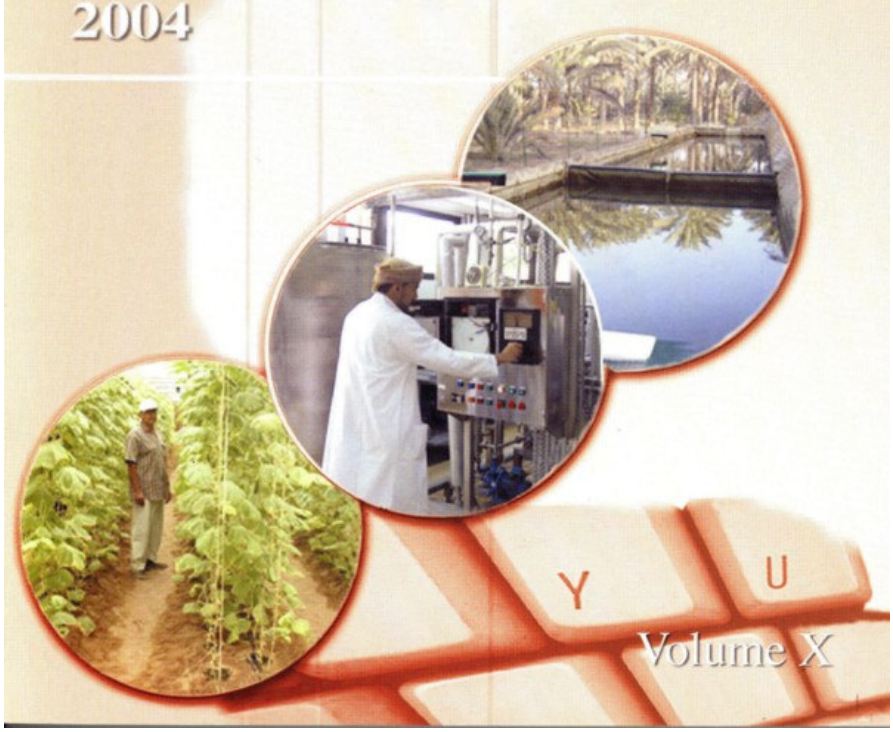
Sultan Qaboos University

College of Agricultural and Marine Sciences

Annual Research Report

2004



Volume X

FACTS
&
FIGURES 2004

- **RO 1,646,472 CAMS Research Budget**
- **50 Refereed Journal Publications in 2004**
- **5 Strategic Projects**
- **17 Externally Funded Projects**
- **78 Research Projects in Total; 9 completed in 2003; 18 completed in 2004**
- **New Projects Awarded in 2004:**
  - **1 SQU Strategic**
  - **10 SQU Grants**
  - **1 Externally Funded**

Annual Research Report 2004

Volume X

Table of Contents

Foreword

The College of Agricultural & Marine Sciences (CAMS) has been providing services in the areas of agriculture and fisheries to the community in the Sultanate of Oman for nearly two decades. CAMS plays a vital role in promoting research in crop sciences, veterinary sciences, marine sciences and fisheries, food sciences and nutrition, and soil and water resource management to enhance sustainable use of the Sultanate's resources. CAMS has gained an international reputation for its basic and applied research in diverse areas of agriculture and fisheries. Most recently the College embraced biotechnology as a research tool, notably marine biotechnology supported by the UNESCO Chair.

In this report, research achievements of faculty, staff and students are recorded for dissemination to the research community in the Sultanate of Oman and elsewhere. During 2004, CAMS faculty were successful to receive approval of a strategic research project from His Majesty's Strategic Research Fund amounting to a total of 74,800 Omani Rials, 10 internally funded research projects with a total of 66,100 Omani Rials, and one SQU–UAE University joint research project. The total amount of research funding from various sources was 1,646,472 and the list of refereed publications is self-explanatory for the College's achievements in research.

In addition to attracting substantial research funds and producing significant research publications, the College has been successful in attracting 100 postgraduate students in different disciplines who are actively engaged in research programs.

I take this opportunity to express my most sincere sense of gratitude and appreciation to all faculty, staff, students and researchers who have contributed to achieving outstanding performance in research. I am indebted to the members of Research Committee for their hard work in achieving the set goals towards improving the research environment. Sincere thanks are also due to the AVPPSR and University administration for their unfailing support.

Nadiya Abubakar Al-Saady, Ph.D.
Assistant Dean for Postgraduate Studies and Research

Research Committee

Dr. Nadiya Abubakar Al Saady, *Chair*

Dr. Sanmugam Prathapar, *Co-chair*

Prof. Saiyed Ahmed

Dr. Houcine Boughanmi

Dr. Jamal Khan

Dr. Linus Opara

Dr. Osman Gaafar

Dr. Shafiur Rahman

The Year in Review

Introduction

The researchers of the College of Agricultural & Marine Sciences (CAMS) for the past two decades have been actively involved in addressing and solving local and regional problems through basic and applied research covering a wide range of disciplines in agriculture, marine and fisheries sciences, veterinary, food and nutrition sciences. CAMS has developed scientific collaboration with many international organization and universities worldwide in pursuit of knowledge and practical solutions to the problems related to the agricultural and fisheries sectors in Oman. It is the prime aim of CAMS diversified research programs to disseminate the outcome to public and private sectors, farmers, fishermen, scientific peers and to the community at large and to collect their feedback for improvement. The postgraduate programs in CAMS are designed to produce high quality researchers who will participate, maintain and enhance the national image in regional and international research and development systems in agricultural, marine and food sciences. CAMS provides its students the opportunity to learn and utilize the latest and most advanced technologies and facilities.

Research Projects and Budgets

For the year 2004, the CAMS total research budget was RO 1,646,472 (Table 1).

In 2003, 9 internal grant projects were completed (Table 2) while 18 were completed in 2004 (Table 3). There were 14 on-going internal grant projects in 2004 (Table 4); abstracts of these projects are on pages 32 to 41. In the same year, the College awarded 10 new internal grant projects (Table 5).

Table 6 lists the five on-going research and development projects which are being funded by His Majesty's Strategic Research Fund from 2001 to 2004.

The College had nine externally-funded research and development projects completed in 2004, seven on-going, and 1 was awarded in the same year (Tables 7, 8 and 9).

Table 1. Summary of research and development projects held by the College over 2000-2004.

Source	Number of Projects	Completed 2003 (RO)	Total Budget 2004 (RO)
Internally-funded (SQU) projects			
• Completed in 2003	9	70,700	
• Completed in 2004	18		101,540
• On-going	14		99,700
• Awarded in 2004	10		66,100
His Majesty's strategic research fund	5		523,744
Externally-funded projects			
• Completed in 2004	9		345,375
• On-going	7		497,063
• Awarded in 2004	1		12,950
Total	78	70,700	1,646,472

Table 2. Internally-funded research and development projects completed in 2003.

Title of Research	Principal Investigator	Grant Dates (start-end)	Amount (RO)
Development of a novel test for the rapid determination of protein quality for aquafeed ingredients	***S Goddard***	2000-2002	9,800
Production, reproduction and clinical manifestations induced by low dietary levels of vitamin B12 in Omani goats	***E. Johnson***	2001-2003	9,600
Investigation and optimization of humidification and dehumidification processes in greenhouses to produce fresh water from saline water	***J. Perret***	2001-2003	8,400
Prevalence of Salmonella in/on eggs in the Sultanate of Oman	***A. Mothershaw***	2001-2003	6,400
Roles of light and copper in the development of off-flavour in milk	***F. Consolacion***	2001-2003	2,400
Quality assessment of fresh yellow-fin tuna at low temperature storage.	***N. Guizani***	2001-2003	9,400

Table 2. . . .

Title of Research	Principal Investigator	Grant Dates (start-end)	Amount (RO)
Development of transgenic potato cultivars expressing d-endotoxin gene resistant against potato tuber moth (phthorimaea operculella) insect	***A.J. Khan***	2001-2003	10,400
Introduction and evaluation of lime somatic hybrids potentially resistant to witches' broom disease of lime	***I. Khan***	2001-2003	9,500
The use of CAT scanning to investigate soil, water and pathogen interactions	***M. Deadman***	2001-2003	4,800
Total			70,700

Table 3. Internally-funded research and development projects completed in 2004.

Title of Research	Principal Investigator	Grant Dates (start-end)	Amount (RO)
Chlorophyll metering: an innovative approach to nitrogen management in forage corn	***H. Esechie***	2000-2002	8,535
Effect of bovine somatotropin (bST) on milk production, health and production in lactating dairy cows in Oman	***A. Kumar***	2000-2003	2,315
Gillnet selectivity study for the Seeb sardine fishery	***H. Al-Oufi***	2000-2002	4,650
Improvement of carcass and meat quality characteristics in Omani goats and sheep	***I. Kadim***	2001-2003	5,400
Nutritional status of Omani population: Assessment of biochemical indicators of vitamin nutriture of male and female university students in Oman	***S. Iqbal***	2001-2003	12,400
Identification of antimicrobial substances in fresh commercially sold pasteurized milk in Oman	***A. Kumar***	2002-2004	3,300
Determination of commercial meat products quality in the Sultanate of Oman	***O. Gaafar***	2002-2004	8,650
Assessment of high hydrostatic pressure blanching technique in food processing	***S. Sablani***	2002-2004	3,900
Textural properties and consumer preference: Identifying optimum quality characteristics of dried dates by rheological profile analysis related to texture	***S. Rahman***	2002-2004	4,100

Table 3 . . . .

Title of Research	Principal Investigator	Grant Dates (start-end)	Amount (RO)
Assessment of concentration polarization in brackish and seawater reverse osmosis systems	***M.F.A. Goosen***	2002-2004	4,080
A quantitative assessment of WTO negotiations on agriculture and food security in Oman	***H. Boughanmi***	2002-2004	3,450
Environmental tolerance limits and physiological adaptations of the Arabian pup fish, *Amphanius dispar* (Ruppell) to extremes in temperature, salinity, and dissolved oxygen	***A. Sutterlin***	2002-2004	3,750
An examination of the life-history parameters of the common grouper, *Cephalopholis hemistiktos* and its application to fisheries management	***J. McIlwain***	2002-2004	10,650
Collection and evaluation of native and exotic germplasm of important crops of Oman	***A. Al-Maskri***	2002-2004	9,600
Assessment of greywater reuse potential in Oman	***M. Ahmed***	2002-2004	9,180
Analytical modeling of multiphase flows in porous media based on the theory of free boundary problems	***A. Kacimov***	2002-2004	3,000
Effects of King fish (*Scomberomorus commerson)* oil on atherogenic factors in rats	***I. Mahmud***	2003-2004	4,200
Evaluation of four water saving hydrophilic copolymers	***H. AbdelRahman***	2003-2004	380
Total			101,540

Table 4. On-going internally-funded research and development projects awarded from 2000 to 2003.

Title of Research	Principal Investigator	Grant Dates (start-end)	Amount (RO)
Development of a solar thermal-powered pumping system	***S. Al-Rawahy***	2000-2002 (extended)	8,400
Solute transport in porous media: physical, analytical and numerical modeling	***S. Al-Jabri***	2002-2004	6,150
Development and testing of a computer controlled, cyclic misted forced ventilation system for cooling dairy cows	***I. Haffar/ L. Opara***	2002-2004	4,000
Scientific and technological aspects in the development of confectionery and ice cream products using mixtures of gelatin and k-carrageenan	***S. Kasapis/ S. Sablani***	2002-2004	10,800

Table 4 . . . .

Title of Research	Principal Investigator	Grant Dates (start-end)	Amount (RO)
Study on the relationship between ascorbic and acid supplementation and heat stress on poultry maintained in open-sided housing	***I. Kadim***	2003-2004	9,700
Three-dimensional fractal analysis of preferential flow paths using CT scanning	***J. Perret***	2003-2005	4,200
Ripening profile of semi hard standard goat's milk cheese	***N. Guizani***	2003-2005	6,000
Use of selection grids to reduce discarding in the demersal trawl	***H. Al-Oufi***	2003-2005	9,900
Introduction and evaluation of exotic germplasm of important solanaceous vegetable crops (tomato and peppers)	***I. Khan***	2003-2005	8,700
Response of chickpea (*Cicer arietinum* L.) to salinity stress	***H. Esechie***	2003-2005	4,400
Integrated management of fruit flies in Sultanate of Oman	***K. Azam/ N. Al-Saady***	2003-2005	4,200
Molecular and serological characterization of alfalfa phytoplasma	***A.J. Khan***	2003-2005	8,000
Fractionation of heavy metals in calcareous soils amended with sewage sludge	***M. Al-Wardy***	2003-2005	4,450
Desalinating soil by linking a novel solar heated process to an augmented water supply	***P. Cookson/ H. AbdelRahman***	2003-2005	10,800
Total			99,700

Table 5. Internally-funded research and development projects awarded in 2004.

Title of Research	Principal Investigator	Grant Dates (start-end)	Total Budget (RO)
Nutritional evaluation of traditional Omani meals-studies on the chemical composition, glycemic responses and atherogenic factors	***A. Ali***	2004-2006	7,700
Studies of foodweb interactions and carbon flow in the mangrove ecosystem of the Sultanate of Oman	***S.I. Ahmed***	2004-2006	9,450
Biometrics of the Indian oil sardine *Sardinella longiceps* val. Along the coast of Oman	***S. Al-Jufaili***	2004-2006	3,600

Table 5. . . .

Title of Research	Principal Investigator	Grant Dates (start-end)	Total Budget (RO)
Seasonal study of dissolved organic matter in relation to phytoplankton in the Gulf of Oman	***A.R. Al-Azri***	2004-2006	7,550
Integrated small-scale tilapia farming in Oman	***S. Goddard***	2004-2006	4,250
Quantification, prediction, and reduction of postharvest losses of fresh food crops in Oman	***L. Opara***	2004-2006	7,500
Methodology to identify redundant piezo-meters and locations for new piezometers in hydro-geologic basins	***S. Prathapar***	2004-2006	5,600
Utilization of power and machinery in arid agriculture	***D. Ampratwum***	2004-2006	2,650
Salinity as a direct and indirect pre-disposing factor for damping off disease in greenhouse cucumber production	***M. Deadman***	2004-2006	9,520
Development and optimization of genetic transformation procedures for Omani Banana varieties	***N. Al-Saady***	2004-2006	8,280
Total			66,100

His Majesty's Strategic Research Projects

In 2004, CAMS was awarded funding for a strategic project to the sum of R.O. 74,800 through His Majesty's Strategic Research Fund to improve the production of vegetable crops through the development of stress tolerant germplasm and improvement of farming systems. The College has been fortunate to acquire His Majesty's Strategic research funding for 4 other projects in the years 2001-2003, summing a total of R.O. 448,944. The projects cover areas of date palm improvement, development of new fish products, use of seawater to cool greenhouses, and reuse of grey water as a means of sustainable water resource. All research conducted through these generous contributions have maintained the highest standards. Findings from these projects will lead to many benefits to the agricultural and fisheries industries in the years to come.

Table 6. On-going research and development projects from 2001 to 2004 funded through His Majesty's research fund.

Title of Research	Principal Investigator	Year Started	Amount (RO)
Improvement of date palm production and dates quality in the Sultanate of Oman	***O. El-Mardi***	2001	167,844
Fish product development for export and the local markets.	***S. Kasapis***	2002	96,000
Seawater greenhouse development for arid climates: An innovative approach for water desalination and crop production	***S. Sablani***	2002	87,500
Evaluation of greywater reuse potential for sustainable water resources management in Oman-Phase 1	***S. Prathapar***	2003	97,600
Improving production of vegetable crops by development stress tolerant germplasm and farming systems research	***I. Khan***	2004	74,800
Total			523,744

Externally Funded Research Projects

The faculty and staff have been very successful in attracting financial sponsorship for research from external agencies as well. In 2004, the College held 17 projects sponsored by external agencies such as the Ministry of Agriculture and Fisheries (MAF), Ministry of Commerce, Muscat Municipality, the Middle East Desalination Research Center (MEDRC), Petroleum Development of Oman (PDO), Electrical Power Development Company of Japan (EPDC), United Arab Emirates University (UAE), University of Florida, USA and University of Agriculture, Faisalabad, Pakistan (Tables 7-9).

Table 7. Externally-funded research and development projects completed in 2004.

