IRT funded project

Project 1: Combating lifestyle diseases associated with over-nutrition through the use of indigenous South African foods

The burden of chronic diseases in southern Africa is enormous. Rapid urbanisation coupled with rising incomes has led to a growing urban adult population in the region.

The inevitable results of this have been poor dietary choices and low levels of physical activity leading to the increasing prevalence of overweight and obesity. These have become the drivers for increased occurrences of chronic diseases of lifestyle such as cardiovascular disease, Type-2 diabetes, certain cancers and collectively, the Metabolic Syndrome.

Indigenous plant materials are currently utilised by the food industry in the manufacturing of various food products. Importantly, what needs to be known is whether the potential functional biomolecules – such as phenolic compounds and bioactive peptides – present in the raw material are physiologically available after processing and the ultimate digestion of the food products.

Many health claims about the alleged benefits of food products are made without the necessary scientific evidence. South Africa's new labelling regulations require claims to be supported by solid research and evidence. The IFNuW research will develop a scientific approach and a set of methodologies to help evaluate the potential health claims of such Functional Foods.

Provide scientific evidence

In the long term innovation and development strategies will be implemented to assist local and international food companies to develop healthy indigenous foods with proven beneficial effects.

The main aim is to provide scientific evidence for the potential health-promoting properties of indigenous commercially produced South African foods. Among the objectives are:

- To identify and characterise useful biomolecules/bioactive compounds from indigenous South African food products;
- To determine the potential health benefits of these bioactive compounds in-vitro and in-vivo (animal studies) to show proof of concept and thus potential efficacy in humans;
- To determine the efficacy of these functional biomolecules in humans through an intervention study.

Wide-ranging outcomes

The outcomes and outputs envisaged for the project are wide-ranging. The primary outcome is a clear demonstration of proof of concept and provision of scientific evidence for health-promoting properties of bioactive compounds in indigenous South African foods.

In addition to publications in international peer-reviewed journals, other expected outcomes will include generation of data and information on the following:

- Secondary metabolite profile of foods (e.g. sorghum-cowpea composite porridges, South African honeys) before and after in vitro enzymatic digestion
- Effect of extracts from foods on the proliferation of cancer cells in vitro and induction of phase II detoxification enzymes

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- Identification and characterisation of ACE-inhibitory peptides in foods as an index of potential anti-hypertensive properties

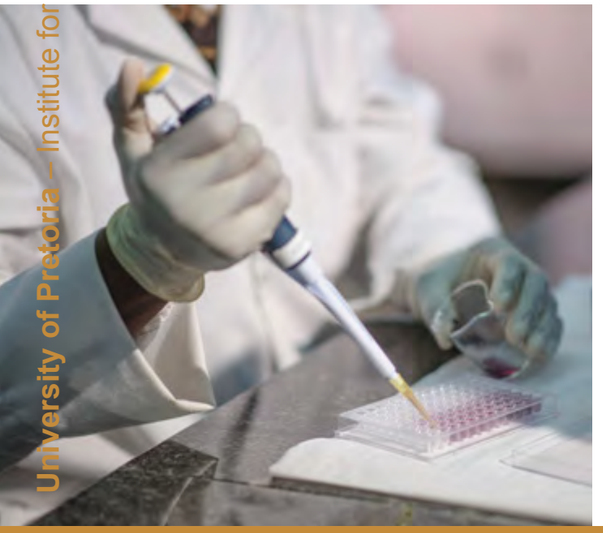
At the early stage of the research it has already determined that honey from the Fynbos region of the Western Cape has similar antioxidant activity similar or even greater than that of well-known, health-promoting manuka honey from New Zealand. Bioactive peptides with ACE-inhibitory activity are found in mageu, a non-alcoholic fermented maize-based beverage. ACE-inhibitors are the active component in many pharmaceuticals used in the treatment of hypertension and congestive heart failure.

A highlight has been the identification of tannin-like compounds in these foods, specifically procyanidin B in cowpea varieties with high phenolic content. This has important implications for their antioxidant activity and potential health benefits.

Consolidating research

The research contributes to achieving the vision of the IFNuW to be a leading international centre of excellence in trans-disciplinary research and post-graduate training.

The team brings together researchers from three faculties namely, Natural and Agricultural Sciences, Health Sciences and Veterinary Sciences. It has been able to extend and consolidate the research and collaboration between the Departments of Anatomy, Biochemistry and Food Science. A next step will be to take advantage of a Memorandum of Understanding between the UP and the Massey University in New Zealand to further extend research collaboration across disciplines and institutions.



The scientific depth of the project will be expanded through utilising diverse cell tissue culture models and animal models for in vivo studies. Additionally, as phytochemical components of foods are not restricted to phenolics and bioactive peptides there are opportunities to study other targeted bioactive compounds.

It is envisaged that the project will also be expanded to study other plant-based foods of importance in Africa such as the pseudocereals and indigenous green leafy vegetables.

An essential component will be working closely with rural communities, bringing in the expertise of social scientists and economics researchers. This will strengthen the trans-disciplinary effectiveness of the project.

Project leader

Prof Kwaku Gyebi Duodu holds a PhD in Food Science and is Associate Professor of Food Chemistry and Food Engineering in UP's Food Science Department. His research focus area is "*Health-promoting African foods and beverages*" in which several interrelated topics are being researched, including:

- Combating conditions and diseases associated with overnutrition such as metabolic syndrome, certain cancers, Type-2 diabetes and cardiovascular diseases with African foods;
- The effect of novel food processing technologies on health-promoting properties of legume-based foods.

