% concentration gels. Bovine and porcine gelatin gels showed higher gumminess and chewiness compared to fish gelatin gels at the same level of concentration. The gels prepared from different sources did not show any generic trends when all mechanical attributes were considered. Dynamic Vapor Sorption (DVS) showed a hysteresis between adsorption and desorption for bovine gelatin, which started from water activity of 0.7 and below, whereas hysteresis in fish skin gelatin started at water activity of 0.6. The values of BET-monolayer water content of gelatin from bovine, porcine and fish skin were 8.00, 8.88 and 6.11 g/100 g solids, respectively.

Title	:	Chemical Composition, Glycemic Index and Effect of Feeding Omani Halwa on Growth, Blood Glucose and Plasma Lipid Profile of Sprague Dawley Rats
Student Name	:	Khalid Mubarak Al-Zuhaibi
Supervisor	:	Dr. Amanat Ali
Department	:	Food Science and Nutrition

The study evaluated the chemical composition, glycemic index and effect of feeding different levels (0,10,15, and 20%) of black and white Omani halwa on blood glucose and plasma lipid profile of Sprague-Dawley (SD) rats. The glycemic index of halwa was determined in 10 normal healthy human volunteers using pure glucose as a standard food. Forty two male SD rats of about 4 weeks of age with an average body weight of 75.5g were randomly divided into 7 groups containing 6 rats in each. Seven experimental diets in which the rat chow was replaced with either black or white Omani halwa at 0.10.15, and 20% level were prepared and randomly allotted to each group. The group fed on rat chow only acted as control. The experiment lasted for 10 weeks. Daily feed intake and weekly weight gains were recorded. No significant (P<0.05) differences were observed in the proximate chemical composition, energy content, and glycemic index of both types of Omani halwa. The moisture, crude protein, total fat, ash, crude fiber, and nitrogen free extract (NFE) contents (g/100g as such basis) ranged between 11.8-12.1, 0.28-0.44, 12.4-13.8, 0.01-0.02, 0.05-0.15, and 74.0-75.0 respectively. The energy values ranged between 413.4-421.3 kcal/100g. The GI value for black and white halwa were 52.0 and 54.8 respectively. No significant (P<0.05) differences were observed in the feed consumption and growth rate of rats fed different levels and types of halwa as compared to control diet. No significant differences were observed in the blood glucose levels of rats fed different experimental diets as compared to control group. The glycated hemoglobin (HbA1c) values however differed significantly (P < 0.05) and the rats fed diets containing 20% of halwa showed significantly (P<0.05) higher HbA1c values as compared to control group. Similarly the rats fed diets containing 20% of halwa showed significantly (P<0.05) higher total cholesterol (TC) and high density lipoprotein (HDL) values as compared to control group. No significant (P<0.05) differences were however observed in triglyceride (TG), low density lipoprotein (LDL) and TC/HDL ratio of rats fed various experimental diets. The plasma creatinine levels differed significantly (P<0.05) whereas the plasma albumin levels did not differ (P<0.05) in rats fed various experimental diets.

Title	:	Biology and Fisheries Assessment of the Longnose Trevally <i>Carangoides chrysophrys</i> (Cuvier, 1833) in the Arabian Sea, Sultanate of Oman
Student Name	:	Issam Humaid Mohamed Al Rasady
Supervisor	:	Dr. Saud Al-Jufaili
Department	:	Marine Science and Fisheries

Longnose trevally (*Carangoides chrysophrys*) samples were collected on monthly basis between April 2005 and September 2006 from two landing sites (Allkbe and Raysot) in the Arabian Sea to study the biology and assess the fishery of this species. Morphometric measurements for each fish include total length (TL), fork length (FL), standard length (SL) and depth of the fish length was taken and total body weight (TW). The fish was then dissected to determine the sex macroscopically and to record the gonad weight (GW), liver weight (LW) and the stomach weight (SW). Otolith was used for ageing and the marginal zone analysis was used for validation. Total mortality estimated from age converted catch curve method. Alagaraja (1984) longevity equation was used to choose the best estimate of different natural mortality equations. The stock was assessed using yield and spawning biomass per recruit analysis.