Title of Research	Grantee(s)	Agency	Date Started	Amount (RO)
Evaluation of safety of poultry meat products in Oman	***I. Kadim***	Muscat Municipality	2003	3,400
Environmental impact assessment, choice of location and economic feasibility of a reef viewing vessel in the Daymaniyat Islands and Musandam	***M. Claereboudt*** ***S. Zekri***	Ministry of Commerce, Oman	2003	10,980
Aquafeed development from by catch	***S. Goddard***	MAF, Oman	2002	160,000
Elasmobranch fisheries of Oman	***H. Al-Oufi*** ***J McIlwain***	MAF, Oman	2000	98,000
Assessment of disposal practices and reuse potential of PDO produced water	***M. Ahmed***	PDO	2003	29,211
Reedbed technology for production water cleanup	***M.F.A. Goosen***	PDO	2001	8,700
Evaluation of the quality of water, soil and herbage at Rahab Farm (PDO	***O. Gaafar***	PDO	2003	5,180
Reedbed treatment and reuse of oil production water	***H. AbdelRahman*** ***H. Esechie*** ***P. Cookson*** ***A. Kacimov*** ***O. El_Mardi*** ***A. Al-Mahruki***	PDO	2000	26,594
Evaluation of a water saving high-absorbency copolymer	***H. Rahman*** ***S. Al-Rawahy***	EPDC, Japan	2000	3,310
Total				345,375

Table 8. On-going externally-funded research and development projects.

Title of Research	Grantee(s)	Agency	Date Started	Amount (RO)
An assessment of the grouper fishery of Oman	***J. McIlwain*** ***H. Al-Oufi***	MAF, Oman	2003	99,220
Management of Oman's kingfish fishery	***H. Al-Oufi***	MAF, Oman	1999	271,000
Spirulina culture using brine water from desalination plants	***J. Perret*** ***A. Mothershaw*** ***M. Claereboudt***	MEDRC	2001	12,000
Assessment of the composition of desalination plant disposal brines	***M. Ahmed***	MEDRC	2002	2,700
Management of groundwater resources in Oman and UAE	***A. Kacimov***	UAEU	2003	60,345
Application for terpenes for the control of Witches' broom disease of lime (WBDL)	***I. Khan***	University of Florida, USA	2000	47,918
Somatic hybridization of citrus to breed witches' broom resistant lime	***I. Khan***	University of Agriculture, Faisalabad, Pakistan	2002	3,380
Total				497,063

Table 9. Externally-funded research and development projects awarded in 2004.

Title of Research	Grantee(s)	Agency	Date Started	Amount (RO)
Research on study of pesticide resistance and residue problems in Omani and UAE vegetable production	***F. Talukder***	UAEU	2004	12,950
Total				12,950

Other Significant Activities

- During 2004, a process to organize and focus all research at CAMS into three research themes was initiated. This process continued into 2005. The process involved workshops and repeated consultations among researchers at CAMS.

- On the 3rd of May 2004, CAMS celebrated the annual Research Day. It was inaugurated by the Dean, Prof Anton Mclachlan and the ADPGSR. Dr. Hamed Al Oufi provided an overview of research activities at CAMS. Drs. Kasapis, El Mardi, Perret, McIlwain, Boughanmi, Kadim, Ampratwum, Al Saady, Iqbal and Ahmed presented results of strategic research projects and of projects nearing completion. In addition to oral presentations, progress of all research projects at CAMS were reported in a poster session.

- On the 20th and 21st of December 2004, a workshop for MAF and CAMS researchers was held at CAMS. The objective of the workshop was to identify common research areas and develop an institutional framework to strengthen collaboration between CAMS-SQU and MAF by sharing resources available to both institutions. The workshop was attended by 67 participants. The meeting started with overviews of the current status and outlines of the objectives of the workshop. Participants then split into three groups dealing with agriculture, livestock and fisheries. Each group was tasked with reviewing the state of knowledge, identifying and prioritizing the main areas of common research interest and outlining a few key collaborative projects relevant to the priority areas. The result of the deliberations of the three groups is summarized below:

  Agriculture
  The Agriculture group identified the following as strategic themes (in order) for collaborative research initiatives. Within each theme, sub-themes were identified and prioritized. For each sub-theme, key personnel were identified. Themes identified were:
    - Crop Protection
    - Salinity and Water Management
    - Germplasm and Crop Improvement
    - Agriculture in Controlled Environments
    - Quality, Postharvest and Marketing
    - Livestock

Animal Science

Two categories of research area were identified, animal science and animal health. Within each of these projects were prioritized as follows:

Animal science

- Determine genetic background of indigenous breeds and evaluate their performance.
- Use of by-products and native plant species as an alternative food source for Omani livestock.
- Developing socio-technical solutions to combat desertification due to animal grazing.

Animal health

- Clinical characterization of animal diseases in Oman.
- Monitoring immune responses of commonly used vaccines in livestock and poultry.
- Establish diagnostic capacity for infectious causes of abortions in livestock.

Fisheries and Marine Sciences

The fisheries and marine sciences group identified many points of common interests in marine and fisheries research. After discussion, the following priority areas emerged and are listed in order of perceived importance:

- Stock assessment
- Ecosystem-based fisheries oceanography
- Aquaculture
- Quality control, post harvest handling and marketing of fish products
- Marine biodiversity
- Fishing gear and fishing bio-economics
- Natural product development and biotechnology

It was felt that, although there is room for additional research topics, these 7 items covered most of the priorities set up by the ministry of Agriculture and Fisheries and the research interest and capabilities of both the Marine Science and Fisheries Center and the College of Agricultural and Marine Sciences. From the top three areas, four potential projects were identified as feasible, desirable and implementable by both sides, two in stock assessment, one in ecosystem research and one in aquaculture.

Significant Research Outcomes

Significant Research Outcomes

1. Agricultural Trade Liberalization
Houcine Boughanmi and John J. Waelti

Dr. Boughanmi and Prof. John Waelti investigated the effects of different approaches to trade liberalization (unilateral, regional and multilateral) on the Oman agricultural sector. They used an economy-wide approach that links the agriculture sector to the rest of the economy through adjustments of the balance of trade and exchange rate. Results showed that, under all trade liberalization scenarios, the economic gains to Oman, in terms of agricultural exports and overall economic welfare, will improve. However, the multilateral trade liberalization approach within the WTO trade agenda promises the greatest effect, offering greater stimulus to domestic prices of agricultural exportable and smaller negative impact on agricultural imports. For all scenarios, the broad based approach, by which trade is liberalized not only in the agricultural sector but in all other sectors, performed better than the sector-specific approach. The results of this study should help policy makers design trade policies that are in line with WTO rules and have better understanding of the effects these policies may have on the production of specific commodities that are important for the food security of the country.

2. Tradable Quotas in Omani Fisheries Management
Hemesiri Kotagama, Slim Zekri and Houcine Boughanmi

Dr. Kotagama and his colleagues initiated a broad study on economic and institutional aspect of kingfish management in Oman. As an initial step, they conducted a literature review to examine the feasibility of adopting Individual Tradable Quotas (ITQ) in Managing Omani Fisheries. The review provides empirical evidence of the success of ITQs in terms of sustaining the fish harvest, reducing over-capitalization in fishing and processing, fish market improvements, etc. Problems relating to fairness in initial allocation of quotas, possibility of monopolization, and alienating the traditional small fisherman have also been reported. For ITQs to be feasible, legislation should allow the possibility of providing transferable rights to fish a specified quota to individual fishermen and also specify the total allowable catch. It was found that though the fisheries act (Ministerial Decree Number 3/82) of Oman has been drafted to support regulatory management, it allows for providing rights to fish (in the form of

licenses that could specify quantities) and in defining the total allowable catch. However the act does not allow for transferring/trading the license.

3. Aflaj Management and Water Markets
Slim Zekri, Houcine Boughanmi and Ahmed Al-Marshudi

Dr. Zekri and his colleagues initiated a research project on the institutional aspects of Falaj management as well as analysis of the efficiency of water trade among farmers. An extensive literature review was carried out in order to highlight the Falaj water laws based on Omani original Arabic references. These water rights were later compared to the recent water laws at international level. The comparison of the different water rights showed that the Omani experience, in terms of legislation, is well advanced. The most important characteristic of such water rights is that shares are expressed in percentage and not in a fixed volume. The access to drinking water is insured for free for all the community members, regardless of whether they own a water right or not. Finally, water rights are treated as any other asset, that is they are inherited, sold and leased. The lesson clearly learned from the Omani experience is that water rights are a must but they are not enough. There is a need to create common water rights that could be leased in order to ensure a flow of income high enough to cover the operating and maintenance costs of the system. The system in Oman has been working independently of any state intervention, which is the final aim of implementing the participatory approach and empowering farmers and water users. The project is still in its first year. The coming step will deal with the economic analysis of water markets in terms of efficiency, monopoly and water rights concentration among few users.

4. Integrated Small-Scale Tilapia Farming in Oman
Stephen Goddard, Linus Opara and Hamed Al-Oufi

This farmer participatory project was designed to examine the feasibility of introducing fish (*Oreochromis niloticus*) as an additional crop on traditional farms. An agreement was signed with a farmer in Barka in April 2004 and the construction of two fish culture tanks and a small breeding facility was completed in May 2004. The tanks were initially stocked with 2000 juvenile fish reared at the Agricultural Experiment Station (AES). In June 2004, a second batch of 3000 fish, a different strain of the same species, was imported from Thailand. A range of temperature, water quality data and fish growth rates has been collected and conditions shown to be favorable for the culture of this species. Approximately one tonne of fish, of

mean individual weight 350g, had been grown and sold by April 2005. To investigate the effects of nutrient enriched effluent from the fish tanks on field crops, preliminary trials were set up by AES staff using treated and control plots of cabbage adjacent to the fish tanks. During the growing period, phosphorus and nitrogen levels were monitored in the plots and the trials were completed in March 2005. The nitrogen content of cabbage treated with pond effluent was 32.5% higher than the control (underground freshwater). Results indicate that the tilapia culture effluent is suitable for vegetable production. Mixing the effluent with fresh water could eliminate the observed reduction in crop yield.

A second production cycle will be started in September 2005. This will be used to support cost-benefit analyses and to extend the study of the performance of field crops irrigated with fish pond effluent.

5. Studies of Foodweb Interactions and Carbon Flow in the Mangrove Ecosystems
Saiyed I. Ahmed , Adnan R. Al-Azri and Khalid A. Al-Hashmi

The start of this project was significantly delayed because of the unavailability of a functional Mass Spectrometer for measurements of the stable isotopes of carbon and nitrogen. Nevertheless, this project did manage to make progress in unraveling the flow of carbon and nitrogen from the primary producers, such as the phytoplankton, the mangrove leaves, seaweeds and seagrasses, to a variety of consumer organisms to establish an understanding of the complexity of trophic interactions in different marine ecosystems. The results largely reiterate previous findings elsewhere, but also illuminate very interesting food chain dynamics that are relevant to the marine environments of the Sultanate of Oman.

6. Shore Litter Along Sandy Beaches of the Gulf of Oman
Michel R. Claereboudt

A short study on the pollution on beaches indicated that beach litter reached on average 27 kg/km. Most of the pollution was found to be associated with either fishing activities (44% in weight) or recreational activities (40%) but industrial waste represented only a small proportion of the total beach litter (<15%). Plastics in the form of bottles, bags and fishing equipment represented 60% of all debris found.

7. Biometrics of the Indian Oil Sardine *Sardinella longiceps* Val. Along the Coast of Oman

Saud M. Al-Jufaili

The objectives of the project are to analyze sardine landings using data from the Ministry of Agriculture annual statistical report; define the sardine spawning season in Oman in the Al-Seeb and Al-Batina areas; obtain sardine weight-length and age-length relationships; and obtain the sardine growth rates. Currently we are still in the process of collecting data from two areas Muscat and Salalah. Al-Batina station was excluded from the project because of the inconsistency in the availability of data. In September 2004 Dr. Linus Opara joined the project; with this collaboration the project will explore the postharvest handling of the sardines in Oman; identify the problems and suggest solutions. Two papers under this project were presented at the conference "postharvest technology and quality management" at SQU from 31 January to 2 February 2005. The two papers are entitled: (1) Postharvest handling and marketing systems of fresh fish in the Sultanate of Oman; and (2) Quantification of fresh fish losses during postharvest handling in the Sultanate of Oman.

8. Seasonal Study of Dissolved Organic Matter in Relation to Phytoplankton in the Gulf of Oman

Adnan R. Al-Azri

This project investigates the seasonality of dissolved organic matter and its interaction with phytoplankton over a period of two years. The project has completed its first year of field work and a number of parameters were recorded. The preliminary results have proven their significance in understanding the dynamics of dissolved organic matter and phytoplankton interactions. For instance, seasonality of water temperature and nutrients have shown the significant influence of the south-west monsoon upwelling as a driving force of productivity and organic matter release in the Gulf of Oman. Taxonomic work on phytoplankton shows promising results which will help us to understand and establish comprehensive knowledge of the phytoplankton dynamics of the Gulf of Oman.

9. Understanding of Artificial Recharge Mechanisms

Anvar Kacimov, Mohsen Sherif (UAE University), Johan Perret, Salem Al-Jabri and Salem Al-Shidi

Dr. Kacimov and his colleagues developed mathematical models, which explain recharge mechanisms at catchment scales. As a part of this study, a linear potential theory (LPT) is implemented to predict the water table dynamics. Results are compared with those obtained from field trials and those obtained from a numerical model. The model is then used to determine strategies to mitigate seawater intrusion in coastal aquifers, and to study the decay of groundwater mounds appearing after pulse-type infiltration events from recharge basins and trenches.

10. Drain Accelerated Recharge (DARE)

Sanmugam Prathapar, Johan Perret and Saif Al-Adawi

Dr. Prathapar and his colleagues designed and numerically evaluated a concept, DARE, which accelerates recharge to groundwater from recharge dams. The concept, Drain Accelerated Recharge, consists of a vertical pipe connected to tile drains installed at shallow depths within the dam reservoir. Recharging water enters the vertical pipe, by-passes the sediment layer, enters the horizontal tile drain, from where it enters the soil matrix and travels to the water table. The concept was numerically evaluated for conditions exist at Al-Khod Dam in Oman. Data show that sediment deposition can be 2 m thick, reducing infiltration rates from 5.76 m per day to as low as 0.36 m per day. However, installation of DARE will permit water to by-pass the sediment layer and enter the soil matrix. Numerical simulations show that, in the presence of DARE, a 10 m column of water will infiltrate in 10 days, which, in the absence of DARE may take up to sixty days.

11. Freshwater Production from Seawater

Johan Perret, Shyam Sablani, Mohammed Al Belushi

Prolonged aridity in the Sultanate of Oman has resulted in freshwater deficit in some parts of the country. In coastal areas aridity, coupled with over-pumping of groundwater, has often resulted in seawater intrusion. Looking for alternatives to provide freshwater for domestic, industrial and agricultural purposes is an ultimate goal for the government. The use of solar radiation in greenhouses to desalinate saline/brackish water was tested. Their sea water greenhouse, a modified Quonset greenhouse, has

two humidifiers (i.e., evaporating pads), to increase water vapor inside the greenhouse as much as possible, and two dehumidifiers (i.e., condensers) to condense this water vapor. Preliminary results show that up to 500 l of freshwater per day can be produced from sea water for irrigation. Furthermore, water demand for cooling was fully met with sea water.

12. Greywater – An Alternative Domestic Water Resource in Oman

Mushtaque Ahmed, Sanmugam Prathapar, Abdullah Al Belushi, Ahmed Al Maskri and Malik Al Wardy

Water for domestic use in Oman is produced at a very high cost. Increasing water availability by treating and reusing wastewater is a government policy in Oman. A large portion of the domestic wastewater is considered greywater, water that has been used for washing dishes, laundering clothes or bathing. Reuse of greywater will reduce the demand for freshwater, reduce the volume of wastewater entering sewer and septic systems and will have positive environmental and economic benefits. Constraints in treating and reusing greywater in Oman were identified. The study shows that the quantity, quality, financial, social, institutional, and legal constraints restrict reuse potential of treated greywater. Fortunately, these constraints are surmountable and therefore, greywater remain an alternative source of water in Oman.

13. Bio-technology to Treat Oil-Production Water

Abdullah Al-Mahruki, Brian Alloway and Heiko Patzelt

The foremost challenge facing Petroleum Development Oman (PDO) over decades is the safe and environmentally sound disposal of large quantities of oil production water. Currently, the company is producing 600,000 m^3d^{-1} of oil-production water, which is expected to rise to 900,000 m^3d^{-1} by the year 2013. This water is contaminated with petroleum hydrocarbons (10-800 mg L^{-1}), traces of phenols, emulsifiers, and a wide range of metals at variable concentrations. The electrical conductivity of this water is 12 dS/m. This project evaluated the efficacy of reed-beds to treat oil-production water in Oman. It showed that the combined interactions between the substrate, macrophytes and the inhabiting microorganisms resulted in considerable reductions in the inorganic and organic contaminants simultaneously. Metals in the effluents were reduced by 78% for Al, Ba, Cr, Cu, Zn & Li, up to 40% for Fe, Li, Mn, Pb and appreciable reductions of As, Cd, Co, Mo, Ni, Se, Tl and V. Consistent reductions were achieved for total hydrocarbons, averaging 96% for the three years of operation. The contaminants were

virtually eliminated within the primary reed bed by aerobic and to a lesser extent by anaerobic processes.