Since 2003, Prof Duodu has acted as supervisor or co-supervisor of 16 master's and doctoral students who have completed their degrees. He has been the main author or co-author of 30 articles in international peer-reviewed journals and five book chapters. Prof Duodu is a member of the editorial board of the *Journal of Food Composition and Analysis* and holds a C3 rating from the National Research Foundation.

Email: gyebi.duodu@up.ac.za

Team members:

- Prof John Taylor - Department of Food Science (UP Faculty of Natural and Agricultural Sciences);
- Prof Amanda Minnaar - Department of Food Science (UP Faculty of Natural and Agricultural Sciences);
- Prof Elna Buys - Department of Food Science (UP Faculty of Natural and Agricultural Sciences);
- Prof Megan Bester – Department of Anatomy (UP Faculty of Health Sciences);
- Dr Anabella Gaspar – Department of Biochemistry (UP Faculty of Natural and Agricultural Sciences);
- Prof Zeno Apostolides – Department of Biochemistry (UP Faculty of Natural and Agricultural Sciences);
- Prof Vinny Naidoo – Director of the UP Biomedical Research Unit.

Students supported by the project:

- Mr Franklin Apea Bah – PhD student (funded by IRT)
- Ms Ilrienne du Plessis – MSc student (Funded by IRT)
- Ms Alice Nderitu – PhD student (Supported by USAID Dry Grains and Pulses CRSP Project)
- Ms Twambo Hachibamba – PhD student (Supported by USAID Dry Grains and Pulses CRSP Project)
- Ms Eugenie Kayitesi – PhD (Part supported by USAID Dry Grains and Pulses CRSP Project)
- Ms June Serem – PhD student (Supported by Dept Anatomy as a member of staff)
- Dr Oluyemisi Adelakun – Post-doc Fellow (Funded by Vice-Chancellor's Post-Doctoral Fellowship Award)

Project partners:

- National Research Foundation (NRF) Incentive Funding for Rated Researchers
- USAID Dry Grains and Pulses CRSP Project

Postgraduate students of the Department of Food Science and Department of Human Nutrition who are working on IFNuW projects and Prof Duodu. Standing from left: Marina Bester, Franklin Apea Bah (PhD), Ilrienne du Plessis (MSc) and Wura Falade (PhD). Seated: Carmen Van Niekerk and Prof Gyebi Duodu

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Project 2: Combating malnutrition through meals prepared from bio-fortified indigenous and African grains and leafy vegetables

Indigenous South African foods – most notably grains and leafy vegetables – offer opportunities to diversify farming activities ensure food security and alleviate poverty. It can provide income to emerging farmers and improve the health of consumers.

Such crops are adapted to local conditions and tolerant to harsh environmental conditions. Many rural South Africans consume these products and they form part of the country and the region's rich traditional heritage.

African leafy vegetables form part of the daily staple diet of many communities and are rich in nutrients, such as iron and vitamin A. Currently most of the crops are wild harvested and few are cultivated.

Positive impact on nutrition

The cross-cutting research project initiated by the IFNuW will determine whether the consumption of indigenous African plant foods, prepared in the form of meals, impact positively on the nutritional status of children under five years of age.

The intended outcome of the research is to develop a composite flour of sorghum and soy, which will be easily made or acquired, and used as the porridge base for an infant complementary food.

The flour composite of sorghum and cowpea has been successfully made. The research team is now preparing the laboratory to do the nutrient availability from the composite as well as from the cooked cowpea leaf and finally, the production of the whole meal.

A scientific paper was published in a peer-reviewed publication, *Food Chem 2012; 131 (1):* Kruger J., Taylor JRN., Oelofse A. *Effects of reducing phytate content in sorghum through genetic modification and fermentation on in-vitro iron availability in whole grain porridges.*

The project has been expanded to include analyses in collaboration with Prof M Smuts from North West University (NWU)and a student from NWU will visit UP for training in technique.

Project leader:

Prof Andre Oelofse is an Associate Professor in the Department of Human Nutrition in the Faculty of Health Sciences at the University of Pretoria.

His primary research interest lies with infant and young child nutrition and health. He has conducted and published on numerous studies assessing the nutritional and health status of vulnerable infants in different communities in both South Africa and other developing

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countries. He has also been working on the potential contribution of indigenous foods to the nutrient and health status of young children. This work has culminated in a comprehensive report on the nutritional value of indigenous green leafy vegetables to alleviate malnutrition. Nutrients of particular interest to his work are Vitamin A, iron and zinc.

Prof Oelofse has initiated work on assessing the bioavailability of key nutrients (Vitamin A, iron and zinc) through human cell line models in collaboration with international partners. He holds an MSc from Stellenbosch University and a PhD from Wageningen University in the Netherlands. Prior to joining the UP he was employed by the Nutrition Intervention Research Unit of the Medical Research Council.