No significant differences between the male and female in morphometrics relationships except for the depth-total length relationship. Analysis of variance found significant length-weight relationships for all maturity groups and sex. The *t*-test for *b* value showed that *C. chrysophrys* displays negative allometric growth for both sex and combined. Analysis of covariance showed no significant difference in length - weight relationship between sex for different maturity groups and combine. The average condition factors (*Kn*) versus length decreases with an increase in size and males have higher average condition factors than females on size and monthly base. The average condition factor (*Kn*) fluctuate around the year and can't related to the spawning season. One opaque band and one hyaline band were deposited in one year and the opaque band lead down between December and March. The otolith weight-age relationships were not significantly different between the sexes. Otolith weight correlated about 0.69 to age subscript for both sexes. sixteen years is the maximum age recorded for both sexes. No significant difference was detected in the sex ratio of the pooled age groups. ARSS analysis showed that the von Bertalanffy growth models for males and females were not highly significantly different suggesting the use of pooled equation of both sexes $L_t = 73.2 (1 - e^{-0.25 (t+1.21)})$.

The sex ratios were significantly difference (df = 1, x^2 = 6.5 in month and length; 6.72 maturity stage, α = 0.05). One peak for the gonadosomatic index (GSI) started from September and ended in February. Liversomatic index (LSI) and coefficient of condition (*K*) were constant around the year. The female mature significantly earlier than male, at 42.08 and 46.90cm total length and at age of 4.1 and 4.7 years, for female and male respectively. Four types of ova were observed immature (6–8md), maturing (18–20md), mature (27 – 29md) and ripe (39 – 41md).

Alagaraja (1984) natural mortality equation gave the best estimate of longevity and hence chosen to present the natural mortality rate. Natural mortality (*M*) equal to 0.288yr⁻¹ and the total mortality (*Z*) equal to 0.3854 yr⁻¹. Length at 50% capture of longnose trevally found at total length of 38.21cm and age of 4yr. The yield and spawning biomass per recruit analysis indicate that the current fishing mortality rate (F_{curr}) smaller than the maximum fishing effort (F_{max}) suggest that it is at an optimum level and should be maintained. However, any increase in the fishing effort may lead to overfishing.

Title	:	Variation of Zooplankton and <i>Noctiluca</i> <i>scintillans</i> Abundance and Composition in the Inshore Waters of the Gulf of Oman
Student Name	:	Raiya Mohammed Al-Kindi
Supervisor	:	Dr. Adnan Al-Azri
Department	:	Marine Science and Fisheries

Variations in zooplankton abundance and composition in the inshore waters of the Gulf of Oman were investigated from July 2005 to February 2006 in relation to environmental variables. Zooplankton samples were collected from two stations, inshore Bandar Khayran (BK) and offshore (OFF), using 150 and 500 μ m mesh size. The parameters investigated were: surface and integrated temperature, salinity, turbidity, dissolved oxygen and chlorophyll *a*.

Altogether 14 taxa were identified, and were distributed into two main groups: holoplankton and meroplankton. Copepods were the predominant taxon during all months. From 150 and 500 μ m samples they contributed about 79 and 37% at inshore station and 82 and 47% at offshore station, from the total zooplankton abundance, respectively. *Noctiluca scintillans* was observed in many of the 150 μ m samples at both stations. Station inshore showed the highest zooplankton abundances throughout the sampling periods, and had higher meroplankton ratios than the offshore station. Major peaks of zooplankton (particularly copepods) and *Noctiluca* abundances were observed on November 28th at both stations.

Cluster analysis of zooplankton samples revealed two distinct groups, at a 60% similarity level. Most 90% of small samples are grouped together and well separated from large samples. ANOSIM analysis of the environmental variables suggested that both site were significantly different. For both 150 and 500 μ m samples, ANOSIM analysis on the abundance data suggested that the two stations showed different zooplankton taxa. BEST procedure identified four environmental variables out of ten as having a link to zooplankton composition, and it was significant for the 500 μ m size classes.

Title	:	Efficiency of Fish Markets in Oman: Transport Modeling Analysis
Student Name	:	Khamis S. Al-Abri
Supervisor	:	Dr. Hemesiri Kotagama
Department	:	Natural Resource Economics