14. Traditions vs. Equity in Access to Aflaj Water

Abdullah Al Ghafri, Sanmugam Prathapar, Ian McCann, W.Ray Norman and Takashi Inove

Farmers at Falaj Al Hager prefer to maintain traditional water sharing practices, even if it may be an inequitable one. Aflaj water has been the backbone of life in rural Oman. It has been shared among locals, without any conflicts for many centuries. Water sharing has been on a time sharing basis, which is perceived to be equitable. Dr. A. Al Ghafri and his colleagues studied equity in access to water in Falaj al-Hageer, where time sharing is still based on a sun dial and the rise of stars. Day length in this falaj varies seasonally, and the falaj's location within high mountains affects the performance of the sundial. Consequently, if farmers were to adhere to design water rights, water would not be shared equitably. In recognition of this, in practice farmers increase the number of athars (time management unit) at night, and rotate water turns. Despite such adaptations, inequity remains an issue at Falaj al Hageer. However, farmers are still reluctant to adopt modern ways of timing to improve equity in access to water.

15. Effect of Fish Oil on Atherogenic Factors in Rats

Ishtiaq Mahmud

This project investigated the possible beneficial effect of kingfish oil in rats which were made hypercholesterolemic after feeding for 4 weeks a 2% cholesterol rich diet. This measured the various lipid profile, nonesterified fatty acids (NEFA) and total antioxidant- status (TAS). Initial results indicate a significant decrease in serum cholesterol, triglycerides (TG) and NEFA upon feeding 5% fish oil diet for 4 weeks to hypercholesterolemic rats, TAS level also showed increase upon feeding of fish oil diet, HDL level showed increase. Finally, when fish oil and cholesterol rich diet were fed together, fish oil was able to prevent increase in atherogenic lipid factors. The findings clearly indicate the beneficial effects of fish oil in the experimental animals. The findings will be helpful in planning studies on humans.

16.Tuna Quality and Safety

Dr. Nejib Guizani

This project assessed the effects of storage conditions on the shelf life and safety of yellowfin tuna *(Thunnus albacares)* caught in Omani coastal waters, by studying microbiology changes, histamine formation, freshness (*K*-values) and sensory evaluation of tuna stored at temperatures of 0, 8, and 20°C. Temperature was found to be a critical variable for the quality and safety of fish. Storage at 0°C greatly extended the shelf-life of yellowfin tuna as compared to 8°C and 20°C. Fish maintained its freshness for up to 17 days, 6 days and 24 hours at 0°C, 8°C and 20°C, respectively. Histamine levels declined during storage at 0°C with values within the acceptable levels specified by FDA (5 mg 100 g^{-1}) and the European Union (10 mg 100 $g^{"1}$). This was in contrast to 8°C and 20°C, where histamine levels increased continuously to reach unacceptable values after 4 days and less than 24 hrs, respectively. This correlated with an increase in the proportion of mesophilic bacteria when compared to 0°C. Sensory evaluation was shown to be an effective method as microbiological and chemical parameters were still within the acceptance limits when the fish became unacceptable in sensory terms.

17. Structure and Pore Formation in Freeze-dried Seafood

Shyam Sablani, Shafiur Rahman, Stefan Kasapis and Nejib Guizani

Information on the characteristics of pores and the mechanical properties of dried food products is needed for process design, estimating properties such as thermal conductivity, density and moisture diffusivity, and determining food quality. Pore characteristics and structural properties of freeze-dried abalone were studied by porosimetry and a mechanical puncture test. The pores were assessed by measuring apparent porosity, pore size and pore size distribution of freeze-dried samples developed by drying it at different temperatures. Similarly, mechanical characteristics were determined by identifying the peak force, bio-yield point, and modulus of elasticity from the puncture force-displacement curve. Apparent and open pore porosity of dried abalone varied from 0.737 to 0.664 and 0.688 to 0.623, respectively when freeze-drying temperature varied from –20 to 15°C. In the case of low pressure, average pore diameter decreased with the decrease of freeze-drying temperature, whereas high pressure showed no trend. The modulus of elasticity and bio-yield point varied from 1.84×10^7 to 0.55×10^7 Pa and 133 to 15 N, respectively having a decreasing trends with the increase of freeze-drying temperature.

18. Nutritional Quality and Glycemic Index of Traditional Omani Food

Amanat Ali

Changes in lifestyle and dietary consumption pattern have resulted in shifting of health problems from the survival issues to lifestyle related problems such as diabetes, heart diseases, hypertension and obesity. This addressed these issues and initiated a study to evaluate the nutritional quality and glycemic index of traditional Omani foods. Glycemic Index (GI) of foods is a useful tool for elucidating the effects of carbohydrate rich foods on glucose and lipid metabolism and has proved to be a more useful nutritional concept than is the chemical classification of carbohydrates. Twenty different types of local Omani foods, including 11 different types of breads, seven different traditional meals (Harees with meat, Harees with chicken, Arsiyah, Meat Biryani, Kabooli Chicken, Maajeen (dried meat from Salalah), Qushat (Coconut sweet from Salalah) and two varieties of dates, have been analyzed for their chemical composition (moisture, protein, fat, fibre, ash, carbohydrates and gross energy contents). The determination of Glycemic Index (GI) of these foods is in progress. The preliminary results indicated that the GI values for white bread (toast), brown bread (toast), Khobz Lebanani white, Khubz Lebanani brown were 51.5, 48.4, 52.5 and 52.6, respectively when pure glucose was used as a standard food.

19. Traditional Dried Meat Products and Their Safety

Shafiur Rahman, Isam Kadim, Ann Mothershaw, Mohd Hamad Al-Riziqi, Nejib Guizani, Osman Mahgoub, Amanat Ali and Zeinab Salman (MSc student)

Traditionally, dried meat products are being produced in many countries around the world. In many cases chemical and microbial safety are major concerns. Recent advances in dried meat product development and the potential health risks of the associated micro-flora were assessed. In addition, experimental work was conducted in developing dried meat products. Thirty *longissimus dorsi* (LD) muscles from Omani male goats were dried by five methods (sun, air, vacuum, freeze and modified atmosphere drying). Dried strips were evaluated for microbial, chemical and physical quality. The method of drying had a significant effect on microbial counts, pH, volume of expressed juice, color, rehydration ratio, and fatty acids content of LD samples. Immediately after drying and 6 weeks of storage, sun dried sample showed significantly higher aerobic plate counts, and levels of *Pseudomonas* and *Staphylococcus* compared to other methods of drying. The drying method significantly affected the types of mold growth in the samples.

20. Hygienic Standards and Eating Quality of a Range of Poultry Products on Sale in Oman

Ann Mothershaw and Jokha Al Aamri (MSc student)

The frequency of internal contamination with *Salmonella* was 0.2%, overall, but reached 2% for one producer, in a sample of 520 eggs from three Omani and two overseas producers. Species of *Serratia, Klebsiella* and *Pantoea* were also isolated from inside eggs. In general, higher storage and production temperatures and age resulted in higher bacterial counts. A range of potential pathogens were isolated from poultry meat. *Staphylococus aureus* was recovered from more than half (55%) of the samples, more frequently from minced meat and burgers. *Salmonella* spp. were isolated from burger and frozen boneless meat samples. All the strains demonstrated some antibiotic resistance; predominantly to tetracycline. Variations in the physical properties of meat stored at different temperatures were demonstrated Overall, chilled samples were the most tender whilst frozen meat showed a trend toward toughness. Fresh meat fell between these two groups.

21. Nutritional Status of Omani Young Adults

Saud Iqbal, Ishtiaq mahmud, Amanat Ali, Mushtaq Khan (College of Medicine) and Omar Obeid (American University Beirut)

Nutritional status of young (age group 19-24 years) male and female Omani adults was studied focusing on dietary patterns, anthropometry, vitamin status and cardiovascular disease risk as reflected by lipid profile of the target population. The average daily intake of milk and dairy products was markedly low at 0.9 servings per day (recommended 2-3 servings/day). Males consumed 150% higher bread and cereals (7.6 servings /day) compared to females (4.9 servings /day). Females (29.7%) were twice as deficient in consumption of meat and meat alternatives as males (15.3%). Overall 62% of the subjects were found to be within the normal body weight range with more than 24% of the subjects being overweight and about 14% to be underweight. While mean blood cholesterol levels did not differ among males and females, mean triglyceride levels were significantly different between the two sexes. Total blood cholesterol and LDL-C levels were higher than normal in 11% and 23% of both male and female subjects, respectively. Male subjects had a higher atherogenic index of 4.78 compared to 3.8 in females. This study indicates a significant influence of a modern life style on dietary habits and food selection criteria of the target population.

22. Research in Animal and Veterinary Sciences

Isam Kadim, Osman Mahgoub, Eugene Johnson and Mohammed Tageldin

- Methods for determination of hormonal and antibiotic residues in poultry and goat meat were developed and work published.
- Feeds made solely from Omani feed ingredients were formulated and fed to Omani sheep.
- Meat quality of Omani sheep and goats was evaluated.
- Determination of accuracy of NIR to predict chemical composition of feed and meat.
- Ongoing studies with *Dientamoeba fragilis* have resulted in the determination of two distint genotypes and anecdotal evidence suggesting a link between this parastic and irritable bowel syndrome in humans.
- The pathological features of theileriosis in indigenous sheep and goats were investigated.

23. Salinity – Disease Interactions

Michael Deadman

Salinity levels of irrigation water in all farms with greenhouses in Al Batinah region have been mapped. The data suggests that salinity levels are limiting cucumber production in parts of Barka and Masanah. *Pythium aphanidermatum* is the the cause of damping-off – the most serious disease of cucumbers. Pythium growth is unaffected by salinity levels that compromise cucumber growth. This suggests synergy between salinity and disease in reducing crop yields and will be examined in detail by mapping salinity, disease and pathogen levels in selected greenhouses.

24. Mango Decline Disease

Michael Deadman

A new pathogen species has been identified and named as *Ceratocystis omanensis*. The pathogen contributes to mango decline disease in Oman. Research has confirmed that the principal pathogen responsible for the disease is the related *Ceratocystis fimbriata*. The pathogen in Oman is genetically most similar to isolates from Brazil – the only other country previously reporting this disease. Genetic studies have shown that all *C. fimbriata* in Oman is derived from a single strain. This suggests that the pathogen entered the country once only, and in the recent past. Mango seed material has been imported and is currently being tested for

resistance to the pathogen. If resistance is established, these varieties will form the basis for regenerating mango production in Oman.

25. Melon Sudden Collapse

Michael Deadman and Iqrar Khan

The latest disease outbreak to significantly threaten a major crop has been defined as melon sudden collapse. It appears that the disease results from a combination of pathogen damage and physiological stresses. Attacking melon and watermelon across large parts of Al Batinah, the disease has compromised yields and caused a substantial reduction in the area planted to the crop, as farmer disaffection increases. Standard soil treatments used to control fungal and nematode diseases are ineffective. A practical solution is being developed based on altering the cultivation techniques to encourage deep crop rooting and reduce stresses. Participatory research with local growers should ensure rapid uptake by the farming community.

26. Salinity Tolerance of Desert Trees

Humphrey Esechie

The impact of salinity on three desert trees, *Acacia tortilis*, *Prosopis cineraria* and *Ziziphus spina-christi*, was defined from a physiological standpoint. There was a significant reduction in the total nitrogen concentration in all three species with increased salinity exposure, while proline (N-containing compound) accumulated in the leaves. Based on this finding, it was suggested that proline accumulation under salinity stress may serve as an organic N reserve which can be utilized during recovery. Others have suggested that proline may be acting as a sink for excess N in salinity stressed plants. Further experimentation is required to explain these results.

27. Assessing Corn Nitrogen Needs with Chlorophyll Meters
Humphrey Esechie

Since most leaf N is contained in chlorophyll molecules, there is a close relationship between leaf N and leaf chlorophyll content. Chlorophyll as quantified by the SPAD 502 chlorophyll meter represents a unitless relative measurement of leaf chlorophyll content. Chlorophyll utilizes red light, and the chlorophyll meter's operation is based on the relationship between the amount of red light absorbed and the amount transmitted through the leaf. Basically, the more red light absorbed means more chlorophyll is present, which, in turn, indicates a greener plant. Utilizing this principle, we are in the process of deriving the N "sufficiency index" for corn from the average values of several Omani corn cultivars.

28. Water Use and Vegetable Production
Iqrar Khan

Oman is an arid country where agriculture has expanded during past 30 years by utilizing very scant underground water. A major agricultural application of water has been the production of hey grass (Rhodes Grass) which is grown as perennial crop under sprinkler irrigation system. Ecological consequences of excessive water mining are evident due to depletion and salinization of the aquifer. Farmers need to be induced to alternative crops and technologies to replace hey production. Vegetable crops have been experimented successfully as a profitable option. Data are lacking on the water use efficiencies of vegetable crops and hey grass. A hey producing field site was divided into 17 plots of approximately one hectare size each and converted into vegetable production farm leaving one plot under hey as a control. Multi-year experiments include measured application of irrigation water. Cabbage, muskmelon and watermelon were compared for relative water use efficiencies and then all of them compared to hey grass. Cabbage produced higher harvestable yield than melons; per day and per cubic meter use of water was also more economical. All vegetables yielded better economic returns than hey grass when compared for daily water use, water use for each kg of produce and gross returns for each cubic meter of water.

29. Screening of 54 Tomato Germplasms for Adaptation in Oman
Iqrar Khan

Tomato is the major vegetable crop grown in Oman. The production is entirely dependent on imported hybrids. The import of seed is not met by any regulatory mechanism leading to exploitation of farmers. The production is restricted to mild winter months of the year while most of the 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 varieties (hybrids and pure lines) as well as to develop local hybrids. Fifty four genotypes of tomato were acquired from AVRDC, Taiwan and evaluated for their adaptation in Oman. They are categorized as fresh market tomato, cherry tomato, and processing tomato. The experiments were planted in CRD with five replications. Data were collected on days to 50% of anthesis (flower), days to 50% of plants have matured fruits; fruit number, fruit size, total yield, and TSS. Results showed significant variation for yield, fruit number, fruit size and TSS. Fresh and cherry tomatoes reached anthesis 28 days after transplanting and fruit matured in 74 days for fresh fruit type and in 62 for cherry type. The processing tomatoes reached anthesis in 32 days and produced mature fruits in 75 days. Fresh tomato accessions CLN2498D and CLN2413R produced highest fruit yields of 8.158 and 8.028 Kg per plant, respectively. The yields of cherry tomatoes ranged 4.2 to 5.4 kg per plant. The processing tomatoes produced low yields of 3.7 kg per plant. Fresh fruit accessions CLN2264J, CLN1466P, CLN1462A and CLN2413R had the largest fruit size. Most of the varieties of fresh market tomato have TSS ranging from 4 to 5.5.

30. Genotypic and Explant Effects on *In Vitro* Callogenesis and Regeneration of Eight Accessions of Tomato
Iqrar Khan

Eight accessions of tomato (CLN2026D, CLN1466P, PT4719A, PT4664B, CLN2037B, CLN2123A, CLN2116B, CL5915-206) acquired from Asian Vegetable Research and Development Center, Taiwan were tested for *in vitro* regeneration responses. Two explants i.e. cotyledon leaf and fully expanded true leaves were cut into leaf discs and cultured on two distinct media. MS salts were modified with BA (1.0 mg/l) and NAA (0.1 mg/l) and IAA (0.1 mg/l) and zeatin (1.0mg/l) for true leaf and cotyledon leaf explants, respectively for callus induction. For shoot regeneration, MS salts modified with zeatin (2 mg/l) and IAA (0.1 mg/l) was used. Data were collected for the percentage of callus induction, callus fresh weight,

size and number of shoots. There were strong genotypic and explants effects observed for initiation and growth of callus. Shoot regeneration occurred after repeated subcultures. Again, genopytic and explant effects were significant. All the accessions gave regeneration response with true leaf explants and the highest percentage (47) for callus induction was for PT4719A. Cotyledon leaf explants of accessions PT4719A, PT4664B and CLN2116B were unresponsive for callus induction and regeneration. The highest percentage of callus was 100% in the case of cotyledon explant of accession CL5915-206. The highest area of callus spread for true and cotyledon explant was observed in PT4719A (2.68 cm^2) and CLN2123A (2.59 cm^2) respectively. Amongst true leaf and cotyledon leaf explants, the callus fresh weight was highest for CLN2123A (1.52 mg) and CLN2026D (2.53 mg), respectively. CLN2026D also produced highest number of shoots per callus (12) from cotyledon explant and 0.4 from true leaf explant. PT4719A gave highest number of shoots per callus from true leaf explant (4.6) whereas it was unresponsive for cotyledon leaf regeneration. The results showed that though some accessions like PT4719A gave highest regeneration response for true leaf explants, it was totally unresponsive for cotyledon explants. In the case of cotyledon explants, it was observed that there was no correlation between the percentage of callus induction and no. of shoots per callus. In summary there was no direct correlation between percentage of callus induction, callus weight, size and no. of shoots regenerated for either of the accessions.