Email: andre.oelofse@up.ac.za

Team members:

- Prof John Taylor – Department of Food Science (UP Faculty of Natural and Agricultural Sciences);
- Prof Megan Bester - Department of Biochemistry (UP Faculty of Health Sciences);
- Dr Zelda White - Department of Human Nutrition (UP Faculty of Health Sciences);
- Prof Paul Rheeder – School of Public Health (UP Faculty of Health Sciences);
- Prof Sheryl Hendriks – Director of the Institute of Food, Nutrition and Well-being (University of Pretoria);
- Prof Amanda Minnaar – Department of Food Science (UP Faculty of Natural and Agricultural Sciences);
- Prof Gyebi Duodu – Department of Food Science (UP Faculty of Natural and Agricultural Sciences);
- Prof Mario Ferruzzi – Department of Nutrition Science (Purdue University, USA)

Students supported by the project*:*

- Ms N Vilakati (PhD)
- Mr A Adetunji (PhD)
- Dr J Kruger (Postdoctoral fellow)

Project partners:

- South African Sorghum Forum (stakeholders and research funding forum)
- SA Agricultural Research Council: Grain Crops Institute (Dr Nemera Shargie); Vegetable and ornamental plant institute VOPI (Dr Yacob Beletse and Mr Willem Janse van Rensburg)
- Medical Research Council MRC: Prof Mieke Faber
- Pannar Seeds South Africa (Mr Dries Booyens)
- Africa Biofortified Sorghum Project (Africa Harvest Biotechnology Foundation International, Dr Florence Wambugu, Pioneer Hi-Bred International Dr Marc Albertsen)
- HarvestPlus Foundation (Dr Fabiana de Moura) and UC Davis (Prof Bo Lonnerdal), and Purdue University (Prof Bruce Hamaker and Prof Mario Ferruzzi)
- ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) Nutriplus Programme (Dr Kiran Sharma)
- INTSORMIL (International Sorghum, Millet and Other Grains Collaborative Research Program and Texas A&M University, USA (Profs Gary Peterson and Dirk Hays)
- Dry Bean and Pulse Collaborative Research Support Program and Prof Maurice Bennink, Michigan State University, USA

Project 3: Protein- and starch-based nano- and micro-biomaterials from local African plant sources for improved nutrition, health and well-being

Indigenous South African foods – most notably grains and leafy vegetables – offer opportunities to diversify farming activities ensure food security and alleviate poverty. It can provide income to emerging farmers and improve the health of consumers.

African grains such as sorghum and teff contain biopolymers with unique properties, which can be utilised to produce biomaterials to combat obesity and can alleviate lifestyle diseases such as Type-2 diabetes and cardiovascular conditions.

There is a growing demand for biopolymers made from natural materials in the nutrition, healthcare, medical and cosmeucetical fields. Biopolymers are polymers – or large molecule structures – produced by living organisms. A problem, however, is that current bioplastic materials made from such biopolymers are inferior in functional properties compared to synthetic plastics.

Natural biopolymers have exciting potential as a “green technology” in South Africa with a wide range of potential applications in food production, nutrition, controlled drug release, re-vegetation and soil restoration following mining activities.

The research has already led to the development of a novel process to make plant-protein-based microparticles, called KEMS. The process for making the KEMS has been patented in South Africa, Europe, the United States of America and China.

Improve the properties

The project sets out to understand at the molecular level how cereal prolamin protein polypeptides self-assemble into various structures, including: microspheres, nanoparticles, fibrils, bioplastic films, membranes and doughs, and how to manipulate the process of self-assembly to improve the functional properties of these structures.

Among its other objectives are:

- Developing protein-based biomaterials for encapsulation of nutrients and nutraceuticals;
- Understanding the functionality of amylose-lipid nanomaterials as a fat mimetic or “replacer” in food products such as mayonnaise, margarine and cheese analogues;
- Developing bi-component protein-starch biomaterials with excellent functional properties by combining prolamin microspheres with amylose-lipid complexes.

New processes

The research has resulted in a new, patented, process to make plant protein-based microparticles

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(microspheres), also known as KEMS. The KEMS have a novel structure, including an extremely large surface area and useful functional properties, such as water-insolubility, hydrophobicity, non-allergenicity and slow degradation by mammalian proteolytic enzymes.

The KEMS can be made into high quality bioplastic films and membranes. These properties enable the KEMS to be used for encapsulation to allow delayed or controlled release of the core material, which may be bio-active molecules, drugs, nutraceuticals or food ingredients.

The research has shown that when starch is wet-heat processed for a prolonged period in the presence of endogenous or added lipid it exhibits uniquely high viscosity paste properties. Using X-Ray Defraction and Differential Scanning Calorimetry the team recently demonstrated that these unique viscosity characteristics are related to the formation of crystalline amylose-lipid complexes, also known as V-amylose.

In addition, the research team has developed a novel process for isolating these starch-lipid complexes, with only food grade chemicals used, and the time taken for isolation is less than six hours. The viscosity characteristics and low calorific value of the starch-lipid complexes indicate that they have great potential as fat replacers in foods.

Some of the research findings have already been published in peer-reviewed scientific journals and applications for patents have been granted, or are pending, in a number of international jurisdictions.

Green technology

The project is unique in its trans-disciplinary nature, bringing together experts across four university faculties to jointly create a platform for the “green technology” of biopolymers.

The focus is both novel and highly relevant, utilising the unique properties of the biopolymers of African grains such as sorghum and teff to improve the health and well-being of South Africans. It has significant potential to address the problem of obesity in society which can alleviate lifestyle diseases such as Type-2 diabetes and cardiovascular conditions.