The hypothesis tested in this study is that the transport function of fisheries market in Oman is inefficient, favoring export markets compared to domestic markets. Two transportation models; i.e. profit maximization and its dual of the cost minimization were used to generate the optimal quantities transported from landing sites (Li) to markets (Mj) and optimal prices in the domestic and export markets. Primary data were collected from a sample of truckers on actual quantities transported from landing sites to markets and prices received by truckers at markets. Secondary data were collected from different ministries in Oman and from Dubai Municipality. The study used a mix of quantitative and qualitative analytical methods for data gathering and analysis. The study analyzed major fish species representing 85% of total fish transported; i.e. Kingfish (29%) and Sardine (56%). The study also analyzed the optimal and observed quantity transported and prices of the composite fish, which contains four species: Kingfish (Scomberomorur commerson), Sardine (Sardinella longiceps), Scavenger (Lethrinus Nebulosus) and Long tail Tuna (Thunnus tonggol). The study found that the transport function of the fisheries market in Oman is efficient. The conclusion is based on high profitability ratio between observed and calculated optimal profits of transported fish (Kingfish 98%, Sardines 93% and Composite 99%). The observed and calculated optimal prices of fish in domestic and export markets were not substantially different. Due to profitability, export markets are preferred vis-à-vis domestic markets. Though the fish market in Oman is efficient, it is not equitable since the export trend has increased gradually over years, whereas availability of fish at the local market has decreased. This study suggests that the trend will continue. Therefore, government intervention would be required to ensure the availability of fisheries in domestic markets.

Title	:	Improving Quality of Hajamta Reservoir Water in Jabal Akhdar Using a Custom-Made Treatment System
Student Name	:	Mohammed Suheil Ahmed Jashoul
Supervisor	:	Dr. Mushtaque Ahmed
Department	:	Soils, Water and Agricultural Engineering

Water is considered the artery of the life and one of the valuable gifts with which God has blessed us. Rapid population growth and development require strong management strategies to conserve water resources, especially in arid and semiarid countries. Moreover, existing water resources must be protected from pollution and used in an efficient way. Polluted waters must be treated using cost-effective treatment methods. The objective of this study is to improve water quality of Hajamta Reservoir in Al Jabal Al Akhdar, Sultanate of Oman, using a custom-made treatment system, to enhance the supply of water for the Shanut village.

Based on previous studies, reservoirs in Jabal Akhdar suffered from eutrophication and pollution. For example Hajamta reservoir was built in 1996 for domestic purposes, but it was eutrophic and some people were afraid even to feed their animals from this reservoir. Therefore, custom-made treatment system was designed and constructed at the reservoir in Shanut. A specific program was undertaken to evaluate the water quality of the reservoir before and after the filtration. Seventy seven samples of water were taken for a period of about two months. For each sample physical, chemical and biological parameters were analyzed.

Acceptance of the treatment unit was determined through questionnaire survey. In addition, a model of the treatment system was tested in the lab under control conditions to evaluate the effect of sand depth of the filter on quality, quantity and flow rate of the effluent. The results from the treatment unit at Hajamta Reservoir showed general improvement in water quality. For example water turbidity was reduced by 87% and suspended solids were reduced by about 86%. Furthermore, total coliform bacteria were completely removed after the treatment. The effect of the system on total dissolved solids (TDS) was negligible. However, TDS values were within Omani Standards for wastewater reuse and disposal. Eventhough the value of Biochemical Oxygen Demand of untreated water was small, the reduction due to treatment was 31%, and Chemical Oxygen demand reduction due to treatment was 62%.

Based on the survey results 100% of respondents agreed that treated water could be used for washing clothes and cleaning homes. The 100% of the interviewees said no algae were found and there was no bad smell in the treated water. Furthermore all the respondents agreed to store treated water in closed tank. Most of the interviewees (85%) indicated that the system was easy to operate and 95% of the participants would like to have the system in their homes.

When the depth of the sand filter increased from 22 cm to 27 cm in the lab model, the production water and flow rate decreased whereas the quality of the water improved.

Title	:	Yield and Water Use Efficiency of Forage Maize (Zea mays L.) Under Treated Wastewater Irrigation
Student Name	:	Saif Ali Salim Al Khamisi
Supervisor	:	Dr. Hayder AbdelRahman
Department	:	Soils, Water and Agricultural Engineering

The Sultanate of Oman is considered to be a country that suffers from limited water resources. Surface water resources are scarce and groundwater is the main source for domestic, agricultural and industrial uses. Over-pumping and reservoir depletion due to water shortage led to seawater intrusion in coastal areas. Soil and ground water resources are becoming extremely saline and adequate resources of good quality irrigation water have become limited. Desalination and treated wastewater are among other alternatives which are currently used for domestic, irrigation, aquifer recharge, fish culture, cooling, construction and industrial purposes. Treated wastewater is the wastewater that has been subjected to one or more of the physical, chemical, and biological processes to reduce pollution and health hazards. Treated wastewater helps maintain environmental quality while providing sustainable agriculture and preserving scarce water sources. The numbers of wastewater treatment plants in Oman have been increased enormously. The produced water has a great opportunity to be utilized in forage production. Wide ranges of forage crops are cultivated in the Sultanate. Maize is one of the most important annual forage grass cultivated in Oman during winter and summer along with Sorghum. Flood irrigation is the most dominant irrigation system used in this type of cropping system.