Summary of Projects Awarded in 2004

Nutritional Evaluation of Traditional Omani Meals – Studies on the Chemical Composition, Glycemic Responses and Atherogenic Factors

A. Ali, S. S. Iqbal, N. Guizani and I. Mahmud

Department of Food Science and Nutrition, College of Agricultural and Marine Sciences, P.O. Box 34, Al-Khodh 123, Sultanate of Oman

Duration: 3 years **Budget:** RO 7,700

Summary

Changes in the lifestyle and food consumption patterns during the past 3 decades in the Arabian Gulf countries had a great impact on the nutritional status of the people. Traditional foods, which mainly consisted of date, rice, milk and fish, have changed to more Western style ready-made foods. Dates and Arabian coffee were taken as snacks between the meals. This change in the dietary pattern has resulted in shifting of health problems from the survival issues to the lifestyle related problems such as diabetes, heart diseases, hypertension, and obesity. The prevalence of malnutrition and the upsurge of nutrition related non-communicable diseases are becoming matters of great concern. Greater attention is therefore required to regulate the high intake of foods rich in fat, salt and cholesterol, while encouraging the intake of nutrient dense foods. Classifying carbohydrates based on their capacity for increasing blood glucose (termed as the "Glycemic Index" or "GI") is a useful tool for elucidating the effects of carbohydrate-rich foods on glucose and lipid metabolism. According to this system, individual foods are assigned values, how fast they are digested and absorbed during the postprandial period. Despite inconsistencies in data, sufficient, positive findings have emerged to suggest that dietary glycemic index is of potential importance in the treatment and prevention of chronic diseases. Data bank of foodstuffs for their GI is therefore important to make dietary recommendations for the diabetic and healthy people. Currently no such data are available for traditional Omani meals. The present study has therefore been planned to determine the nutritional value of the traditional Omani meals, their effects on glycemic responses and atherogenic factors in normal human subjects and animal models.

Seasonal Study of Dissolved Organic Matter in Relation to Phytoplankton in the Gulf of Oman

A. Al-Azri, S. Ahmed and K. Al-Hashmi

Department of Marine and Fisheries Science, College of Agricultural and Marine Sciences, P.O. Box 34, Al-Khodh 123, Sultanate of Oman

Duration: 3 years **Budget:** RO 7,550

Summary

In the marine environment, dissolved organic carbon (DOC) represents one of the largest reservoirs of exchangeable organic matter at the earth's surface Furthermore, this fraction is influenced by both biological and physicochemical processes spatially and temporally dependent. However, little is known on the specific mechanisms leading to the coupling of the processes of production and consumption which are considered as the main processes in the carbon cycle. It is therefore the aim of this research to investigate the dynamics of the DOM in the Gulf of Oman in relation to primary production and heterotrophic uptake of DOM. This can be achieved by studying phytoplankton dynamics and observation of other biological and physicochemical parameters.

Studies of Foodweb Interactions and Carbon Flow in the Mangrove Ecosystem of the Sultanate of Oman

S. Ahmed, A. Al-Azri and K. Al-Hashmi

Department of Marine and Fisheries Science, College of Agricultural and Marine Sciences, P.O. Box 34, Al-Khodh 123, Sultanate of Oman

Duration: 3 years **Budget:** RO 9,450

Summary

Mangrove ecosystems are considered to be among the most productive ecosystems in the world. They may provide habitat and protection for juvenile fish and also act as nursery grounds. They may export fixed carbon to adjacent estuaries, thus supporting significant fisheries, play a role in coastal protection, and act as a first line of defense during storm surges. Despite the importance of mangroves, our current understanding of benthic metabolism and nutrient dynamics in such ecosystems is invariably based upon only a few studies conducted in North America, Australia, and Southeast Asia. Yet these investigations have shown that results obtained at one location may be significantly different from those found elsewhere. To test this hypothesis, a comprehensive study of the stable isotopes of C and N will be conducted in samples of other potential primary producers to establish a direct link between such representatives of primary producers and the animal consumers of this habitat. Through their biomass determination and their overall contribution to primary productivity, an attempt will be made to ascertain their significance in overall carbon and energy balance. Such studies will be further supplemented by selected studies with benthic chambers to measure rates of oxygen consumption and benthic metabolism. The successful conclusion of these studies will not only shed additional light on the dynamics of C and energy flow in an important ecosystem that is now under increasing environmental threat, but holds the promise and the potential for providing scientific data which may accelerate the development of enlightened management and conservation policies for the protection of valuable natured resources in the Sultanate of Oman.

Integrated Small-Scale Tilapia Farming

S. Goddard, H. Al-Oufi, L. Opara and A. Al-Souti

Department of Marine and Fisheries Science, College of Agricultural and Marine Sciences, P.O. Box 34, Al-Khodh 123, Sultanate of Oman

Duration: 3 years **Budget:** RO 4.250

Summary

Farm trials for the production of Nile tilapia in brackish water ponds will be conducted on a farm in Barka. Semi-intensive production methods will be evaluated using supplementary feeds. Stocking of ponds and feeding protocols will be optimized and a production/cost model developed. Nutrient-enriched freshwater and sediment from tilapia ponds at AES will be used to fertilize and irrigate a tomato crop as an investigation into the potential integration of field crops with tilapia production.

Tilapia production represents a new enterprise in areas where salt-water intrusion into ground water restricts the growth of conventional farm crops. Information arising from this project will be made available to farmers through extension activities.

Biometrics of the Indian Oil Sardine *Sardinella longiceps* Val. Along the Coast of Oman

S. Al-Jufaili

Department of Marine and Fisheries Science, College of Agricultural and Marine Sciences, P.O. Box 34, Al-Khodh 123, Sultanate of Oman

Duration: 3 years **Budget:** RO 3,600

Summary

The collection of basic fish biological data is very important in fisheries science. These biological data include length, weight, sex, maturation, fecundity, age, etc. Parameters obtained from such data are important for fish stock assessment and management. Due to the ecological and economic importance of the Omani sardines the proposed study will estimate the different biological parameters in regards with the Omani sardine (*Sardinella longiceps*). Approximately ninety five percent of the small pelagic landings in Oman is of this species (Dorr III 1991). Sardines are considered to be very important fish along the Omani coast as they are generally an easy catch for the Omani fishermen and good source of income as well. Sardines are also important food sources for the bigger fish like kingfish and tuna.

Quantification, Prediction, and Reduction of Postharvest Losses of Fresh Food Crops in Oman

L. Opara and D. Ampratwum

Department of Bioresource and Agricultural Engineering, College of Agricultural and Marine Sciences, P.O. Box 34, Al-Khodh 123, Sultanate of Oman

Duration: 3 years **Budget:** RO 7,500

Summary

Postharvest crop loss is a major problem in agriculture and horticulture industries. Losses may occur at any stage in the handling chain, resulting in downgrading of produce or complete wastage. Consumers worldwide are increasingly demanding a consistent supply of good quality fresh products that are blemish-free, nutritious, safe, and traceable. Furthermore, in countries that are net importers of fresh food products, such as Oman, the incidence of high postharvest handling damage and related losses is exacerbated by the occurrence of multiple handling of commodities from the country of origin to the consumer. Improvements in postharvest handling practices will reduce losses, maintain quality and thereby enhance the overall high quality food supply without the need for additional resource inputs such as water and pesticides. Although industry practitioners and other stakeholders in Oman generally agree that the incidence of postharvest losses are unacceptably high and need to be reduced, there is a dearth of information on the magnitude and source of losses, types of damage that contribute to these losses, and the susceptibility of different food crops to handling damage. Postharvest technology research and innovation are therefore warranted to address these gaps in knowledge so as to develop appropriate technological tools to minimize the occurrence of postharvest crop losses. The overall aim of this project is to establish a postharvest technology research and development program at Sultan Qaboos University. The objectives of the current project are to determine the amount and sources of losses occurring in the handling chain, and to develop appropriate prediction tools for assessing the susceptibility of products to damage under Omani conditions. Investigative surveys will be carried out at the Central Fruit and Vegetable Market in Muscat and at selected supermarkets to quantify the magnitude of losses. Samples of produce will be selected at random and studied in the laboratory to characterize the types of damage that occur. Appropriate instrumentation will be developed and experiments will be conducted at the Agricultural Experiment Station to determine the

susceptibility to damage of selected fruit and vegetables under Omani conditions. These results will be correlated to the outputs of an Impact Recording Device (IRD) to assist in the development of predictive tools for product damage assessment. Technology transfer will be an essential component of this program through the development and demonstration of practical guidelines and training tool-kits for reducing the incidence of handling damage for selected food crops.

Methodology to Identify Redundant Piezometers and Locations for New Piezometers in Hydro-Geologic Basins

S. Prathapar , J. Perret and S. Al-Adawi

Department of Soil and Water Sciences, College of Agricultural and Marine Sciences, P.O. Box 34, Al-Khodh 123, Sultanate of Oman

Duration: 3 years **Budget:** RO 5,600

Summary

Temporal and spatial variability in the hydraulic head within an aquifer provide valuable information to groundwater resource managers to manage the aquifers in a sustainable manner. Spatial and temporal variation in hydraulic head within an aquifer is determined by monitoring the hydraulic head in a network of piezometers. Therefore, it is imperative that the information collected by a network of piezometers is a true representation of groundwater use behaviour within the hydro-geologic basin. The groundwater use patterns in any hydro-geologic basin vary as a result changes to groundwater water use patterns in Agricultural, Industrial and Urban sectors. Therefore a performance review of the piezometric network needs to be undertaken periodically to ensure that the data collected truly represent the groundwater use behavior within the basin. Rationalization of hydrometric monitoring (rain gauge networks, snowfall-monitoring stations), is very common among hydrologists. But, in spite of substantial benefits, similar progress has not been made in hydrogeology. Furthermore, limited studies carried out identified redundant piezometers within a network, but failed to identify locations where new piezometers ought to be installed to reflect the change in groundwater use pattern.

In this study, we propose to develop and test a methodology which combines multivariate analysis, geo-statistical analysis and Geographic Information Systems to identify redundant piezometers in a network, as well as locations for new piezometers. The methodology will be tested using data collected in the Muscat hydro-geological basin in Oman

Utilization of Power and Machinery in Arid Agriculture

D. Ampratwum, L. Opara[1] and A.S.S. Dorvlo[2]

[1]Department of Soil and Water Sciences, College of Agricultural and Marine Sciences, P.O. Box 34, Al-Khodh 123, Sultanate of Oman
[2]Department of Mathematics and Statistics, College of Science, P.O. Box 36, Al-Khodh 123, Sultanate of Oman

Duration: 3 years **Budget:** RO 2,650

Summary

There is a positive correlation between yield and power input to crop production. It was estimated in the early 1980s that available power for agriculture in Arab countries is 0.15 KW per hectare. This compares unfavorably with a recommended minimum disposal power of 0.75 KW per ha. for crop production. The Gulf Co-operation Council (GCC) countries, which are an integral part of Arab countries, are in an arid zone. The GCC countries have invested heavily in powered equipment to boost agricultural production and horticultural activities since the latter part of the twentieth century. Proper selection and management of power units and associated machinery are necessary for successful mechanized agricultural production. The selection and management of power and machinery require relevant basic technical and cost data which are lacking in the region. To promote proper equipment selection and management this project is proposed with the long term goal of establishing a reliable basis for the successful mechanization of arid agriculture with particular reference to Oman.

The short term goals or specific objectives of the project are to:

- Examine current usage of power and machinery and establish future mechanization needs.
- Acquire basic data for power and machinery selection and management
- Determine optimum power and machinery sizes and management requirements for agricultural production and horticultural activities.

Salinity as a Direct and Indirect Predisposing Factor for Damping Off Disease in Greenhouse Cucumber Production

M. Deadman, A. Al-Saady[1] and S. Al-Jabri[2]

[1]Department of Crop Sciences / [2]Department of Soil and Water Sciences,
College of Agricultural and Marine Sciences, P.O. Box 34,
Al-Khodh 123, Sultanate of Oman

Duration: 3 years **Budget:** RO 9,520

Summary

This proposal outlines research that will evaluate the relationship between soil salinity and predisposition to infection by soil-borne pathogens, especially *Pythium* spp. responsible for causing damping-off disease – the main cause of plant death in greenhouse cucumber production in Oman. The research will generate a reliable profile of salinity in greenhouse soils in Al Batinah region. This will be related to incidence and severity of damping off disease in the same soils. Within identified individual greenhouses maps of salinity will be generated at the individual plant level. Changes in salinity will be related to management practices such as soil ridging, soil changing and irrigation amounts. Salinity levels, soil water levels, soil temperature and pathogen populations will be used as a predictors of probability of pathogen attack.

Development and Optimization of Genetic Transformation Procedures for Omani Banana Varieties

N. Al-Saady and A. Al-Subhi

Department of Crop Sciences, College of Agricultural and Marine Sciences,
P.O. Box 34, Al-Khodh 123, Sultanate of Oman

Duration: 3 years **Budget:** RO 8,280

Summary

Banana is one of the major crop grown in the sultanate of Oman. Banana plantations in Oman are faced with several diseases such as fruit rot, cigar end rot and leaf spot. Other diseases that threaten banana plantations elsewhere in banana growing regions, such as *Mycosphaerlla fijiensis* Morelet (black sigatoka) also pose a threat to banana plantations in Oman. This necessitates the need to develop programs for the improvement of banana. Genetic transformation has proven to be a useful alternative method for introducing foreign genes into plants to create plants with improved or novel characteristics. For many traits improved using genetic engineering, high levels of expression of the introduced transgenes are necessary. This requires the use of a strong suitable promoter that has high levels of expression in all organs or a specific organ of banana. The aim of this project is to develop an effective method for the stable transformation and regeneration of banana (*Musa* species) including local Omani varieties by using either particle bombardment or *Agrobacterium*-mediated transformation. Also to test different promoters driving the reporter gene *gus*A for suitable expression in banana.

Activities under this project will be:

- To select different promoters that have shown strong promoter strength in monocots.
- To construct constructs using the different promoters driving the expression of a reporter gene.
- Transformation of Musa species (banana) with the above constructs using particle bombardment.
- Transformation of Musa species (banana) with the above constructs using *Agrobacterium tumefaciens.*
- Selection and regenaration of transgenic tissue culture.
- Analysis of transgenic plants both qualitatively and quantitatively to determine expression of the reporter gene in the transgenic plants

Graduate Program

Graduate Program

The CAMS Masters program, currently in its eighth year, offers M.Sc. programs in Crop Protection, Crop Production, Marine Science and Fisheries, Animal and Veterinary Sciences, Agricultural Economics, Soil and Water Management, Bioresources Engineering and Food Sciences.

The program currently has a total of 100 graduate students of which 34 were first enrolled in 2004. Twelve graduate students graduated in the year 2004. The graduate program focuses on providing quality education and research training in the areas of Agriculture and Fisheries. As part of the masters degree, students are expected to conduct a research project culminating in a thesis. Involvement of graduate students in funded research projects strengthens the research quality of their thesis. Various abstracts of the thesis work done by the graduate students are presented in pages 42 to 55. Successful completion of the program will allow integration of our graduates into the industrial sector thus creating bridges between CAMS and the Omani community.

A proposal to embark on a PhD program with more comprehensive requirements for research and productivity has been provisionally approved by the University Council.