Because of the non-allergenic nature of the biomaterials, they have potential as “natural scaffolds” for the repair and regeneration of soft and hard tissue, for the treatment of burns and possibly to combat degenerative diseases such as osteoporosis.

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Project leaders

- **Prof John Taylor (see profile on page 53)**

Dr Mohammad Naushad Emmambux is a senior lecturer in UP’s Food Science department. He teaches food chemistry, cereal science and food rheology. His research deals with the science and technology of carbohydrate-based food biopolymers, with a focus on food nanotechnology. He has specific expertise in the isolation, characterisation, modification and application of indigenous African grain starches in food and non-food systems. A highlight is that Dr Emmambux and his research team have successfully isolated starch nanomaterials from indigenous African cereal grains. They have shown that these nanomaterials have considerable potential as low kilojoule fat replacers in foods and as nanofillers in bioplastic films. His research is also focused on ‘in situ’ modification of starches with food-friendly chemicals for low GI foods.

Dr Janet Taylor holds a PhD in Food Science from the University of Pretoria and is a Research Officer in the Department of Food Science. In addition to research, her responsibilities include the co-supervision of postgraduate students both at a master’s and PhD level. Her main research interests are in the functional properties of plant protein based bioplastics and biomaterials, with specific interest in the prolamin proteins of sorghum and maize. She has authored and co-authored a number of papers in international peer reviewed journals on various aspects of sorghum prolamin protein digestibility and as biomaterials and this work has been presented at numerous

Project 4: Nutritional exposure and environmental sustainability of animal product intake in South Africa and fatty acid profile of South African animal products

The most recent data from the South African National Health and Nutrition Examination Survey (SANHANES-1) indicates that many South African children under 14 years of age are stunted with increasing rates of overweight and obesity observed.

These continue to co-exist with persistent vitamin A and iron deficiencies in children. The majority of South African adults, and especially women, are overweight or obese, while many women also suffer from the consequences of micronutrient deficiencies, i.e. anaemia and vitamin A deficiency. South Africa is experiencing the Nutrition Transition – the paradox of persistent under-nutrition and increasing incidence of overnutrition – together with high reported values of household food insecurity. Addressing this huge nutrition challenge requires a new paradigm.

The typical diets of South African families are heavily dependent on maize meal and brown bread as staple foods. These diets are often nutritionally first limiting in lysine, iron and vitamin B12. However, even a small amount of animal products could significantly complement the nutritional value of meals comprising these staple foods.

On the other side of the malnutrition scale, the overconsumption of food, and specifically animal products that are high in saturated fatty acids and cholesterol have been linked to overweight, obesity and subsequent diseases of lifestyle. Although the production of livestock has increased in developing communities, under-nutrition, including insufficient consumption of protein and other nutrients, remains a persistent problem. Nutrient composition, bioavailability and digestibility within the food matrix need to be interpreted. Additionally, correct and accurate intake data are required to determine human dietary exposure. To meet this need, we are developing appropriate tools to gather the relevant information.

Comprehensive database:

This will result in a comprehensive database on the nutrient composition of animal food products, to formulate evidence-based guidelines and policies for consumption by South Africans.

The broad aim of the project is to determine the nutrition-sensitivity and sustainability of livestock production and consumption in South Africa. The data gathered will contribute to evidence-based alignment of relevant health, agricultural, food system and educational policies, programmes and frameworks.

The project focuses on two specific issues:

- Nutritional exposure and environmental sustainability of animal product intake in South Africa:
  - Determining the contribution of animal products to the exposure of nutrients and anti-nutrients of South Africans;
  - Determining how the nutrient

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international and national conferences. She is also the co-author (with Prof John Taylor) of a series of International Association for Cereal Science and Technology Sorghum Grain Quality Standards. These standards are widely used in the sorghum industry.

Team members:

- Dr Johan Labuschagne – UP Department of Chemical Engineering
- Prof Vinny Naidoo – UP Biomedical Research Centre
- Prof Michael Pepper – UP Institute for Cellular and Molecular Medicine
- Prof Suprakas Ray - Centre for Nano-structured Materials, CSIR
- Prof Marlena Kruger - Institute of Food, Nutrition and Human Health, Massey University, New Zealand and Extraordinary Professor, UP Department of Human Nutrition
- Dr Stuart Johnson - School of Public Health, Curtin University, Australia

Students supported by the project:

- Ms Alex Sly (MSc student) – Industry funded
- Ms Malory Links (MSc student) – National Research Foundation (NRF) and industry funded
- Ms Thabeleng Maphalla (MSc student) – NRF funded
- Ms Juliet Muronzwa (MSc student) – INTSORMIL funded
- Mr Prelen Moodley (MSc student) – Winter Cereals Trust funded
- Ms Adeliwura Falade (PhD student) – UP Institutional Research Theme (IRT) funded
- Mr Welday Teklehaimonot (PhD student) – IRT funded
- Mr Mohammed Mustafa (PhD student) – UP funded
- Dr Joseph Anyango (Postdoctoral fellow) – UP funded
- Dr Obiro Wokadala (Postdoctoral fellow) – UP funded

Project partners:

- AFGRI Animal Feeds
- Blue Sky Venture Partners

From left to right: Ms Malory Links, Ms Wuru Falade, Mr Joseph Anyango, Ms Thabelang Maphalla, Ms Memory Chawafambira, Mr Fidelis Ocloo, Ms Alex Sly, Mr Welday Tekiehaimanot and Ms Charity Magwenzi

Front Row: Prof John Taylor and Dr Janet Taylor

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IRT and RMRD funded

contribution of red meat relates to the impact of the production of red meat on the environment.