Field experiments were conducted during the 2006/07 season at Agricultural Research Center, Directorate General of Agricultural & Livestock Research in Rumais to determine the effect of water quality (tertiary treated wastewater and fresh water), water quantity (1.4ETc, 1.0ETc and 0.6ETc), and their interaction on the growth, yield and water use efficiency of forage maize. In addition, the chemical composition of forage maize plant that had been irrigated with treated wastewater was evaluated in comparison with those irrigated with fresh water. Soil moisture distributions and salinity redistributions were monitored through out the experiments.

The results indicated that treated wastewater leached more salts down the profile than fresh water. Treated wastewater also reduced the SAR by 74% whereas fresh water reduced it by 68%, but fresh water had a higher SAR to start with. The higher the quantity of water applied, the higher was the salinity and SAR reductions. Fresh water treatments were observed to have higher moisture content in comparison with the treated wastewater. This was attributed to the fact that treated wastewater contained dissolved organic matter that slightly improved the physical conditions of the soil which resulted in increased water penetrations, and contained higher amounts of nutrients that resulted in vigorous plants which abstracted more water.

The results also indicated that plants irrigated with treated wastewater contained higher nitrogen concentrations at all levels of water quantities than those irrigated with fresh water. But K, P, Ca, Mg, Fe, S, B, Zn, Cu and Mn uptakes of forage maize did not show any significant differences between fresh and treated wastewater.

Plants irrigated with treated wastewater had higher growth rates (in term of plant height) in comparison with those irrigated with fresh water. The number of leaves/plant, Leaf length and leaf area (cm²) did not show any significant differences among water types, water quantities or their interactions. Treated wastewater had shorter time for 50% male and female flowering of forage maize plants than fresh water, indicating earlier maturity. Plants irrigated with treated wastewater had higher chlorophyll content than those irrigated with fresh water for all levels of water applications.

Treated wastewater gave higher average green forage yields (60.79 t/ha) and dry matter yields (11.57 t/ha) than fresh water which yielded 36.27 t/ha and 9.46 t/ha of green forage and dry matter respectively. Plants irrigated with treated wastewater were more efficient in using the water than those irrigated with fresh water for all water quantities. The highest water use efficiency ($3.51 \text{ kg/m}^3 \text{ DM}$) was achieved with treated wastewater under the 1.0ETo water applications.

This study concluded that treated wastewater irrigations increased yields of forage maize and their water use efficiency without significantly affecting any metal accumulations in the soil or plant leaves. Further economical studies and use as animal feed are recommended.

Title	:	Assessment of Oil Pollution in Mina Al Fahal, Muscat, Sultanate of Oman
Student Name	:	Jamal Nasser Rashed Al-Sabahi
Supervisor	:	Dr. Malik Al-Wardy
Department	:	Soils, Water and Agricultural Engineering

Environmental monitoring is a tool used to assess the current issues and to take actions. Global warming and oil spills add adverse effects to sustainability of the environment safety. There are many causes that contribute to pollution in oil-related environment: tanker accidents and poor maintenance practices, natural spills, off-shore activities and landbased oil activities. Oil is of crucial importance to the national economy of Oman. Oil Refining and crude oil exporting take place in Mina Al Fahal which is the main oil-exporting zone to the world in Oman. Previous studies for the assessment of oil pollution had been done mainly in Mina Al Fahal. A gas chromatograph equipped with mass spectrometer (GC/MS) was used in this study for hydrocarbon analysis. The petroleum hydrocarbons in the collected intertidal sediments were in the range of 16.8 (± 0.93) to 6394.5 (± 206) µg/kg dry- wt. The highest value (6394.5 ± 206) µg/kg-dry wt.) was obtained in the collected sediments where the liquid effluent was flowing close to it on its way to the sea. Traces of petroleum hydrocarbons (16.8 \pm 0.93-19.0 \pm 1.15 µg/kg-dry wt) were found opposite to Oman Refinery Company (ORC). In the area where the terminal operations of crude oil take place, the concentration of petroleum hydrocarbons was in the range of 19.5 (\pm 0.91) to 27.6 (\pm 3.47) µg/kg dry-wt. The petroleum hydrocarbons in the collected subtidal sediments were in the range of 20 (± 0.60) to 1693 (± 385) µg/kg dry-wt. Petroleum hydrocarbons were not detected in the area opposite to Oman Refinery Company. In the zone of the terminal operations of crude oil, hydrocarbons with a range of 831 (± 216) to 1693 (± 385) μ g/kg dry-wt was obtained. The levels of petroleum hydrocarbons were below the detection limit (6.15 μ g/l) in the collected seawater samples. Concentrations of the discharged liquid effluents, collected at different distances of the channel, were in the range of 85.2 (± 36.6) to 241.6 (\pm 9.1) µg/l. The acceptable level of disposing effluent to the Omani marine environment is 15 mg/L (MECA, 2005).