Thesis Abstracts of Graduated Students 2004

Title	:	Quality Control and Development of Fish Burgers
Student Name	:	Sultan Rashed Salem Al-Maamari
Supervisor	:	Dr. Stefan Kasapis
Department	:	Food Science and Nutrition

Abstract

The rich and diverse fish stocks of Oman, the main source of wealth after oil, are the most important long-term renewable resource. However, they are not fully utilized. A proportion of the fish harvest is exported, but fish quality represents a serious problem for export. This happens at a time of increasing demand for marine resources both locally and abroad. Fish product development in the local industry is in its infancy, but it is necessary for manufacturing companies to develop fish products in order to expand sales and achieve organic growth.

The aim of the project is the purposeful development of fish burgers, which should take into consideration the demand of the local market and abroad, availability of good quality fish, cost of raw materials, quality control and effectiveness of processing. Fish source has been identified based on the color and structural properties of the protein or the low market value of the raw material. Fish burger have been designed and preparations made taking into account the aforementioned criteria for the raw material.

In methodology, the large deformation properties of these burgers were identified using compression testing, and specific attributes were handshaken with the overall acceptability of the product on the basis of a hedonic scaling method.

Traditional fish burgers are made mostly with added starch but fail to meet consumer expectations of eating quality characteristics. Improved formulations, however, can offer a new marketing position in the area of processed fish products. Promising functional ingredients that can improve organoleptic properties include milk protein, citrus pectin and bovine gelatin. The quality of the burgers was further manipulated by introducing additional ingredients to the formulation, e.g. soya protein, κ-carrageenan, frozen vegetables and dried fruits.

In conclusion, distinctive upper and lower bounds of the values of hardness, firmness, adhesiveness and the ratio of inflectional to maximum stress were defined in relation to optimum sensory acceptability of the product.

Title	: Development of Date Confectionery
Student Name	: Amani Salim Al-Rawahi
Supervisor	: Dr. Nejib Guizani
Department	: Food Science and Nutrition

Abstract

The world production of dates is increasing year after year. The Middle East is still the biggest date producer in the world and Oman produces large amounts of dates annually. In 1999, Oman produced 281,000 tons of dates, most of that for local consumption. The need to utilize dates in a more efficient way is a must.

The Thesis undertook a new date candy development for the first time using two Omani date varieties; Khalas and Umesilla. In order to analyze the newly developed product, texture analysis was performed on the product using the Texture Profile Analysis (TPA). Umesilla date candy had higher values of hardness, firmness, and brittleness than that of the Khalas date candy except for the adhesiveness which was much lower in Umesilla date candy due to difference in physical and chemical characteristics such as: varieties of date used, moisture content, and sugar content.

Sensory evaluation was conducted on the product using Quantitative Descriptive Analysis (QDA) assessed by taste panelists. Results demonstrated that there was no significant difference between the samples in firmness, brittleness, hardness, adhesiveness, cohesiveness, springiness, and the overall acceptability. Chemical analysis was conducted on the product and the moisture, ash, crude protein, crude fiber, crude fat, gross energy, and total carbohydrates were determined. Uncooked Khalas provided 480 kcal, cooked Khalas provided 477 kcal, uncooked Umesilla provided 446 kcal, and cooked Umesilla provided 450 kcal/100 g dry matter. The four products were found to be richer in most macro-elements, but were comparatively low in microelements.

Shelf – life studies were done by running microbial tests and studying the effect of aging on microbial occurrence and on textural attributes throughout a period of 12 weeks. The total aerobic counts decreasing in all four types of date candies to reach its minimum in week 12. Same results were found when total molds count was analyzed. Coliforms were absent throughout the aging period, which had increased the safety of the products during the investigation period. During the aging period, the cooked Khalas date candy was getting harder, firmer, and more adhesive in comparison with the other types of date candy. This might be due to the concentration of sugars due to the low level of moisture

content. The latter had decreased due to the evaporation of some water. These attributes were more stable in the other three date candies. The study has also investigated the economic feasibility of these products and concluded that new investments in their production are economically sound and profitable.

In conclusion. this study was able to develop a new product using dry dates. This product has proved to be stable in its textural and sensory attributes, has a high general acceptability in taste, flavor, and texture, nutritious, safe, affordable, and could significantly contribute to the economical use of dry dates in Oman and promoting new investments in date processing. This product could be used as is for direct consumption or to be used as a filling in biscuits, wafers, or in pastries, as well as flavor for ice cream, yogurt, and cakes. Results of this study have proved that the processing dates could be utilized in the processing industry side by side with the table dates.

Title	:	Comparison of High Hydrostatic Pressure and Hot-Water Blanching Methods on Drying Kinetics and Quality Parameters of Potato
Student Name	:	Mohammed K. Al-Khuseibi
Supervisor	:	Dr. Shyam Sablani
Department	:	Food Science and Nutrition

Abstract

Drying rates and quality parameters of potato were evaluated as affected by high pressure processing and hot-water blanching. Potato (*Solanum tuberosume* L.) were used as 1.5 cm cubes. Pressure of 400 MPa was used with holding time of 15 minutes and 1% citric acid solution as immersion medium. Hot-water blanching was conducted in a boiling water for 3 minutes. Drying kinetics and quality parameters (i.e. rehydrability, texture, colour and apparent density) were assessed for the high pressure (HP) and thermally treated (TH) samples and for dehydrated samples. Drying rates were found to be higher ($p<0.05$) in the initial period of drying for the pressure treated samples. At later stages of drying, it was close to that of thermally blanched samples. Modeling of the drying data was carried out using three models. Page model was found to better fit drying data of the thermally treated samples, and Two-term model better described the drying behavior of high pressure treated samples. High pressure treated samples had a similar rehydrability as of thermally treated samples. It was found that pressure treated samples had a hardness value close to that of fresh samples, whereas thermal treatment resulted in a soft texture. After rehydration, samples of both treatments returned their texture before drying. The total colour difference (ΔE) for the thermally blanched samples was higher ($p<0.05$) than for pressure treated samples before drying and after drying. High pressure treated and dried potato cubes had a color close to that of fresh potato cubes. High-pressure treated and air-dried samples were found to have higher ($p<0.05$) apparent density than thermally treated samples.

Title	:	Pore Formation in Apple During Air Drying as a Function of Temperature
Student Name	:	Intisar Mohammed Al-Zakwani
Supervisor	:	Dr. Shafiur Rahman
Department	:	Food Science and Nutrition

Abstract

Drying rate of apple rings increased with the increase of air-drying temperature, thus indicating the possibility of crust formation at higher temperature. Characteristics of air-dried apple produced by drying at 50, 80 and 105 ^{0}C were studied by measuring true, apparent and material density, apparent and open pore porosity, and pore size distribution with helium gas pycnometer and mercury porosimetry. Apparent porosity increased with the decrease of moisture content as well as with the increase of drying temperature. Fresh apple showed negligible closed pores, whereas drying caused collapse of surface pores and consequently forming high closed pores. The shrinkage-expansion coefficient increased with the increase of drying temperature, indicating enhancement of pore formation at higher temperature. Pore-size distribution for fresh apple showed two sharp peaks, one at 5.8 μm and another one at 3.6 μm, respectively. Apple rings dried for 20 h showed only one sharp peak at 3.6 μm, and 30 h dried sample showed 3 peaks at 10, 5.8 and 3.6 μm, respectively. Hysteresis was observed in intrusion and extrusion curves due to the different path followed by extrusion curve compared to the intrusion path. Application of high pressure (0.12-414 MPa) resulted in very negligible intrusion of mercury in the sample. Fractal analysis indicated the formation of more micropores due to air drying.

Title	:	Microbial Contamination of Eggs on Sale in the Sultanate of Oman
Student Name	:	Jokha Abdullah Khalfan Al-Aamry
Supervisor	:	Dr. Ann Mothershaw
Department	:	Food Science and Nutrition

Abstract

The bacterial contamination of eggs on sale in the Sultanate of Oman was investigated. In total 520 eggs from five producers, three Omani and two overseas producers, were studied. The eggs were collected from retailers, which are using different storage temperatures. Overall, the frequency of internal contamination with Salmonella spp. was 0.2%, but reached 2% for one producer. In addition, species of Serratia, Klebsiella and Pantoea were isolated from egg contents. Staphylococcous and Micrococcus species were the most frequently isolated. In general, eggs stored at higher temperatures (30 °C) and eggs produced during the hotter months had higher bacterial counts than eggs stored at lower temperatures (10 °C) or produced during the cooler months. A positive correlation between storage period of eggs and bacterial counts was observed with eggs exceeding 80 days having higher plate counts. The effect of packaging materials on the survival of Escherichia coli showed that the Escherichia coli survived better on molded paper pulp (MPP) than expanded polystyrene (EPS).

Title	: Analysis of Plasticizers in Food Containers: Effect on Storage and Sensory Quality of Halwa
Student Name	: Muadh Salem Mohammed Al-Hinai
Supervisor	: Dr. Shyam Sablani
Department	: Food Science and Nutrition

Abstract

The objectives of the study were to carry out a general characterization as well as an investigation on plasticizers that may migrate from packaging materials into Omani Halwa.

Results have shown that out of 13 raw plastic material samples analyzed, 7 indicated the presence of plasticizers. Eight plastic packages were also analyzed; four have shown the presence of different types of plasticizers. Gas Chromatography Mass Spectrophotometer (GC-MS) was used to carry out the analysis. Plasticizers found were: bis (2-ethylehexyl) phthalate, phthalic acid, diisooctyl ester, diisooctyl adipate, dibutyl phthalate, didodecyl phthalate and di-n-octyl phthalate. On the other hand, it was found that there was no migration of plasticizers into halwa samples during the one-month of storage period at temperatures ranging from 4 to 37oC.

Results of the sensory evaluation following the triangle test showed that there was no significant difference ($P \leq 0.05$) between halwa samples packed in plastic and glass containers, separately.

The effect of storage time and conditions on physical properties of halwa, such as color and texture (adhesiveness) was studied. Results have shown that after four weeks of storage, the halwa samples stored in glass package were more adhesive than the ones packed in plastic. On the other hand, results of color analysis has shown that the overall change in color of halwa samples stored in the plastic container was higher than that of glass container.

Title	: Biomass, Phytoplankton Composition and Species Dynamics in Bandar Khayran Bay, Gulf of Oman
Student Name	: Khalid Abdullah Al-Hashmi
Supervisor	: Dr. Michel Claereboudt
Department	: Marine Science and Fisheries

Abstract

The dynamics and biomass of the Chl a and net phytoplankton (diatoms and dinoflagellates) community and their relationship to physico-chemical parameters in Bandar Khayran Bay were investigated from monthly samplings between January 22, 2001 to January 22, 2002, at 4 stations. The parameters investigated were: temperature, salinity, turbidity, dissolved oxygen, nitrite, nitrate, phosphate, and silicate.

The annual cycle of surface temperature at Bandar Khayran followed a clear cycle with maximum values during summer (34 ^{0}C) and minimum values during winter (22.5 ^{0}C). Even in summer, fluctuation of up to 8 ^{0}C was recorded over short periods of time. The water column was mostly homogenously distributed from January to May when stratification occurred with the development of a thermocline ranging from 5 m to 15 m from May to October, respectively.

In the winter, in a more homogenous water column, dissolved oxygen was distributed about evenly in the water column and ranged from 4.5 to 6.5 mg/L. With increased stratification occurring during summer, summer months showed large variations ranging from 6.88-2 mg/L but these variations decreased during July.

Nitrite concentrations at all stations ranged between 0.1 to 0.4 µM throughout the sampling periods. Nitrate concentrations ranged from 0.1 to 0.5 µM during most the study period except on February 7 when maximum concentrations ranged from 2.0 to 2.7 µM. Phosphate concentrations were at a more constant rate at 1.0 µM except for station "Out", which showed an average concentration of 3.0 µM during the months of April and May. The level of silicate at the Bay was almost steady with concentrations of about 2.0 µM, except on August 20 and September 9 when station "East" showed an increase in concentration to 2.95 and 4.5 µM, respectively. Within the Bay station "Man" behaved differently, exhibiting higher silicate concentrations at all time reaching maximum concentrations of 7.9 on July 16.

Surface Chl a remained below 1.0 µg/L throughout the sampling periods except during the period from May to September when a sharp increase in concentrations occurred. The highest concentration (3.7 µg/L) was recorded on July 16, whereas the lowest concentration at all stations (0.1 µg/L) were recorded on February 7. The profile of Chl a with depth showed that the concentrations remained below 1.0 µg/L at all depths during most of the sampling periods except from May 28 to July 16 when concentrations ranged from 3.5 to 5.0 µg/L between 5-15 m depth.

Size class fractionations revealed that picoplankton (< 2µm) dominated the entire study area throughout the year making up on average 70% of the total biomass. The peak of picoplankton biomass at all stations was recorded during July 16 to October 14. Net phytoplankton (>20µm) contributed more than 40% to the total biomass only on Jan 22, March 12 and December 26.

A total of 269 net phytoplankton taxa were identified during this study. The Dinophyta (dinoflagellates) contributed with the highest number of species (141) followed by Bacillariophyceae (diatoms) (125), Cyanophyta (cyano-bacteria) (2) and Dictyochopyceae (1). Twenty six species (4 diatoms, 20 dinoflagellates, 1 cyanobacterium and 1 dictyocha) can be considered toxic or harmful in various concentrations. Alexandrium spp, Dinophysis acumintata, Dinophysis acuta, Scripsiella trochiodea, Peridinum quinquecorne and Gymnodinium centatum are considered toxic dinoflagellat species.

Tremendous fluctuations were found in phytoplankton population densities, with a minimum density of 52 cells L-1 observed on May 8 and a maximum of 33,230 cells L-1 recorded on October 15. The diatoms flora was comprised of 65 species from the order Pennales and (53) from the order Centrales. Five genera were found to be more dominant than the others, Pleurosigma, Nitzschia, Chaetoceros, Coscinodiscus and Thalassiosira. Diatoms were minor constituents of phytoplankton populations at both “In” and ‘out” stations as compared to dinoflagellates, which made up between 60 – 95 % of the total phytoplankton. The dominant species of dinoflagellates were Prorocentrum micans, Scripsiella sp., Protoperidinium sp. and Ceratium sp. These species were presented in countable amounts throughout the sampling period.

Title	:	Studies on the Biology and Feeding Potential of the Predatory Beetle, *Menochilus sexmaculatus* Fabricius (Coleoptera: Coccinelidae)
Student Name	:	Nasr Saif Abdullah Al-Shamsi
Supervisor	:	Prof. Khaja Moh'd Azam
Department	:	Crop Sciences

Abstract

Studies on the biology and feeding potential of the predatory coccinellid, *Menochilus sexmaculatus* were carried out in the laboratory (21 ^{0}C and 68 % RH) and the greenhouse (15-25 ^{0}C and 40-70 % RH). The life cycle duration (from egg deposition until adult emergence) was 19.35 ± 1.11 days. The females lived for 90.5 ± 7.53 days, whereas the males lived for 79.75 ± 7.93 days. The egg, larval and pupal stages lasted for 4.41 ± 0.51, 9.65 ± 0.61 and 5.29 ± 0.59 days, respectively. In the greenhouse, the life cycle duration was 19.13 ± 1.36 days. The egg, larval and pupal stages lasted for 4.63 ± 0.52, 8.50 ± 0.53 and 6.00 ± 0.76 days, respectively. The larvae of *M. sexmaculatus* consumed 446.78 ± 75.95 individuals of the cucumber aphids, *Aphis gossypii,* whereas the adult females and males consumed 5891.60 ± 700.40 and 4380.83 ± 506.20 aphids, respectively. Age of larvae and adults of the predator greatly affected their feeding potential. There was a general decline in food consumption by the adults with the increase in their age. The females of *M. sexmaculatus* laid 938.89 eggs throughout their life span with 79.26 % hatching percentage. Parthenogenesis was observed in this predator but the numbers of eggs produced were negligible. Age had a negative effect on fecundity of the predator. The predator has a wide host range but the cabbage aphid, Brevicoryne brassicae was not a preferred host for it. Temperatures of 30 and 35 ^{0}C greatly increased the rate of development of different life stages of *M sexmaculatus* and thus decreased their developmental durations. However, decrease in egg hatching and larval survival were also observed within this range. The preferred range of temperature for rearing the predator was 15 to 25° C. Egg cannibalism by the larvae of *M. sexmaculatus* was noticed, and the 4th instar larvae, when starved, formed the greatest risk to the eggs. The adults of *M. sexmaculatus* lived for a shorter time when fed on bee pollen, sweetened agar and bee honey than when fed on natural food (aphids).