- The fatty acid profile of South African animal products as a source of natural bio-active components
    - Developing a national database on the total fat and fatty acid profile of South African animal products;
    - Research and capture of available fatty acid data generated in prior research on South African animal products at the University of Pretoria.
    - Analysis of the fatty acid profile of selected South African animal products, including lamb, mutton, beef, goat, veal, dairy products and poultry.

Important insights:

During the initial project stages the research team produced a visual book of meat portions and three questionnaires designed to target three different income groups participating in the survey. The project was then rolled-out among low-income communities in five districts in rural Limpopo and in Gauteng among middle-income groups.

The first results already provide important insights into consumer behaviour and preferences. Middle-income consumers preferred to consume animal products on a daily basis. A relatively high consumption of take-away food was observed. Participants in the survey indicated that they receive the bulk of their information about red meat from TV, family and friends, with the most trusted information sources being family, doctors, dieticians and friends.

Among low-income communities no correlation was found between livestock ownership and households' average monthly expenditure on animal protein foods. This suggests that households would rather purchase animal protein foods from retail channels, despite limited budgets, than consuming their own reared livestock.

Valuable lessons were learnt from the survey and will be applied to improve further actions within the larger consumer research project.

A database master sheet was developed in collaboration with the South African Medical Research Council to determine the fatty acid composition of South African animal products and an analysis of data is currently underway.

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Well-balanced diet

Good nutrition consisting of an adequate and well-balanced diet, combined with regular physical activity is considered a cornerstone of good health. Agricultural production provides the food – and nutrients – to the food supply chain and, increasingly, the nutrition-sensitivity and sustainability of agricultural and food systems are being investigated globally.

The project will provide researchers and decision-makers with current evidence-based insights on the consumption patterns of animal products by low, middle and high income communities as well as a database of the fatty acid composition of South African animal products.

Red meat plays a critical role in the diet of most South Africans and it is often regarded as a central food in dietary patterns. The impact of red meat consumption on the nutrition and health status of the national population needs to be determined including its contribution to the daily requirements of specific nutrients.

The project should be expanded by:

- Increasing the representation of consumers from all three income groups;
- Expanding the database to include other nutrients and anti-nutrients;
- Identifying gaps in knowledge which need to be further investigated resulting in an evidence-based alignment of the red meat industry.

Project leaders:

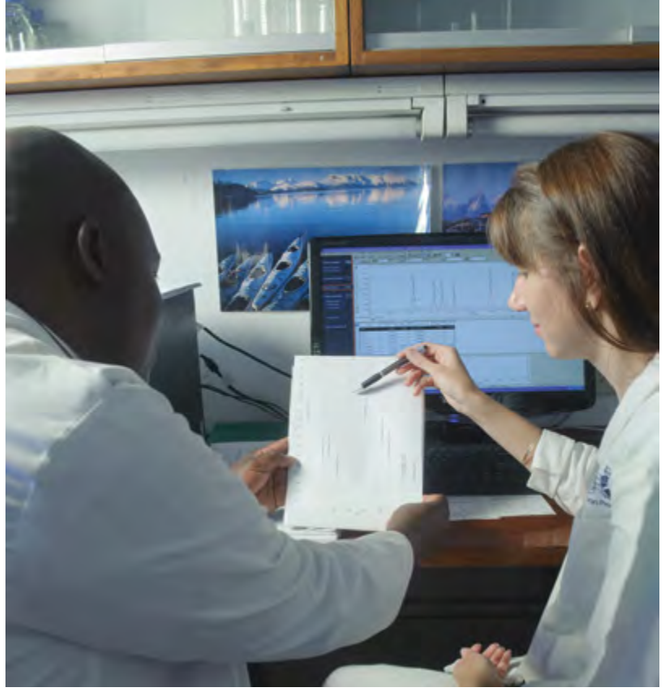
Professor Hettie Schönfeldt is a NRF C-rated researcher and a registered Natural Scientist (nutritionist and food scientist) and mentor in the fields of human nutrition and food composition. She is a Professor Extraordinaire in the Faculty of Natural and Agricultural Sciences, Department of Animal and Wildlife Sciences and an Associate of the Institute of Food, Nutrition and Well-being.

Under her guidance 25 post graduate students have received their degrees and has published

more than 60 contributions in numerous international journals and books, 117 technical reports for industry and more than 130 contributions to conferences.

She has been part of the Faculty of International Training Courses being held worldwide, including participation on the Advisory Board for the Production and Use of Food Composition Data in Nutrition Courses. She was chief rapporteur for the Food and Agriculture Organization (FAO) of the United Nations Expert Consultation on Protein Requirements for Human Health, as well as being part of the evaluation team of the FAO's work in Nutrition. Prof Schönfeldt was recently invited by the United Nations Systems Standing Committee on Nutrition (UNSCN) to perform a descriptive review of food and agricultural policies in South Africa to encourage discussion on nutrition-sensitive agriculture.