International Collaborations

International Collaborations

No.	Organization	Type of Cooperation	Contact Dept / Extent of Benefit
1.	MATFORSK (Norwegian Food Research Institute) Norway	Health related quality of fruits and spices	Food Science and Nutrition (FSN)
	inolicaco, norway	Measurement of allicin in fresh and dried garlic; and functional foods	
2.	University Kebangsaan Malaysia, Malaysia	State diagram of gelatin from porcine, bovine and fish skin; and development of low fat Omani halwa	FSN
3.	University of Queensland, Australia	Glass transition of spaghetti	FSN
4.	School of Food Technology, University of Tunisia	Use of plant coagulants in cheese manufacture	FSN
5.	Gothenburg University, Sweden	Collaboration research and capacity building	UNESCO Chair in Marine Biotechnology (UNESCO)
6.	Chalmers University of Technology, Sweden	Collaboration research and capacity building	UNESCO
7.	Ajman University, UAE	Collaboration research and capacity building	UNESCO
8.	H.E.J. Research Institute of Chemistry (HEJRIC), Karachi, Pakistan	Collaboration research and capacity building	UNESCO
9.	Biotechnology MIRCEN, Iran	Collaboration research and capacity building	UNESCO
10.	Willmington Marine Laboratory, North Carolina	Collaboration research and capacity building	UNESCO
11.	Royal Swedish Academy of Sciences/Marine Station, Sweden	Collaboration research and capacity building	UNESCO

Table 11.	International	collaborations	as of 2008.

Table 11 . .

No.	Organization	Type of Cooperation	Contact Dept/Person/ Extent of Benefit
12.	Challenge Program for Water and Food, CGIAR, C/-IWMI, Sri Lanka	Collaborative research and capacity building	Soil, Water and Agricultural Engineering (SWAE)
13.	Regional Center for Urban Water Manage- ment, Teheran, Iran	Collaborative research and capacity building	SWAE
14.	Wageningen Agricultural University, The Netherlands	Collaborative research and capacity building	SWAE
15.	International Rice Research Institute, Los Baños, Philippines	Collaborative research and capacity building	SWAE
16.	Australian Center for International Agricultural Research, Australia	Collaborative research and capacity building	SWAE
17.	International Atomic Energy Authority, Vienna, Austria	Collaborative research and capacity building	SWAE
18.	National Centre for Oceanography, UK	Scientific and research cooperation	Marine Science and Fisheries (MSF)
19.	University of Reading, UK	Collaboration on research projects in pest and disease control	Crop Sciences (CROP)/ Joint supervision of PhD students
20.	University of Pretoria, South Africa	Collaboration on mango disease control	CROP /Joint supervision of postgraduate students
21.	National University of Ireland	Farmer decision making	CROP /Joint supervision of PhD student
22.	University of Reading, UK	Collaboration on research projects in pest and disease control	CROP /Joint supervision of PhD students
23.	University of Pretoria, South Africa	Collaboration on mango disease control	CROP /Joint supervision of postgraduate students

Table 11 . . .

No.	Organization/ Contact Person	Type of Cooperation	Contact Dept/Person Extent of Benefit
24.	National University of Ireland	Farmer decision making	CROP /Joint supervision of PhD student
25.	University of Kassel, Germany	Collaborative research	Animal & Veterinary Sciences (AVS) / Joint supervision of post- graduate students
26.	University of Hohenheim, Germany	Collaborative research	AVS / Joint super- vision of postgraduate students
27.	Dr. Elshorbagy United Arab Emirates Univ (UAEU)	Scientific and research cooperation	MSF Dr. M. Claereboudt
28.	Dr. Peter Proksch Institut für Pharmazeutische Biologie und Biotech- nologie Heinrich-Heine- Universität Düsseldorf Universtitätsstr., Germany/	Scienfific and research cooperation	MSF Dr. S. Dobretsov
29.	Prof. Benni W. Hansen Universitetsvej 1 16.1 DK-4000 Roskilde, Denmark	Scientific and research cooperation	MSF Dr. S. Dobretsov
30.	Prof. Valerie Paul Smithsonian Marine Station, Fort Pierce, Seaway Drive 701, Florida, U.S.A.	Scientific and research cooperation	MSF Dr. S. Dobretsov
31.	Prof. C.J. Chang Dept of Plant Patology University of Georgia, Georgia, USA	SR project on WBDL	CROP Dr. R. Al Yahyai
32.	Dr. Iqrar Khan Agricultural University of Faisalabad, Pakistan	SR project on WBDL	CROP Dr. R. Al Yahyai
Table 11..