Title	: Study of Genetic Variations in Local Germplasm of Alfalfa (*Medicago sativa* L.) Using Random amplified Polymorphic DNA (RAPD) Technique
Student Name	: Saleh Ali Said Al-Hinai
Supervisor	: Prof. Humphrey Esechie
Department	: Crop Sciences

Abstract

This investigation was carried out to study morphological and agronomic characteristics and to estimate genetic variations of 15 alfalfa (*Medicago sativa*) accessions. Genetic diversity was analyzed using Random Amplified Polymorphic DNA (RAPD). Seeds of the indigenous alfalfa accessions were collected from different regions in Oman and sown under field conditions at Sultan Qaboos University Experiment Station in Muscat. Plants were evaluated for their height, fresh and dry matter weights for two consecutive cuts as well as their re-growth rate after the first cut.

Results showed that Sur accession was more productive with respect to green and dry matter weights either per plant or per hectare. Sohar accession had the lowest green and dry matter weights per area. Saham accession showed the highest leaf number while Al-Kamil had the lowest. Salalah accession had the highest average plant height while Sohar had the lowest.

Generally, all accessions were taller and produced higher green and dry matter weights per plant and per hectare in the second cut than in the first cut. All accessions had greater plant re-growth rate in the second week than in subsequent two weeks. They had higher plant re-growth rate in the third week than in the fourth week except for Sohar where there was a decline in re-growth rate. Bahla II and Yanquol II exhibited rapid re-growth following harvest whereas Manah accession showed low re-growth rate.

Bulked samples of genomic DNA from 24 alfalfa plants per accession were used as templates in polymerase chain reaction with different random primers to produce RAPD patterns. Using eight RAPD primers, 70 bands were scored as present or absent across the accessions. Genetic identity between accessions ranged from 0.6429 to 0.9429. The highest level of genetic diversity was between Ibri and Hamra whereas the lowest level of genetic diversity was found between Manah and Sur.

The dendogram constructed through cluster analysis illustrated seven clusters encompassing 14 accessions. Sohar did not group directly with other accession. Ibri and Dank were tightly clustered and formed a distinct branch on the dendogram.

Title	:	Clinical Picture, Haematology and Serum Biochemistry of Omani Goats Fed Low Levels of Dietary Cobalt
Student Name	:	Khalid Rasheed Saif Al-Habsi
Supervisor	:	Prof. Eugene H. Johnson
Department	:	Animal and Veterinary Sciences

Abstract

Seventy three, ten weeks old newly weaned Omani goats were randomly allocated to two groups, namely control (n= 38) and treated (n= 35). Kids in both groups were fed Rhodegrass hay ad libitum that contained less than 0.1 mg/kg Dry matter cobalt and 150 grams per day of a commercially prepared ruminant concentrate that contained approximately 0.12 mg/kg DM cobalt. This diet provided the minimum daily requirement of cobalt as specified for sheep. The treated goats were supplemented with monthly subcutaneous injections of 2000 µg of hydroxycobalamin. In order to prevent parasitic infections, all animals were treated for ectoparasites by dipping them in Gamatox solution and subcutaneously injecting them every two months during the experiment with 1% Ivermectin. All goats were weighed and blood samples collected monthly for haematolgical, clinical, biochemical and serum vitamin B12 analysis for a ten-month experimental period.

The control animals exhibited significantly ($p<0.05$) lower weight gains, pale mucus membranes and had dry scruffy hair coats. In addition, there was a decline in erythrocyte counts, mean haemoglobin level, pack cell volume, mean corpuscular volume, mean corpuscular haemoglobin and mean corpuscular haemoglobin concentration. On day 0 of the experiment, the control and treated groups had average serum vitamin B12 levels of 521.9 and 519.7 pg/ml, respectively ($p>0.05$) in all three breeds. Over the ten-month period the serum vitamin B12 values of the control animals dropped to 142 pg/ml ($p<0.05$). In contrast, the treated group, maintained levels that were not significantly different ($p>0.05$) from their values on day 0.

Control animals also exhibited significantly ($p<0.05$) lower levels of total serum proteins and elevated levels of serum alkaline phosphatase and aspartate aminotransferase compared to treated goats. Twenty two male goats slaughtered at the end of the experiment exhibited gross and histopathological evidence of hepatic lipidosis. Conclusive evidence has therefore been presented that contrary to the popular belief that goats are more resistant to cobalt deficiency than sheep that this does not apply to Omani goats.

Title	:	Effect of Date Fiber Supplemented with Exogenous Enzymes on Performance and Meat Quality of Broiler Chickens
Student Name	:	Nasser Mohammed Said Tabook
Supervisor	:	Dr. Isam Kadim
Department	:	Animal and Veterinary Sciences

Abstract

Date fiber is one of the cheap and readily available date by-products in Oman. The aim of this study was to evaluate the potential of partially replacing corn with date fiber as an alternative energy source in poultry feeds.

Date fiber had higher gross energy than corn by 8.7%, crude fiber by 75% and lower in total amino acid by 9.1%, lower in indispensable amino acid by 27.2% and higher in dispensable amino acid by 14.7%. An ileal digestibility assay using 30 birds was carried out to determine the digestibility coefficients of individual amino acids, crude fiber and apparent metabolizable energy of date fiber. Date fiber had lower digestibility coefficient than corn for dry matter (0.35 vs. 0.83), crude fiber (0.20 vs. 0.54) and apparent metabolizable energy contents (8.7 vs. 13.6). Corn had higher digestibility coefficient by 29% and 32% for indispensable and dispensable amino acid respectively than date fiber. For the most important individual amino acids for bird's performance, the date fiber had 30%, 33% and 36% less digestible methionine, threonine, and lysine respectively.

Based on the results of the preliminarily study, a growth trial was conducted in an attempt to use exogenous enzymes to improve the nutritive value of date fiber in poultry diets. Four hundred birds were divided into eight groups with10 replicates, each containing 5 birds. Three levels of date fiber (5%, 10% and 15%) with and without enzyme supplementation were evaluated. Daily feed intake, body weight gain, and feed conversion ratio were measured. At the end of the growth experiment period (42 days), 160 birds were selected randomly and slaughtered to evaluate carcass and meat quality traits, as well as measuring ileal viscosity. Substitution of corn by 10% and 15% date fiber significantly ($P<0.05$) depressed the apparent metabolizable energy. Apparent metabolizable energy utilization slightly increased as the bird grew older. Enzyme supplementation did not improve the crude fiber digestibility. The inclusion of date fiber in the diets, except at

5% decreased average daily gain, feed intake, and feed conversion ratio. Addition of date fiber caused a significantly increase ($P<0.05$) in the weights of bird's total digestive tract, pancreas and cecum. Addition of date fiber or exogenous enzyme had no significant effect on carcass or meat quality characteristics. Date fiber increased ($P<0.05$) the ileal digesta viscosity compared to the control. Addition of exogenous enzyme decreased ($P<0.05$) the viscosity of the basal diets, as where it has no effect on the date fiber containing diets. This study indicated that date fiber can be included at a level of 5% in broiler's diets without affecting broiler performance.

Title	:	Seasonal Effects on the Immune Response of Dhofari Goats
Student Name	:	Rashid Mohammed Rashid Al Busaidi
Supervisor	:	Prof. Eugene Johnson
Department	:	Animal and Veterinary Sciences

Abstract

Goats are held in large numbers in Oman and are widely appreciated for their meat. Infectious diseases are important risk factors that limit their production and increase the cost of management. The study of the caprine immune system is therefore crucial for an understanding of the host - parasite interaction in this species. Generally, It is assumed that heat stress, leads to suppression of the immune system and therefore increases the susceptibility of these animals to disease. However, based on a number of observations at the field level, it appears that morbidity and mortality figures in goats increase for a significant number of diseases during the winter months of the year versus the summer months. This study is, therefore, an attempt to investigate the effect of seasonal variations on different immune system parameters, including the bactericidal activity of caprine polymorphonuclear granulocytes (PMNs) against the target bacteria Staphylococcus aureus and the production of serum immunoglobulins. In addition, serum cortisol, total protein and hematological values were measured.

Six healthy male goats approximately one year of age were maintained together in a closed pen at the Agriculture Experimentation Station at Sultan Qaboos University for a period of one year. The goats were fed Rhodesgrass hay ad libitum and a commercially prepared ruminant concentrate. Blood samples were collected monthly for hematological, serological and cortisol analysis, as well as to study the phagocytic activity of PMNs. An automated weather station was used for meteorological monitoring of solar radiation, air temperature, relative humidity, rainfall and wind speed as well as photoperiod.

The average ambient temperature during winter (October – March) was 24± 0.3 ^{0}C versus 34 ± 0.3 ^{0}C in summer (April–September) ($P<0.05$). The photoperiod was significantly shorter in winter versus summer, 9.6 ± 0.5 and 11.3 ± 0.8, respectively. During summer, there was an increase in the level of serum IgG ($P<0.05$), and an increase in the phagocytic activity of PMNs against *Staphylococcus aureus* ($P<0.05$). Also during the summer season there were significantly lower levels ($P<0.05$) of serum cortisol (26.5 ± 2.2) than that recorded during the winter season (34.9 ± 5.1). During summer goats had higher

WBC ($P<0.05$), lymphocyte ($P<0.05$) and eosinophil counts ($P=0.05$) than during winter season. There were no statistical differences in neutrophil ($P=0.32$), monocyte ($P=0.47$) and basophil counts ($P=0.7$) between the two seasons.

The seasonal differences in phagocytic activity and levels of IgG could have been partially related to varying cortisol levels. However, it could also have been related to differing photoperiods during the two seasons. The increase in the incidence of various infectious diseases during the winter season in goats in Oman may be at least partially due to suppressed phagocytic and/or opsonisation activity.

International Collaboration

International Collaboration

International collaboration has become an important part of CAMS research initiatives. The College holds collaborative agreements through Memoranda of Understanding with many universities around the world. New links have been established with the Universities of University of Aachen for Technology, University of Reading, Harvard Medical School, Guilford Development, S.A. Company, Ecole Nationale Superiure Agronomique de Rennes of France, UAE University, University of Arizona, Glasglow Caledonian University, American University of Beirut, University of Adelaide (LOA), University of South Australia, University of Bristol, University of Bologna, University of Nottingham, Netherlands Organization for International Cooperation in Higher Education, National Centre for Oceanography, German Academic Exchange Service (DAAD) and others which have helped to raise still higher, the international profile for research excellence in the College. The CAMS faculty are involved in collaborative projects with the University of Reading, Harvard Medical School, United Arab Emirates University, University of Bologna, Italy, the University of Arizona, USA, University of Bristol, University of Nottingham, American University of Beirut and many others.

Memoranda of Understanding on Scientific Cooperation are held with the following Scientific Organizations:

No.	Organization	Type of Cooperation	Extent of Benefit
1.	University of Aachen for Technology	Assistance in establishing new academic programs Consultancy and research Short courses and master program Teaching staff mobility	None
2.	University of Reading	Consultancy and research	Dept of Animal and Veterinary Sciences proposed a research project titled: "Enhancing Nutritive Value of Feedstuff in Sultanate of Oman."
3.	Harvard Medical School	Research Exchange of academic staff or researchers for lecturing and conducting seminars Education and the exchanges of students and scholars	None

No.	Organization	Type of Cooperation	Extent of Benefit
4.	Guilford Development, S.A. Company	Cover expenses and overhead costs (40%) of SQU project	The Company agreed Dr. P. Cookson to be provided press and publicity statements and attend one or more press conferences relating to the project.
5.	Ecole Nationale Superiure Agronomique de Rennes of France	Travel fund, living expenses and health insurance for a student to undertake up to six months study on fisheries development in Oman Cover research costs at RO 1,200 for the project study of French student	Provided advice and joint supervision in a project suitable for a French student, Mr. Antoine Philippe Anne in SQU
6.	UAE University	Consultancy and research collaboration	Control of Indian red date palm weevil and heat stress in animals research collaboration
7.	University of Arizona	Teaching and training Collaborative research Technical assistance	Service agreement with the University of Arizone (Dr. Salim Al-Rawahy)
8.	Glasglow Caledonian University	Educational collaboration	Establishment of an educational program in food technology
9.	American University of Beirut	Teaching Research Outreach programs	Collaboration in aquaculture
10.	University of Adelaide (LOA), South Australia	Encourage research of mutual interest with support of external funding Staff and student exchanges Exchange information and research publications	Visit by a representa-tive from the LOA to CAMS
11.	University of Bristol	Research collaboration	Research project collaboration with Department of Soil and Water Sciences about soil and tree nutrition that grows under severe stress and produce highest quality Frankincense resin.

No.	Organization	Type of Cooperation	Extent of Benefit
12.	University of Bologna	Research collaboration	Molecular characterization of phytoplasmas
13.	University of Nottingham	Research collaboration Teaching	Joint research project with Food Science and Nutrition and Crop Sciences Departments. The FSN Dept project is: "Characterization and Physiochemical Measurements of the Structural Properties of High Solids Food Products
14.	Netherlands Organization for International Cooperation in Higher Education	Develop academic exchange Scientific cooperation	None
15.	National Centre for Oceanography	Scientific and research cooperation	AD-PGSR expressed an interest to establish cooperation with Iranian institution
16.	German Academic Exchange Service (DAAD)	Scholarships Scientific cooperation	Visit by a delegation from the DAAD to CAMS. Organized marine resource workshop

Publications in 2004

Publications in 2004

Fifty refereed journal publications were recorded for the year 2004. Figure 1 highlights the number of refereed publications for the period 1994-2004. This represents published refereed journal papers only, and excludes manuscripts in press, accepted or prepared at present.

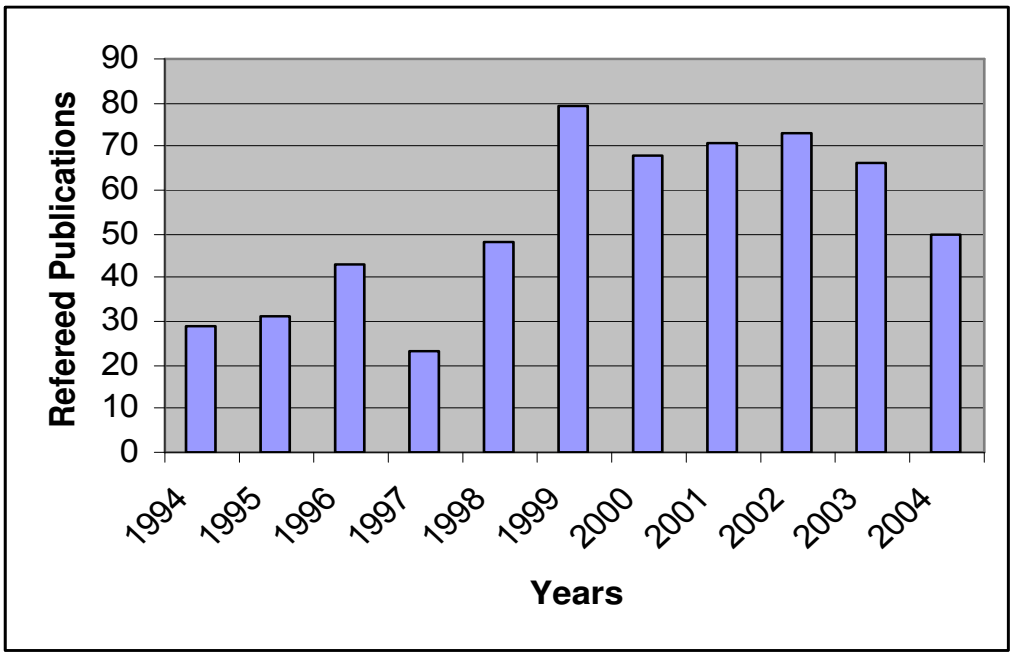


Figure 1. Number of refereed journal publications from CAMS over the past 11 years.

Also published in the year 2004, were 1 book, 6 book chapters, 53 conference proceedings, 11 abstracts, 3 papers presented in local workshops/seminars, 5 popular articles, 2 reports, 2 on-line reports, 1 manual and 3 PhD dissertations.