Email: hettie.schonfeldt@up.ac.za



Prof Eddie Webb is Head of the Department of Animal and Wildlife Sciences at the University of Pretoria. A graduate of the University he completed his postdoctoral studies at the University of Ghent in Belgium and Nutreco in The Netherlands on aspects of fatty acid synthesis in ruminants and growth modelling.

He has been President of the South African Society of Animal Science since 2008 and deputy-editor of the *SA Journal of Animal Science*. He also serves on the editorial board of *Small Ruminant Research*.

Prof Webb served on the organising committee and as special editor of the International Conference for Meat Science and Technology held in Cape Town in 2008. He is a member of the advisory committee on meat science research for the Agricultural Research Commission and was the chairperson of the scientific committee of the 8th International Congress on Goats.

During his career Prof Webb has published 72 papers in peer-reviewed scientific journals, delivered 85 papers at international conferences and participated as guest lecturer at international symposia and universities.

He holds a C-rating from the NRF and has mentored eight PhD and 33 master's students. Prof Webb is registered, professionally, with the SA Council for Natural and Scientific Professions, the SA Association for Professional Animal Scientists and the SA Society for Animal Science.

Email: edward.webb@up.ac.za

Team members:

- Prof Gerry E Swan – Dean Faculty of Veterinary Sciences;
- Prof Johann Kirsten – – Department of Agricultural Economics, Rural Development and Agricultural Extension (UP Faculty of Natural and Agricultural Sciences);
- Dr Beulah Pretorius – Department of Animal and Wildlife Science (UP Faculty of Veterinary Sciences);
- Mrs Nicolette Hall – Department of Animal and Wildlife Science (UP Faculty of Veterinary Sciences);
- Mrs Hester Vermeulen – Department of Agricultural Economics, Rural Development and Agricultural Extension (UP Faculty of Natural and Agricultural Sciences);
- Prof Una MacIntyre – Department of Human Nutrition (UP Faculty of Health Sciences);
- Dr Gerrie du Rand – Department of Consumer Science (UP Faculty of Natural and Agricultural Sciences);
- Dr Annemarie Viljoen – Department of Consumer Science (UP Faculty of Natural and Agricultural Sciences);

Students supported by the project:

- Mr Oliver Mwale (PhD student) – supported by IRT
- Ms Nicolette Hall (PhD student) – supported by Red Meat Research and Development (RMRD SA)
- Ms Innike Rajput (PhD student)
- Ms Marina Bester (MSc student)
- Ms Leandi Bain (M student)
- Ms Alizia Alison(M student)

Project partners:

- Red Meat Research and Development (RMRD SA)

Front from left to right: Dr Annemarie Viljoen, Mr Oliver Mwale, Prof Edward Webb and Prof Hettie Schönfeldt

Back from left to right: Dr Beulah Pretorius, Ms Carmen van Niekerk, Ms Nicolette Hall and Ms Marina Bester

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IRT and MRC funded project

Project 5: Effects of food components and bioactives on murine and human bone cells

Osteoporosis, the most commonly occurring bone disease, is the leading cause of serious morbidity and functional loss in the elderly. This disease is considered a major public health problem in the Western world with an increasing prevalence in the developing world.

The World Health Organisation (WHO) lists osteoporosis as one of the major diseases that needs to be reduced as the loss of quality of life is considerable and often results in complete dependency on healthcare systems and care takers. There are concerns that despite the existence of management guidelines for osteoporosis only a few patients currently receive preventative drugs. It is of the utmost importance that drug-based prevention and treatment must be preceded by changes in lifestyle and nutrition.

Nutrients with the proven potential to support bone health and reduce bone loss include long chain polyunsaturated fatty acids, phytoestrogens and polyphenols. This project investigates whether selected long chain polyunsaturated fatty acids derived from plant and animal sources and bioactives, including phytoestrogens and polyphenols found in soy beans and local teas such as rooibos and honeybush affect the biological activity of bone cells in vitro.

Support public health

The acquired knowledge can be applied to in vivo bone research and may support public health initiatives towards the prevention and treatment of bone diseases such as osteoporosis.

The primary objectives are:

- To investigate the effects of food components and bioactives on cell proliferation in murine osteoblast (MC3T3-E1) and monocyte (RAW 264.7) cell lines;
- To investigate the effects of the various food components and bioactives on:
  - osteoclast formation in RAW 264.7 murine monocytes and CD14+ human monocytes;
  - TNF-alpha secretion in differentiating osteoclasts;
  - bone resorption by visualisation of pit formation on synthetic bone-analogue plates and bone slices;
  - the levels of osteoclast markers such as cathepsin K, MMP-9 and TRAP in cell lysates by Western blotting;

Secondary objectives are:

- To determine if the antioxidant and anti-inflammatory activities of black, rooibos and honeybush teas have a beneficial effect on murine and human osteoblasts and osteoclasts function;
- To identify the bioactive components contributing to these antioxidant and anti-inflammatory effects specifically related to murine and human osteoblast and osteoclast functioning;

Beneficial effects

The research is investigating the possible beneficial effects of rooibos tea compounds on bone cell functioning in vitro. We are also

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establishing the antioxidant content of the tea. Rooibos tea extracts, prepared from both fermented and unfermented leaves, were applied to RAW 264.7 murine macrophages. Results showed no significant effect of the teas on cell proliferation. Both types of rooibos tea showed high antioxidant content which may in part explain the protective effects of the teas on bone in vitro.