No.	Organization/ Contact Person	Type of Cooperation	Contact Dept/Person Extent of Benefit
33.	Prof. Bruce Shaffer Tropical Research and Education Center, Univ of Florida, USA	Mango & citrus research projects	CROP Dr. R. Al Yahyai
34.	Dr. Richard Campbell Fairchild Tropical Garden, Florida, USA	Mango & citrus research projects	CROP Dr. R. Al Yahyai
35.	Dr. Thomas E. Marler College of Agricultural & Life Sciences, Univ of Guam, Guam, USA	Mango and citrus research projects	CROP Dr. R. Al Yahyai
36.	Dr. Rachel Sotto Dr. Leon O. Namuco Univ of the Philippines at Los Baños, Laguna, Philippines	Mango and citrus research projects	CROP Dr. R. Al Yahyai
37.	Miami Subtropical Horticulture Research Station, USDA, Miami, Florida USA	Mango and citrus research projects	CROP Dr. R. Al Yahyai

Publications in 2008

Publications in 2008

Sixty-two journal publications were recorded for the year 2008.

Also published in the year 2008, were 1 book, 3 chapters in book, 92 presentations at international conferences / symposium /workshops /seminars, 19 presentations in local work-shops/seminars, 19 popular articles, 21 presentations during the 2008 University Research Day, 9 research final reports and 4 MSc/PhD dissertations.

Table 12. Summary of total publications in 2008.

Chapters in book	3	
Presentations at international	92	
conferences/symposium/workshops/meetings		
(Papers: 73; Posters: 5; Abstracts: 9; Invited as Speaker: 5)		
Presentations in local workshops/seminars	19	
Popular articles (local and international)	19	
Research presentations during University Day	21	
(Oral: 6; Posters: 15)		
Research final reports	9	
Staff MSc/PhD dissertations	4	
Total	230	

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- Victor, R., M. Ahmed and M. Al-Haddabi. Water quality assessments and some aspects of water use efficiency. *Proceedings of the Mountains of the World: Ecology, Conservation and Sustainable Development.* Al Jabal Al Akhdar Initiative Abstract. 10-14 February 2008.
- Waly, M. and R. Detha. 2008. Neurodevelopmental toxins deplete glutathione and inhibit folate and vitamin B12-dependent methionine synthase activity: a link between oxidative stress and autism. Federal Societies of Experimental Biology, Washington DC, USA .*The FASEB Journal*, 22:894.1.
- Waly, M., R.M. Ahmed, M.Abo-Seif Hilmy and O. Darwish. 2008. Evaluation of the prevalence of folate associated megaloblastic anemia among pregnant females in Alexandria's Maternal Health Centers in Egypt. Federal Societies of Experimental Biology, Washington DC, USA. *The FASEB Journal*, 22:894.2.

Invited as Speaker

- 1. Rahman, M.S. Preservation, safety and yield technologies. Teleconference Workshop on AgroFresh: Roadmap for Growth. *Organized by Deloitte Consulting*, New York. 10 June 2008 (speaker as expert).
- Rahman, M.S. 2008. Food stability beyond water activity and glass transition: macro and micro region concept in the state diagram. *Keynote lecture presented at the 18th International Congress of Chemical and Process Engineering*, Prague, Czech Republic. 24-28 August 2008.
- 3. Soussi, B. Functional foods from seafood. *Invited speaker at the International Conference on the Economic Importance of Fisheries and their Impact on Public Health*, Oman. 8-10 March 2008.
- 4. Soussi, B. Concept of Marine Biotechnology Center for Oman. *Invited* speaker at Investor Meeting with the Ministry of Commerce and Industry, Paris, France. 17 September 2008.
- Soussi, B.S. Value-added raw materials and health: science and business. *Invited speaker at Marine Biotechnology Symposium*, Bio Business Section, North Carolina, USA. 15 October 2008.