Refereed Journals

1. Abdel Rahman, H.A. and H.S. Al-Wahaibi. 2004. Water use efficiency and yield of irrigated cucumber (*Cucumis sativus* L.) under greenhouse and field conditions in Oman. *SQU Journal for Scientific Research – Agricultural and Marine Sciences* 9 (2):31-41.
2. Al-Bulushi. I.M. 2004. Inedible fish (in Arabic). *Al-Bia-Wal-Tanmia* (Lebanon) 9(78):56-58.
3. Al-Haddabi, M., M. Ahmed, A.R. Kacimov, S. Rahman, S. Al-Rawahy. 2004. Impact of treated wastewater from oil extraction process on soil physical properties. *Communications in Soil Science and Plant Analysis* 35(5):751-758.
4. Ali, A. and M.H. Akhtar. 2004. Food safety and chemical contaminants: An overview. *SQU Journal for Scientific Research - Agricultural and Marine Sciences* 9(2):43-50.
5. Al-Masroori, H., H. Al-Oufi, J.L. McIlwain and E. McLean. 2004. Catches of lost fish traps (ghost fishing) from fishing grounds near Muscat, Sultanate of Oman. *Fisheries Research* 69:407-414.
6. Al-Oufi, H. 2004. Heterogeneity and efficiency in a coastal fishery: The case of the artisanal fishery in Al-Batinah Region, Sultanate of Oman. *Pakistan Journal of Social Sciences* 2(2): 122-126.
7. Al-Oufi, H., E. McLean, A.S. Kumar, M. Claereboudt and M. Al-Habsi. 2004. The effects of solar radiation upon breaking strength and elongation of fishing nets. *Fisheries Research* 66:115-119.
8. Al-Rawahy, S.A., H.A. Abdel Rahman and M.S. Al-Kalbani. 2004. Cabbage (*Brassica oleracea L.*) response to soil moisture regime under surface and subsurface point and line applications. *International Journal of Agriculture and Biology* 6:1560-8530.
9. Al-Saady, N. A., K. A. Torbert, L Smith, I. Makarevitch, G. Baldridge, R. J. Zeyen, G. J. Muehlbauer, N. E. Olszewski and D. A. Somers. 2004. Tissue specificity of the Sugarcane Bacilliform Virus promoter in oat, barley and wheat. *Molecular Breeding* (14):331-338.
10. Al-Zadjali, A., E.H. Johnson and A. Srikandakumar. 2004. Serum vitamin B_{12} levels in Omani goats. *Tropical Animal Health and Production*. 36:473-482.
11. Ampratwum, D., A. Dorvlo and L.U. Opara. 2004. Usage of tractors and field machinery in agriculture in Oman. *Agricultural Engineering International: the CIGR Journal of Scientific Research and Development*. (Invited Overview Paper). 6:1-9.

12. Claereboudt, M.R. 2004. Shore litter along sandy beaches of the Gulf of Oman. *Marine Pollution Bulletin* 49:770-777.
13. Claereboudt, M.R. and I. Al-Amri. 2004. *Calathiscus tantillus*, a new genus and new species of scleractinian coral (Scleractinia, Poritidae) from the Gulf of Oman. *Zootaxa* 532:1-8.
14. Claereboudt, M.R., H.S. Al-Oufi, J.L. McIlwain, and J.S. Goddard 2004. Relationships between fishing gear, size frequency and reproductive patterns for the kingfish (*Scomberomorus commerson*, Lacepede) fishery in Oman. In Management of Shared Fish Stocks. Payne, A.I.L., C.M. O'Brien and S.I. Rogers, S.I. (Eds). Oxford, Blackwell, 56-67.
15. Easter, W. and S. Zekri. 2004. Reform or irrigation management and investment policy in African development. *South African Journal of Economic and Management Sciences* 7(4):652-663.
16. Goddard, S., H. Al-Oufi and L. Opara. 2004. Tilapia culture: Farmers participate in Oman research. *Global Aquaculture Advocate* 7(6):33-34.
17. Goosen, M.F.A., S.S. Sablani, H. Al-Hinai, S. Al-Obeidani, R. Al-Belushi and D. Jackson. 2004. Fouling of reverse osmosis and ultrafiltration membranes. *Separation Science and Technology* 39:2261-2297.
18. Ishaq, M., M. Usman, M. Asif and I.A. Khan. 2004. Integrated pest management of mango against mealy bug and fruit fly. *International Journal of Agriculture and Biology* 6(3):452–454.
19. Johnson, E.H., J. Windsor and C.C. Graham. 2004. Emerging from Obscurity: Biological, clinical and diagnostic aspects of *Dientamoeba fragilis*. *Clinical Microbiology Reviews* (Invited Review Paper) 17:553-570.
20. Johnson, E.H., K. Al-Habsi, E., Kaplan, A. Srikandakumar, I.T. Kadim, K. Annamalai, R. Al-Busaidi and O. Mahgoub. 2004. *Caprine hepatic lipidosis* induced through the intake of low levels of dietary cobalt. *Veterinary Journal* 168:174-179.
21. Kacimov, A.R. 2004. Capillary fringe and unsaturated flow in a reservoir porous bank. *Journal of Irrigation and Drainage* (ASCE) 130:403-409.
22. Kacimov, A.R. 2004. Discussion of "Hydraulically Efficient Power-Law Channels" by Arif A. Anwar and Tonny T. de Vries. *Journal of Irrigation and Drainage* (ASCE) 130:445-446.
23. Kacimov, A.R., Y.V. Obnosov, J. Perret. 2004. Phreatic surface from a near-reservoir saturated tongue. *Journal of Hydrology* 296:271-281.
24. Kadim, I.T., O. Mahgoub, A. Srikandakumar, D.S. Al-Ajmi, R.S. Al-Maqbaly, N.M. Al-Saqri and E.H. Johnson. 2004. Comparative effect of low levels of dietary cobalt and parenteral injection of vitamin B_{12}

on carcass and meat quality characteristics in Omani goats. *Meat Science* 66:837-844.
25. Kadim, I.T., O. Mahgoub, D.S. Al-Ajmi, D.S. and R.S. Al-Maqbaly. 2004. The Influence of season on quality characteristics of hot-boned beef M. *longissimus thoracis*. *Meat Science* 66:831-836.
26. Kasapis, S., H. Al-Oufi, S. Al-Maamari, I. Al-Bulushi and S. Goddard. 2004. Scientific and technological aspects of fish product development. Part I: Handshaking instrumental texture with consumer preference in burgers. *International Journal of Food Properties* 7:(3):449-462.
27. Khan, I.A. and J.W. Grosser. 2004. Regeneration and characterization of somatic hybrid plants of *Citrus sinensis* (sweet orange) and *Citrus micrantha,* a progenitor species of lime. *Euphytica* 137(2):271-278.
28. Mahgoub, O, I.T. Kadim, N.M. Al-Saqri and R.M. Al-Busaidi. 2004. Effects of body weight and sex on carcass tissue distribution in goats. *Meat Science* 67(4):577-585.
29. Mahgoub, O. and C.D. Lu. 2004. Effects of various levels of metabolizable energy on chemical composition of whole carcass and non-carcass portion of goats and sheep. *South African Journal of Animal Science* 34:81-84.
30. Mahgoub, O., I. T. Kadim, D.S. Al-Ajmi, N.M. Al-Saqry, A.S. Al-Abri, A.R. Ritchie, A.S. Al-Halhali and N.E. Forsberg. 2004. Use of local range tree (*Prosopis spp.) pods* in feeding sheep and goats in the Sultanate of Oman. *Options Méditerranéennes. Serie A: Séminaires Méditerranéennes, Numéro* 59:191-195.
31. Mahgoub, O., I.T. Kadim, N.M. Al-Saqry, D.S. Al-Ajmi, A.S. Al-Abri, A.R. Ritchie, K. Annamalai and N.E. Forsberg. 2004. Effects of replacing Rhodes Grass (*Chloris gayana*) hay with Ghaf (*Prosopis cineraria*) pods on performance of Omani native sheep. *Tropical Animal Health and Production* 36(3):281-294.
32. Mahmud, I., A. Hossain, S. Hossain, A. Hannan, L. Ali, and M. Hashimoto. 2004. Effects of (*Hilsa ilisa*) fish oil on the atherogenic lipid profile and glycemic status of streptozotocin-treated type 1 diabetic rats. *Clinical and Experimental Pharmacology and Physiology* 31:76-81.
33. Marcotte, M., S.S. Sablani, S. Kasapis, O..D. Baik and P. Fustier. 2004. Thermal kinetic parameters of starch gelatinization in the presence of other cake ingredients. *International Journal of Food Science and Technology* 39: 807-810.
34. Mothershaw, A.S. and T. Jaffer. 2004. Antimicrobial activity of foods with different physico-chemical characteristics. *International Journal of Food Properties* 7(3):629-638.

35. Omezzine, A., H. Al-Oufi and Y. Al Akhzami. 2004. The marketing system of fresh fish products on Masirah Island in the Sultanate of Oman: A comprehensive re-assessment. *Marine Resource Economics* 9:407-416.
36. Opara, L.U. 2004. Emerging technological innovation triad for smart agriculture in the 21st century. Part I. Prospects and Impacts of Nanotechnology in Agriculture. Invited Overview Paper. *Agricultural Engineering International: The CIGR Journal of Scientific Research and Development* 6:1-27.
37. Opara, L.U. 2004. Outlook for agricultural engineering education and research and prospects for developing countries. *Outlook on Agriculture* 34(1):101-112.
38. Opara, L.U., S.S. Al-Adawi and T.Y. Al-Shukeili. 2004. Students' perceptions of Agricultural Engineering education at Sultan Qaboos University in Oman. Part 2: Curriculum content and career preferences. *World Transactions on Engineering and Technology Education 3*(1):143-146.
39. Opara, L.U., S.S. Al-Adawi and T.Y. Al-Shukeili. 2004. Students' perceptions of aricultural egineering education at Sultan Qaboos University in Oman. Part 1: Academic program selection. *World Transactions on Engineering and Technology Education 3*(1):139-142.
40. Rahman, F.B., E.K. Chowdhury, S. Hossain, A. Hannan, S.R. Alim, S.U. Shekhar, L. Ali, A. Rahman, and I. Mahmud. 2004. Effect of pangas fish oil on atherogenic factors in diabetic rats. *Bangladesh Journal of Life Science*. 16(1):61-69.
41. Rahman, M.S, N. Guizani and M.H. Ruzeiki. 2004. D- and Z-values of microflora in tuna mince during moist-heating and dry-heating. *Lebensm.-Wiss. U.-Technology (Food Science and Technology)* 37(1):93-98.
42. Rahman, M.S. 2004. State diagram of date flesh using differential scanning calorimetry (DSC). *International Journal of Food Properties* 7(3):407-428.
43. Rauf, S, M. Usman, B. Fatima, T.M. Khan and I.A. Khan. 2004. *In Vitro* Regeneration and multiple shoot induction in upland cotton (*Gossypium hirsutum* L.). *International Journal of Agriculture and Biology* 6(4):704–707.
44. Sablani, S.S., S. Kasapis, M.S. Rahman, A. Al-Jabri and N. Al-Habsi. 2004. Sorption isotherms and state diagram for evaluating stability of dried abalone. *Food Research International* 37:915-924.
45. Srikandakumar, A. and E.H. Johnson. 2004. Effect of heat stress on milk production, rectal temperature, respiratory rate and blood

chemistry in Holstein, Jersey and Australian milking Zebu cows. *Tropical Animal Health and Production* 36:658-692.
46. Srikandakumar, A., E.H. Johnson, H. Nsanzi and K.S. Al-Abri. 2004. Microbes and anti-microbial substances in pasteurised milk sold in Oman. *International Journal of Food Properties* 7:615-627.
47. Wille, K., R. Jain, E. McLean, J.S. Goddard, E.J. Kaplan and H. Leven. 2004. Flatbed scanning as a novel approach for examining lipid distribution in fish: comparison with MRI and traditional chemical methods. *International Journal of Recirculating Aquaculture* 5:1-17.
48. Youngs, E.G., A.R. Kacimov, and Y.V. Obnosov. 2004. Water exclusion from tunnel cavities located in the saturated capillary fringe with uniform precipitation flowing to a waterbearing substratum. *Advances in Water Resources* 27:237-243.
49. Zaibet, L., H. Boughanmi, T. Al-Hinai and A. Al-Marshudi. 2004. Internationalization of Oman fisheries firms after the European Union Ban. *SQU Journal for Scientific Research - Agricultural Sciences* 9(2):1-6.
50. Zaibet, L., S. Dharmapala, H. Boughanmi, O. Mahgoub and A. Al-Marshudi. 2004. Social changes, economic performance and development: The case of goat production in Oman. *Small Ruminant Research* 54:131-140.

Book

1. Tamraz, J., C. Outin, M. Forjaz Secca and B. Soussi. 2004. Principes d'Imagerie par resonance magnetique de la téte, de la base du crane et du rachis. Approche anatomo-clinique et guide d'interprétation. 2ieme ed., Springer Verlag, Paris 2004. ISBN: 2-287-59742-5.

Book Chapters

1. Ahmed, M., D. Hoey, W. Shayya, and M.F.A. Goosen. 2004. Brine disposal from inland desalination plants: current status, problems, and opportunities. *Published in Volume II of Environmental Sciences and Environmental Computing (Electronic Book Series).* EnviroComp Consulting, Inc. CA 94539, USA.
2. Claereboudt, M.R.G., H.S. Al-Oufi, J. McIlwain and J.S. Goddard. 2004. Relationships between fishing gear, size frequency and reproductive patterns for the kingfish (*Scomberomorus commerson* Lacépède) fishery in the Gulf of Oman. In: *Management of Shared Fish Stocks,*

A.I.L. Payne, C.M. O'Brien and S.I. Rogers (Editors), 56-67. Oxford; Blackwell.
3. Rahman, M.S. 2004. Dehydration. In: *Encyclopedia of Life Support Systems*. UNESCO and EOLSS Publishers, Oxford.
4. Rahman, M. S. 2004. Food preservation. In: *Encyclopedia of Life Support Systems*. UNESCO and EOLSS Publishers, Oxford.
5. Rahman, M. S. 2004. Mechanical properties of foods. In: *Encyclopedia of Life Support Systems*. UNESCO and EOLSS Publishers, Oxford.
6. Rahman, M.S., Sablani, S.S. 2004. Thermal processing. In: *UNESCO Encyclopedia of Life Sustaining Systems,* UNESCO and EOLSS publishers. Oxford.

Conference Proceedings

1. Abbas, M., M. M. Khan, S. M. Mughal, Jafar Jaskani and I.A. Khan. 2004. Propagation of Kinnow mandarin by microbudding for multiplication of CTV free plants. *10th International Citrus Congress*, 15-20 February 2004, Morocco.
2. Ahmed, M., S.A. Prathapar, A. Al-Jamrah, A. Al-Maskri and A. Al-Belushi. 2004. Greywater reuse in arid countries: problems and possibilities. *Proceedings of the 2nd APHW Conference in Singapore*, July 5-9, 2004, pp 517-525.
3. Ahmed, M., H. Esechie and A. Al-Ajmi. 2004. Biosaline Agriculture: Perspectives from Oman. *Presented at a Workshop on Biosaline Agriculture.* 27-30 June, Wageningen, The Netherlands.
4. Ahmed, S.I., B.J. Zahuranoc and H.S. Al Oufi (Editors). 2004. *Proceedings of the U.S. Oman Workshop, Prospects and Opportunities for Marine Living Resources Development in Oman.* 7-11 February 2004, Muscat, Oman.
5. Ahmed, S.I., H.S. Al-Oufi and K.A. Al-Hashmi. 2004. An overview of the dynamics of marine living resources of Oman: sustainable development and rational utilization and management. *Proceedings of the U.S. Oman Workshop, Prospects and Opportunities for Marine Living Resources Development in Oman.* 7-11 February 2004, Muscat, Oman.
6. Al Saadi, A.M., I.A. Khan, and M.L. Deadman. 2004. Economic impact of witches' broom disease on lime production in Oman. *Proceedings of the 10th International Citrus Congress 2004*, Agadir, Morocco, February 2004.
7. Al-Azri, A. 2004. The importance of DOC in the marine environment: lessons learned from the Menai Strait waters. *Proceedings of the U.S. Oman Workshop, Prospects and Opportunities for Marine Living*

Resources Development in Oman. 7-11 February 2004, Muscat, Oman.