We are establishing the optimal experimental conditions to determine whether selected polyunsaturated fatty acids in combination with the phytoestrogens genistein and daidzein synergistically inhibit osteoclast formation and bone resorption. The effects of arachidonic acid and docosahexaenoic acid on osteoclast formation and bone resorption in the CD14+ human monocyte cell line are being determined.

This project contributes to knowledge on how deficiencies in nutrition, particularly fatty acid deficiency, may affect human health. The information can be used to help design and create new functional foods that will deliver high value nutrition and support skeletal health.

The participation of international researchers with strong backgrounds in nutrition and health supports international visibility and is helping to build the UP as a centre of human health research.

Studies will focus on the effects of polyunsaturated fatty acids in combination with the phytoestrogens on osteoclastogenesis. The project will also be expanded to include research into the effects of the bioactives in human CD14+ osteoclast precursors. In contrast to work using murine precursor cells as model, CD14+ precursor cells purified from human peripheral blood mononuclear cells has direct relevance to human health. Long-term objectives include investigation into the cellular pathways that the compounds may act upon when modulating osteoclast formation and activity.

Project leaders

Dr Magdalena Coetzee is a senior lecturer in UP's Physiology Department. She completed a BSc Hons at the Potchefstroom University of Higher Education in 1978 and started her career as a Physical Science school teacher while continuing with post-graduate studies. In 1981 she joined the Catholic University of Leuven, Belgium to do preliminary research for her MSc degree.

She was appointed as lecturer in the Department of Physiology in 1996 and completed a PhD *'Differential effects of arachidonic acid and docosahexaenoic acid on cell biology and osteoprotegerin synthesis in osteoblast-like cells'* in 2005. In this study, osteoblast-like cell models were used to investigate mechanisms of action of polyunsaturated fatty acids on bone cell functioning.

Dr Coetzee is co-author of a number of research publications and acts as supervisor for post-graduate students. She made research visits to various international facilities including the Department of Medical Sciences, Uppsala University Hospital, Sweden; Nordic Bioscience, Herlev, Denmark; and the Institute of Food, Nutrition and Human Health, Massey University, New Zealand.

Email: magdalena.coetzee@up.ac.za

Prof Marlena Kruger is Professor of Nutritional Physiology, Deputy Head of the Institute of Food, Nutrition and Human Health (IFNHH) and Director of Research for the College of Health at Massey University, New Zealand.

She obtained a PhD in 1986. After completing a six month's science exchange through the German Academic Exchange Service (DAAD) she progressed to a three year postdoctorate in Biochemistry at the University of Texas, Austin, USA. She joined UP's Physiology Department in 1991, and subsequently set up a bone research laboratory with the focus on fatty acids and bone health.

She joined Massey University in 2000, as Senior Scientist at the IFNHH, where her role was to help establish bone research at the university. She was appointed Associate Professor in 2002, Director of the Division of Human Nutrition and Member of the Executive of IFNHH in 2005, and was also promoted to her current position as Chair of Nutritional Physiology in 2005. She took on the role of Director of Research for the College of Health in 2013. Prof Kruger was appointed as extraordinary professor in Human Nutrition at the University of Pretoria in 2012.

Professor Kruger has over 95 publications in international peer reviewed journals. Her current research focus is nutrition and bone health with an emphasis on dairy foods, polyphenols and lipids.

Email: M.C.Kruger@massey.ac.nz

Team members:

- Prof Megan Bester (Department of Anatomy, UP);
- Prof Annie Joubert (Department of Physiology, UP);
- Prof Kwaku Gyebi Duodu (Department of Food Science, UP);
- Ms Gerda Gericke (Department of Human Nutrition, UP);

Students supported the project:

- Mr Abe Kasonga (MSc student, UP staff),
- Ms Sumari Marais (MSc student, UP staff)
- Ms Shaakirah Moosa (BSc Honours student, NRF supported)

Project partners:

- South African Medical Research Council;
- National Research Foundation.

From left to right: Dr Vishwa Deepak, Prof Marlena Kruger, Dr Magdalena Coetzee, Mrs Sumari Marais, Mr Abe Kasonga and Miss Shaakirah Moosa

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Funded by the Howard W. Buffett Foundation through the Norman Borlaug Institute for International Agricultural Research of Texas A&M University

Project 6: Sorghum production and end-use product development for increased food security

Indigenous African cereal grains should be significant contributors to food and nutrition security in sub-Saharan Africa. Sorghum, an important traditional cereal grain grown primarily by small-holder farmers, provides a reliable food security crop.

This can be attributed to its adaptation to harsh environments, capability of producing harvestable grain in multiple cropping systems and grain that can be processed into nutritious food products.

Value-added products could provide sustainable cash income to small-holder farmers. Potential market opportunities exist provided there is a consistent supply of quality grain and products with sorghum or composite flour products have a reliable market niche.

This project is supported by The Howard W. Buffett Foundation through the Norman Borlaug Institute for International Agricultural Research of Texas A&M University.

Small scale entrepreneurs

The project will evaluate and develop improved sorghum genotypes and production technology using the Ukulima Research Farm in Limpopo as the base environment. The objective is to develop food science and technology suitable for small scale entrepreneurs and evaluate sorghums for potential benefits as health foods.