Presentations in Local Workshops/Seminars/Meetings

- 1. Ahmed, M. Greywater reuse guidelines for Oman. Seminar presented at SQU. World Water Day, 21 March 2008.
- Al-Ani, M. Functional foods and health. World Food Day. CAMS, October 15, 2008. Invited as speaker.
- 3. Al-Ani, M. Enteral Nutrition Symposium. Ministry of Health, Al-Nahdha Hospital, April 13, 2008. Invited as speaker.
- Al-Dhuhli, H. and S. Al-Rawahy. Effect of two types of mulching on soil salinity, moisture and temperature. Workshop on Recent Advances in Biosaline Research (in collaboration with ICBA). Ministry of Agriculture, Oman. 13-14 January 2008.
- 5. Al-Jufaily, S. *Workshop on Fish Marketing and Marketing*, Ministry of Fisheries Wealth, Oman. 26-30 October 2008.
- 6. Al-Maktoumi, A., Lockington, D.A., Volker, R.E. 2008. Salinity evolution patterns in a layered-coastal aquifer subject to shallow abstraction. *SAME seminar at CAMS, SQU*, Muscat, Oman.
- Al-Saady, N., A.R. Kacimov and R.G. Kacimova. Bibliometrics of refereed journal papers/citations as research indicators of an Omani and research entity: comparisons and lessons from a case study. *Quality Assurance Conference*, Oman.

- 8. Al-Subhi, L.K. Health education: views and perceptions. *Training Workshop on Diabetes/Hypertension Management at Primary Care Level*, Ministry of Health, Oman. 15 January 2008.
- Al-Wahaibi, A.K. 2008. Biological control: alternative pest management for Oman's urban landscapes. Abstracts presented at the Workshop on Biological Control of Pests in Oman. 3-4 March 2008. Al-Nakheel Hall, Ministry of Agriculture. pp 29-30.
- Al-Yahyai, R. Providing effective educational materials for e-learning in agricultural sciences. *Moodle Majlis 2008.* 18-20 October 2008. Sultan Qaboos University, Oman. Abstract.
- 11. Al-Yahyai, R. Indoor plants: cultivation and propagation. AES, SQU. 11-12 February 2008.
- 12. Claereboudt, M.R. Connectivity between coral reefs in the Gulf of Oman and the Arabian Sea: a Lagrangian simulation study. *SAME seminar at CAMS, SQU*, Muscat, Oman. November 2008.
- Deadman, M.L. Biological control of plant diseases. Workshop on Biological Control of Pests in Oman. Ministry of Agriculture, Muscat, Sultanate of Oman. 3-4 March 2008.
- 14. Dobretsov S. September 2008. Quorum sensing in marine environment and its prevention. *SAME seminar at CAMS, SQU*, Muscat, Oman.
- Henderson, A.C. 2008. Shark research in Oman: opportunities for international collaboration. Indian Ocean Rim Community – Association for Regional Development. Annual Meeting. Muscat, Oman
- 16. Mahgoub, O. 2008. The animal sector in Oman: constraints, threats and improvement opportunities. *Workshop for Launching Veterinary Technology Program.*
- 17. Palfreman, A. 2008. A proposal for a wholesale fish market for Oman. *SAME seminar at CAMS, SQU,* Muscat, Oman.
- Rahman, M.S. Food stability beyond water activity and glass transition: macro and micro region concept in the state diagram. SAME seminar at CAMS, SQU, Muscat, Oman. 27 October 2008.
- 19. Soussi, B.S. Center of Excellence in Marine Biotechnology Vision. Invited speaker at VC's presentation, 25 September 2008.

Popular Articles (Local and International)

- Ahmed, M., R. Victor, M. Jashoul and S. Al-Adawi. A custom-made treatment system in Al-Jabal Al Akhdar Region of Oman for Utilization of Low Quality Surface Water. Arab Water World, December 2008 issue.
- Ahmed, M., S.A. Prathapar and S. Al-Adawi. 2008. Greywater: an alternative source of water for Oman. SQU Magazine Horizon, Issue 139. Also reprinted in Oman Daily Observer, August 13, 2008.
- 3. Al-Ani, M. Fish = balanced diet = healthy and productive community. *Oman Newspaper* (Arabic). February 2008.