8. Al-Jufaili, S. 2004. A preliminary investigation on the Omani sardines and anchovies stocks oscillations; recommendations for future studies. *Proceedings of the U.S. Oman Workshop, Prospects and Opportunities for Marine Living Resources Development in Oman*. 7-11 February 2004, Muscat, Oman.
9. Al-Masroori, H. 2004. Trap ghosts fishing in Oman. *Proceedings of the U.S. Oman Workshop, Prospects and Opportunities for Marine Living Resources Development in Oman*. 7-11 February 2004, Muscat, Oman.
10. Al-Oufi, H.S. 2004. The fisheries co-management experience; challenges and prospects. *Proceedings of the U.S. Oman Workshop, Prospects and Opportunities for Marine Living Resources Development in Oman*. 7-11 February 2004, Muscat, Oman.
11. Al-Saadi A.M., I.A. Khan and M.L. Deadman. 2004. Economic losses caused by witches' broom disease of lime and some management aspects in Shinas area of Oman. *10th International Citrus Congress*, 15-20 February 2004, Morocco.
12. Al-Saady, N.A., M.S. Al-Mahruqi, A.M. Al-Sibhi and A.J. Khan. 2004. Molecular characterization of tomato yellow leaf curl virus from field grown tomatoes in Oman. *Association Francaise Des Protection Des Plantes*, 8-19 December 2004, Dijon, France.
13. Al-Shihi, R. 2004. Potential of Omani marine living resources for bioprospecting. *Proceedings of the U.S. Oman Workshop, Prospects and Opportunities for Marine Living Resources Development in Oman*. 7-11 February 2004, Muscat, Oman.
14. Claereboudt, M.R. 2004. Coral communities in the Sultanate of Oman, state of knowledge. *Proceedings of the U.S. Oman Workshop, Prospects and Opportunities for Marine Living Resources Development in Oman*. 7-11 February 2004, Muscat, Oman.
15. Deadman, M.L., H. Al Hasani and K. Al Kiyoomi. 2004. Biofumigation and other non-chemical methods for the control of soil-borne diseases in greenhouse crops in Oman. *6th Congress of the Spanish Society for Ecological Agriculture.* Almeria, Spain, September 2004, p. 78.
16. Goddard, S. 2004. Utilizing fisheries by-catch in aquafeeds. *Proceedings of the U.S. Oman Workshop, Prospects and Opportunities for Marine Living Resources Development in Oman*. 7-11 February 2004, Muscat, Oman.
17. Gunnarsson, G., I. Undeland, A. Lindgård, A. Sandberg and B. Soussi.2004. The effect of herring muscle press juice on the

generation of reactive oxygen species from human monocytes stimulated with phorbol myristate acetate. Invited lecturer, *34th WEFTA Annual Meeting,* Lübeck, Germany, 12-15 September.

18. Gunnarsson, G., I. Undeland, A. Lindgård, A. Sandberg and B. Soussi.2004. The effect of herring muscle press juice on the generation of reactive oxygen species from human monocytes. Invited lecturer, Livsmedelsforskardagarna I Goteborg, 15-16 November.
19. Iqbal, S. S., Al-Zadjali, J., Ali, A., Obeid, O. 2004. Dietary habits of Sultan Qaboos University Students. *Poster Presentation at 2nd Arabian Conference on Nutrition* held in Bahrain 7-9 December 2004.
20. Jamrah, A., Al-Futaisi, S.A. Prathapar, M. Ahmad and Ali Al Harasi. 2004. Evaluating greywater reuse potential for sustainable water resources management in the Sultanate of Oman. *International Conference on Water Demand Management*. Dead Sea. Jordan.
21. Kacimov, A.R., Y.V. Obnosov, and E.G. Young. 2004. New analytical solutions in tension-saturated and saturated flows around cavities. *Proceedings of XVII International School on Continuum Mechanics*. 4-10 July 2004, Kazan, Kazan Mathematical Society Press, pp 229-232.
22. Kadim, I.T. and O. Mahgoub. 2004. Camelidae genetic resources: Report on three Arabian Gulf Countries. *34th ICAR Session and INTERBULL Meeting*. May 28-June 2004, Sousse-Tunisia.
23. Khan, A.J. and A.M. Al-Subhi. 2004. Production of polyclonal antibodies against alfalfa phytoplasma. *American Phytopathological Society (NEPD*), 6 – 8 October, 2004, State College, PA, USA.
24. Khan, A.J., N.A. Al-Saadi, and A.M. Al-Subhi. 2004. Development of polyclonal antibodies against alfalfa witches' broom pathogen, phytoplasma. *Association Francaise Des Protection Des Plantes,* December, 8–19, 2004, Dijon, France.
25. Khan, I.A., R.F. Lee, J.W. Grosser and J. Hartung. 2004. Screening selected germplasm for resistance to witches' broom disease of lime. *10th International Citrus Congress*, 15-20 February 2004, Morocco.
26. Mahgoub, O., I. Kadim, I. Al-Amri and A.A. Ambu Ali. 2004. Assessment of fibre types in Omani native sheep wool using Electron microscopy. *Oman's 1st Electron Microscopy Conference.* SQU, Muscat, Oman, March 2004.
27. Mahgoub, O., I.T. Kadim, A. Mothershaw, S.A.,Al Zidjali, K. Annamalai and F.A. Al-Mibsili. 2004. Chemical composition and quality attributes of meat from native and imported goats slaughtered at the central slaughterhouse in the Sultanate of Oman. *Proceedings of the 8th International Conference on Goats.* July 2004, Pretoria, South Africa.

28. Mahmud, I. 2004. Fish oil and its affect on atherogenic factors and glycemic Status in Streptozotocin - treated Diabetic rats. In: *The 4th ANRAP International Seminar* held in Kolkata, India, January 16-18, 2004.
29. McIlwain, J. Marine fisheries research at SQU: 1999-2003. *Proceedings of the U.S. Oman Workshop, Prospects and Opportunities for Marine Living Resources Development in Oman.* 7-11 February 2004, Muscat, Oman.
30. McLachlan, A. and M.R. Claereboudt. 2004. Coastal ecology of Oman. *Proceedings of the U.S. Oman Workshop, Prospects and Opportunities for Marine Living Resources Development in Oman.* 7-11 February 2004, Muscat, Oman.
31. Opara, L.U. 2004. The past and future of agricultural engineering (Invited Paper). *Proceedings of the Workshop on Agricultural and Bioresources Engineering,* 29 October 2004, University of Nigeria, Nsukka, 27 pages.]
32. Opara, L.U. 2004. Is academic advising an 'academic exercise' or a pragamatic response to institutional commitment? – Experiences at a New Zealand University. *Proceedings of a Symposium on Academic Advising*, 6-7 April 2004, Sultan Qaboos University, Muscat, Oman. 1-22 pages.
33. Opara, L.U. 2004. Microstructure and function in fresh food crops. *Poster Presented at Oman's 1st Electron Microscope Workshop*, 6-9 March, Sultan Qaboos University, Sultanate of Oman.
34. Opara, L.U. 2004. Linking farmers to markets through improvement of postharvest practices - Global trends and future prospects. *Paper Presented at a Seminar on Postharvest Technology,* University of Dar es Salaam, Tanzania, 6 February.
35. Opara, L.U. 2004. Postharvest industry development in Tanzania – An overview. *Paper Presented at a Seminar on Postharvest Technology,* University of Dar es Salaam, Tanzania, 6 February.]
36. Prathapar, S.A, A. Jamrah, M Ahmed, S Al Adawi, S Al Sidairi and A. Al Harassi. 2004. An objective evaluation of treated greywater reuse in Oman. *Waste Water Conference*, Muscat, Oman.
37. Prathapar, S.A, A. Jamrah, M Ahmed, S Al Adawi, S Al Sidairi and A Al Harassi. 2004. Overcoming constraints in treated greywater reuse in Oman. *Environmental Risk Assessment*, Cairo, Egypt.]
38. Prathapar, S.A, J.S.M. Perret and D. Seckler. 2004. Bypassing silt deposition in recharge dams with DARE: Drain Accelerated Recharge. *Regional Conference on Artificial Recharge*, Iran.]

39. Prathapar, S.A, J.S.M. Perret and D. Seckler. 2004. Bypassing silt deposition in recharge dams with DARE: Drain Accelerated Recharge. *Environmental Risk Assessment*, Cairo, Egypt.
40. Prathapar, S.A. 2004. Sustainable ecosystems with subsurface evaporation basins. *SEA-KKU Conference*, Thailand.
41. Prathapar, S.A., M Ahmed, S. Al Adawi and S. Al Sidairi. 2004. Variation in quality and quantity of greywater produced at two mosques in Oman. *International Wastewater Conference*, Salalah, Oman.]
42. Rahman, M. S. 2004. Prediction of pores in foods during processing: from regression to knowledge development from data mining (KDD) approach. *Proceeding of International Congress on Engineering and Food* (ICEF 9) held in Montpellier, France, 7-11 March 2004.
43. Sablani, S.S., S. Kasapis, M.S. Rahman, A. Al-Jabri, and N. Al-Habsi. 2004. Sorption isotherms and state diagram for evaluating stability criteria of abalone. *Proceeding of International Congress on Engineering and Food* (ICEF 9) held in Montpellier, France, 7-11 March 2004.
44. Sablani, S.S. 2004. Role of drying in determining nutritional/functional quality of food and biomaterials, *International Workshop and Symposium on Industrial Drying*, Mumbai, India, 20-23 December 2004.
45. Sablani, S.S. 2004. Simplified solutions for inverse heat conduction problems using neural networks, *International Congress on Engineering and Food*, Montpellier, France, March 7-11.
46. Sablani, S.S., S. Kasapis and M.S. Rahman. 2004. Dried food products: evaluating stability criteria, *International Workshop and Symposium on Industrial Drying*, Mumbai, India, 20-23 December 2004.
47. Sablani, S.S., M.S. Rahman, N. Al-Habsi, R. Al-Belushi, M. Al-Ruzeiqi, O. Mahgoub, and A. Al-Marzouki, A. 2004. Drying of fish and seafood. *Poster Presentation. CAMS Fisherman's Day*, 13 April, 2004.
48. Saeed, T., M. Usman, M.M. Khan, B. Fatima and I.A. Khan. 2004. Recovery of spontaneous polyploids in citrus. *10th International Citrus Congress*, 15-20 February 2004, Morocco.
49. Soussi, B. 2004. Recent advances in clinical and experimental MR Spectroscopy. Invited lecturer, *Joint Scientific Meeting of the Lebanese Society of Radiology & Pan Arab Neuroradiology Society*, Beirut, 16-18 September.
50. Soussi, B. 2004. Understanding the brain mMetabolism by MR Spectroscopy. Invited lecturer, *Joint Scientific Meeting of the Lebanese Society of Radiology & Pan Arab Neuroradiology Society*, Beirut, 16-18 September.

51. Soussi, B. 2004. MRS as a tool in clinical neuroscience. Invited lecturer*, Joint Scientific Meeting of the Lebanese Society of Radiology & Pan Arab Neuroradiology Society*, Beirut, 16-18 September.
52. Soussi, B. 2004. Evaluation of antoxidative capacity of herring (*Clupea Harengus*) light muscle press juice. Invited lecturer, *The 1st International Congress on Antioxidant Test Methods,* Orlando, USA, 16-18 June.
53. Tageldin, M.H., E.H. Johnson, R.M. Al-Busaidi and I. Al-Amri. 2004. Caprine arthritis encephalitis virus (CAEV) in Omani goats: An ultrastructural study. *Oman's 1st Electron Microscopy Conference.* March 2004, SQU, Oman.

Abstracts

1. Abbas, M., M.M. Khan, S.M. Mughal, J. Jaskani and I.A. Khan. 2004. Propagation of Kinnow mandarin by microbudding for multiplication of CTV free plants. *10th International Citrus Congress*, 15-20 February, Morocco.
2. Al-Oufi, H. and Y.K. Al-Akhzami. 2004. Experiences with Fisheries Co-management in the Sultanate of Oman. *The 12 Biennial Conference of the International Institute of Fisheries Economics and Trade (IIFET),* Tokyo, Japan, July 26-29, 2004. p 54.
3. Al-Saadi A.M., I.A. Khan and M.L. Deadman. 2004. Economic analysis of losses caused by witches' broom disease of lime. *10th International Citrus Congress*, 15-20 February, Morocco.
4. Kacimov A.R., Y.V. Obnosov, M.M. Sherif and J. Perret. 2004. Seawater intrusion problem:mathematical models versus field studies. *Abstracts of the International Conference "Algebra and Analysis".* Proc. Lobachevsky Mathematical Center, Kazan Mathematical Society Press, V.23, 112.
5. Khan, I.A., R.F. Lee, J.W. Grosser and J. Hartung. 2004. Screening selected germplasm for resistance to witches' broom disease of lime. *10th International Citrus Congress*, 15-20 February, Morocco.
6. Khan, I.A., T. Al-Mandhari, M.J. Jaskani, M.I. Ahmad and K.A. Al-Habsi. 2004. Multivariate analysis of nursery performance of citrus rootstocks in Oman. *10th International Citrus Congress*, 15-20 February 2004, Morocco.
7. Mumtaz, S., M.M. Khan, M. Abbas and I.A. Khan. 2004. Studies on the morphology of Kinnow mandarin and Feutrell's early. *10th International Citrus Congress*, 15-20 February, Morocco.

8. Obnosov, Y.V. and A.R. Kacimov. 2004. Design of ultimately stable slopes of earthworks. *Abstracts of the International Conference on Advanced Problems in Mechanics.* Institute of Applied Mechanics, Sanct-Petersburg, 81.
9. Opara, L.U. and Y.S. Senani. 2004. Postharvest handling systems and incidence of fresh produce losses in the Sultanate of Oman. Book of Abstracts, *APEC Symposium on Quality Management in Postharvest Systems,* Aug 3-5, Radisson Hotel, Bangkok, Thailand, p. 32.
10. Opara, L.U. 2004. Postharvest innovation, value-addition and prices of fresh produce: trends at supermarket level in Australasia and the Arabian Gulf. Book of Abstracts, *APEC Symposium on Quality Management in Postharvest Systems,* August 3-5, Radisson Hotel, Bangkok, Thailand, p. 53.
11. Saeed, T., M. Usman, M.M. Khan, B. Fatima and I.A. Khan. 2004. Recovery of spontaneous polyploids in citrus. *10th International Citrus Congress*, 15-20 February 2004, Morocco.

Papers Presented in Local Workshops/Seminars

1. Boughanmi, H. 2004. Intersectoral growth linkages: A social accounting matrix approach. *University Research Day*, SQU, Oman.
2. Mothershaw, A., N. Guizani and J.A. Al-Aamri. 2004. Prevalence of Salmonella in/on eggs in the Sultanate of Oman. *SQU University Day.*
3. Rahman, M.S. 2004. Opportunities to add value to Omani primary produce. *Workshop on Strengthening MAF-SQU Collaboration*, 20-21 December, 2004, Sultan Qaboos University, Muscat.

Popular Articles

1. Abdullah Al-Ghafri, 2004, Aflaj irrigation systems (first published on the Newsletter No. 12, 2002 then it was posted on the website of the INPIM on March 2004).
2. Ahmed, M. 2004. Brine disposal: problems and opportunities (Cover story). *Horizon* 24, SQU Publication, Oman.
3. Goddard, S.J, H. Al-Oufi and L. Opara. 2004. Tilapia Culture: Farmers Participate in Oman Research. *Global Aquaculture Advocate*. 7(6):33-34.
4. Khan, I.A. 2004. Improving vegetable production in Oman. *Horizon* 30:4, SQU Publication, Oman.

5. Rahman, M. S., Al-Kharusi, N. 2004. Date coffee? Potential of date pits: functionality and health benefits. *Horizon* 35:5, SQU Publication, Oman.

Reports

1. Al-Futaisi, A., A. Al-Jamrah and M. Ahmed. 2004. Final Report. Evaluation of clay content and investigation of Boron adsorption to clays in Nimar fields formation-Phase I. Submitted to PDO, Oman.
2. Rahman, M.S., M. Ahmed and X. Chen. 2004. Final Report. Assessment of the innovative freezing-melting process for desalination of seawater. MEDRC, Muscat, Oman.

On-Line Reports

1. Al-Bahry, S., A.E. Elshafie, and M. Deadman. 2004. First report of *Ganoderma* colossus on *Delonix regia* in Oman. *New Disease Reports*, July 2004, www.bspp.org.uk/ndr/july2004/2004-38.asp
2. El Shafie, A., S. Al Bahri, A. Al Saadi, A. Al Raeesi, Y. Al Maqbali and M. Deadman. 2004. First report of *Ganoderma colossus* on *Ficus altissima* in Oman. *New Disease Reports*, July 2004, www.bspp.org.uk/ndr/july2004/ 2004-37.asp

Manual

1. Mothershaw, A.S. 2004. Food Inspection and Change Management for HND students. Muscat Municipality.

Ph.D. Dissertations

1. Al-Ghafri, A. 2004. Study on water distribution management of Aflaj irrigation systems of Oman. Ph.D. Dissertation, Hokkaido University, Japan.
2. Al-Ismaily, S.S. 2004. Nitrogen mineralization of manure-amended soil: Effects of salinity and moisture content. PhD. Dissertation, The University of Arizona. Tucson, AZ, USA.

3. A. Al Mahruki. 2004. The application of reed bed technology for treating oil production waters and the associated chemical and biological processes. Ph.D. Dissertation, The University of Reading, UK.