Sorghum plots will include trials for adaptation, resistance to disease, insects and drought and grain quality. Food science research will include sorghum, and sorghum-cowpea or sorghum-peanut composites.

The technology developed will be evaluated for applicability to real world situations. Post-graduate student research and training in food science and plant pathology will be major components of the project.

Project leader:

- Prof John Taylor **– see profile on page 53**

UP team members:

- Prof Kwaku G Duodu – **see profile on page 56**
- Dr Janet Taylor – **see profile on page 63**

Project partners:

- Texas Agrilife Research
- Texas A&M University
- University of the Free State
- Zambia Agricultural Research Institute
- University of Limpopo (associate partner)
- South African Agricultural Research Council (associate partner)

Students:

- Mr Adeoluwa Adetunji (PhD student, project funded)
- Mr Mohammed Mustafi (PhD student, UP supported)
- Ms Pamela Dovi (MSc student, project funded)

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Funded by AFGRI Operations and the Technology and Human Resources Programme – THRIP

Project 7: Prolamin protein coatings for micronutrients

The project is developing technology for the encapsulation of essential micronutrients, to improve their nutritional availability. The micronutrients are encapsulated in a cereal prolamin protein-based coating. This type of protein is both hydrophobic and only slowly digestible and therefore a good barrier. A successful proof of concept has been developed. The project involves developing prototype particles encapsulating micronutrients and evaluating them in vitro and in vivo into cattle.

The project is developing technology for the encapsulation of essential micronutrients, to improve their nutritional availability. The micronutrients are encapsulated in a cereal prolamin protein-based coating. This type of protein is both hydrophobic and only slowly digestible and therefore a good barrier. A successful proof of concept has been developed. The project involves developing prototype particles encapsulating micronutrients and evaluating them in vitro and in vivo into cattle.

The project is supported by AFGRI Operations and the Technology and Human Resources Programme – THRIP – research initiative of the Department of Trade and Industry and the NRF. The THRIP-supported component is enabling fundamental scientific research and development undertaken by post-graduate students to improve the effectiveness of the barrier properties of the protein coating and reduce the cost of the coating materials. This will be done through the usage of by-products and waste products of the South African cereals, beverage and bioethanol industries.

Project leader:

- Prof John Taylor – **see profile on page 53**

UP team member

- Dr Janet Taylor – **see profile on page 63**

Students

- Dr Joseph Anyango (Postdoctoral fellow, UP funded)
- Ms Alexandra Sly (MSc student, project funded)
- Ms Malory Links (MSc student, NRF and project funded)

Project partners:

- AFGRI Operations

Funded by the Allen Foundation Inc

Project 8: The effect of an enriched maize-based beverage on linear growth, bone length and bone status of Grade 5-7 learners in Bronkhorstspruit area, South Africa

Despite significant research on micronutrient supplementation there is still a paucity of data on the impact of such products on growth in African children aged between nine and 12 years. There are also few studies done on bone growth and mineralisation in this age group.

Other research indicates that black children may suffer compromised growth, possibly due to lack of various nutrients. This project will evaluate an affordable multi-nutrient drink made from maize products, which could improve growth and nutritional status in growing children, especially at the age before the adolescent growth spurt.

The study, initiated in September 2013 will be the first to investigate the effectiveness of an enriched maize-based meal supplement on linear growth, bone length and bone status. The outcomes will provide important information about the effect of these specific nutrients on bone accretion and improvement in nutritional status.

The study assesses nutritional status, vitamin D sufficiency and body composition in a group of primary school children in the Bronkhorstspruit area of Gauteng Province, South Africa. This will be followed by a nutritional intervention over a period six months.

- Part A (Baseline assessment): The determination of the nutritional status, dietary intake and anthropometry of Grade 5-7 learners from two primary schools in a rural community; their vitamin D status and body composition in a randomly selected sub-group.
- Part B (Intervention): Nutritional intervention for six months among a group of Grade 5-7 learners to assess the effect of a protein/ micronutrient supplement on linear growth, bone length, bone status and vitamin D status.

This project presents an opportunity to build capacity and expertise in the area of bone health and vitamin D status. A novel procedure to assess vitamin D in blood will be standardised and validated and the methodology to assess bone health and body composition in children will be established.

Address malnutrition

The outcome and findings of the study will contribute to national efforts to address malnutrition in communities with limited access to resources.

The research findings will provide valuable information to assist decision-makers to make informed choices about the importance and

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potential impact of multiple micronutrient interventions in primary school children.

The study will make a valuable contribution to South Africa's Integrated Nutrition Programme, specifically the Primary School Nutrition Programme (PSNP) on the use of maize-based meal supplements in school feeding to reach the most vulnerable groups of children.

Project leader

- Prof Marlena Kruger – **see profile on page 73**

Team members:

- Ms Gerda Gericke - Department of Human Nutrition (UP Faculty of Health Sciences);
- Dr Zelda White - Department of Human Nutrition (UP Faculty of Health Sciences);
- Dr Jane Muchiri - Department of Human Nutrition (UP Faculty of Health Sciences);

Student

- Ms Michelle Fourie (Postdoctoral fellow)

From left to right seated: Dr Zelda White and Prof Marlena Kruger

Standing: Prof Gerda Gericke, Dr Jane Muchiri and Dr Rendani Lladzani

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