- 4. Al-Ani, M. Fish is a food and drug. *Oman Newspaper* (Arabic). February 2008.
- 5. Al-Ani, M. Fish = Health and immunization from disease. *Oman Newspaper* (Arabic). February 2008.
- 6. Ali, A. Ranking foods by glycemic index. Horizon, p.4. Sept 2008.
- Al-Ruhaili, A., R. Al-Yahyai and L. Al-Kharusi. Landscape project design for undergraduate students enrolled in Ornamental Horticulture in Oman. 1st WSEAS International Conference on Landscape Architecture (LA '08), Algarve, Portugal. 11-13 June 2008.
- 8. Al-Yahyai, R. Date palm tradition of Oman, *Horizon* (SQU) 142:4. 30 August 2008.
- 9. Al-Yahyai, R. SQU exploring ways to rejuvenate lime cultivation. *Times* of Oman. 22 November 2008.
- 10. Al-Yahyai, R. Rejuvenating the lime tradition of Oman. *Oman Daily Observer.* 22 November 2008.
- 11. Al-Yahyai, R. Witches' broom. *Al-Baheth* (SQU-Arabic) 42:11. September 2008.
- 12. Al-Yahyai, R. Do not forget dates. *Horizon* (SQU) 125:4. 10 January 2008.
- 13. Goddard, J.S. 2008. Macrobrachium: shrimp with a big future. Fish Farming International, 35(6):16-17.
- 14. Rahman, M.S. Garlic as a medicinal food. Horizon. 20 May 2008, p.4.
- Rahman, M.S. 2008. State diagram of foods. Scirus Topic Pages. <u>http://topics.scirus.com./State</u> Diagramof_Foods.html.
- Soussi, B. Functional foods from seafood. . . profitable commercial opportunities from developing science for human health. *Al-Watan*, 8 March 2008. (in Arabic).
- Soussi, B. Functional foods from seafood. Oman Daily Observer, 17 February 2008.
- Soussi, B. Functional seafood products have become need of the hour. Oman Tribune, 8 March 2008.
- 19. Soussi, B. The rise of marine biotechnology. Horizon, 20 March 2008.

Reports (Research/Technical)

- SR/AGR/BIOR/03/01 Evaluating greywater reuse potential for sustainable water resources management I Dr. S.A. Prathapar, PI.
- IG/AGR/FISH/00/01 Development of a novel test for determination of protein quality for aquafeed ingredients. *Dr. S. Goddard*, PI.
- IG/AGR/PLANT/06/03 –Mango rootstock evaluation, conserva-tion and use in the Sultanate of Oman. *Dr. M. Deadman*, P.I.

- 4. Bose, S., H.S. Al-Masroori and others. 2008. Preliminary assessment of demersal trawl fishery performance in Oman. Report submitted to the Ministry of Fisheries Wealth.
- 5. Goddard, J.S. 2008. Review of aquaculture in Oman (Food Safety and Environment), 52 pages Joint consultancy with FAO.
- Goddard, J.S. 2008. Review of tilapia culture/food safety issues, 10 pages. Special report prepared for the Oman Government Cabinet at the request of the Ministry of Fisheries Wealth.
- Govender, A. and S. Zekri. 2008. An evaluation of Kingfish (Scomberomorus commerson) data collected by the GCC countries and its usefulness for determining population dynamic parameters and for undertaking stock assessments. A technical document submitted to the Ministry of Fisheries Wealth for the GCC Meeting, 29-30 Dec, 2008, Oman. 13pp.
- Govender, A. 2008. Stock status of *Epinephelus coioides* harvested in Oman. A chapter to be included in the grouper final report commissioned by the Ministry of Fisheries Wealth. 6pp.
- Shekar B. and H. Al-Masroori. 2008. Preliminary assessment of demersal trawl fishery performance. Report submitted to Ministry of Fisheries Wealth, Sultanate of Oman. 36 pp.

Staff MSc/PhD Dissertation

- *Al-Abri, Mohammed. 2008. Genetic variability of health disorders in Ontario Holstein cows. MSc thesis, McGill University, Quebec, Canada.
- 2. Al-Ajmi, Dawood. 2008. Studies in the shedding of *E. coli* 0157:H7 in feedlot cattle. *PhD thesis*, The University of Queensland, Australia.
- 3. Al-Jabri, Omar. 2008. Promoting small-scale fisheries on the Batinah coast, the Sultanate of Oman: a supply chain strategy and management approach. *PhD thesis*, The University of Queensland, Australia.
- Al-Masroori, Hussein Samh Harib. 2008. An assessment of the commercial trawl fishery of the Sultanate of Oman using the ecologically sustainable development framework. *PhD thesis*, University of Tasmania, Australia.

^{*}Addendum - Reported graduated in 2007 (Annual Research Report 2007).

Appendix

Appendix - CAMS Research Profile, 2008.

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