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A WINDOW ON.... the Department of Food Science, University of Pretoria, South Africa

Amanda Minnaar outlines the Department's aims and ongoing research on African cereal and legume grains and associated potential health-promoting food products and ingredients

Introduction

The University of Pretoria (UP) is the leading research university in South Africa and one of the largest residential universities in the country. The Department of Food Science originated in 1920 as the Department of Dairying. In 1980, the teaching was extended to cover the broader field of food science and technology and the name was changed to Food Science. This year we are celebrating our 30th year of existence as a Department of Food Science. The academic staff complement is small by international standards, just six PhDs, but is the highest concentration of National Research Foundation (NRF)-rated food science academics in South Africa.

The Department of Food Science

Our vision

- To be recognised internationally as the leader in Food Science and Nutrition specialising in the health and well-being of the people of Africa.

Our mission

- To provide relevant, world-class, integrated education and training of future leaders in Food Science and Nutrition.
- To be the centre of excellence in integrated Food Science and Nutrition research focussing on the health and well-being needs of the people of Africa.
- To apply our skills in Food Science and Nutrition to improve the quality of life of all the people of Africa.

The Department is responsible for undergraduate and postgraduate programmes in Food Science, Food Science and Technology and Nutrition and Food Sciences. Since 1980 we have awarded no less than 535 degrees (including 128 Masters and Doctoral degrees).

The Department of Food Science has a very strong research-based postgraduate programme. Today, students from all over sub-Saharan Africa come to UP to study Food Science and Technology at the Masters and Doctoral level. Current postgraduate students are from Benin, Cameroon, Ghana, Kenya, Mozambique, Namibia, Nigeria, Rwanda, Swaziland, Zambia, Zimbabwe, in addition to South Africa.

The Department has many regional and international links, particularly in respect of research through participation in international projects such as EU-INCO and the African Biofortified Sorghum Project. We also have research agreements with USAID-supported Dry Grain Pulses and Sorghum and Millet Collaborative Research Support Programmes.

Research areas

Some of our food science research focuses on potentially useful attributes of underutilised indigenous foodstuffs to satisfy consumer demands for desirable, natural and health-promoting food products and ingredients. Some specific examples follow.

African cereal grain quality

Biofortified sorghum

Sorghum (*Sorghum bicolor* (L.) Moench) (Fig.1) is a staple food of some 300 million people in Africa. However, its protein quality is poor relative to other cereals. It is very low in lysine and its protein digestibility is reduced on wet-cooking into food. Sorghum's low protein quality is a contributory factor to the high incidence of Protein Energy Malnutrition in Africa. Our research and that of others has shown that the major cause of sorghum's poor protein digestibility is that its cysteine-rich, gamma-kafirin prolamin storage proteins cross-link on wet-cooking. We are a partner in the Bill and Melinda Gates Foundation Grand Challenges in Global Health Africa Biofortified Sorghum (ABS) project. ABS is improving sorghum nutritional quality through genetic engineering combined with conventional breeding. Through this work, biofortified sorghum has been developed with double the level of lysine and substantially improved protein digestibility.

Fig. 1. Ear of Sorghum.

Sorghum lager beer

A revolutionary development, now commercialised in East and Central Africa, is brewing with just whole grain

Figure 2. Sorghum lager beer from Uganda.

sorghum and enzymes (Fig. 2). Through the USA-Africa International Sorghum and Millet Collaborative Research Support Programme (INTSORMIL) and in collaboration with commercial supplier and brewing companies, we are working to improve the efficiency of the process. Areas of activity are sorghum brewing cultivar selection, grain end-use quality methods of analysis and standards, and process improvement. Through this work, we have developed four International Association for Cereal Science and Technology (ICC) sorghum quality standards. These simple standards can be applied by farmers, grain traders and processors.

Kafirin biopolymers

Not only is the sorghum kafirin prolamin poorly digestible, it is also relatively hydrophobic. These attributes make it an ideal choice for making bioplastics, especially as the kafirin can be obtained as a co-product of sorghum brewing and milling. We have developed a patented process to produce micron-size particles from kafirin, which have vacuoles in them (Fig. 3). These microparticles can be used to produce very thin, free-standing, flexible films (approx. 15 microns thick) and ultra-thin coatings, with good gas barrier properties. The microparticles can also be used as slowly digestible microencapsulating agents for nutraceuticals. The process also enables the production of matrices or scaffolds with potential medical device applications.

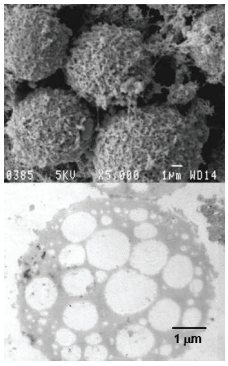

Figure 3. Kafirin microparticles. Top – SEM image, Bottom – TEM image.

We have also used the sorghum kafirin prolamin in edible fruit coatings. A sorghum protein-based edible coating has been shown to extend the shelf-life and maintain the quality of export quality avocados by up to 7 days once ripened. The coating also extends the period required to reach eat-ripeness by one week. The coating is a good gas barrier and helps to decrease the respiration rate and ethylene production of the avocados. This results in the shelf-life extension of the fruit. South Africa is one of the world's major exporters of avocados and as such generates a considerable income in foreign exchange. Avocados are exported in a physiological mature state but they are not yet edible, as they are unripe. On ripening, the shelf-life of the avocado is very short. The fruit are prone to physical damage and are subject to browning and softening, which is unacceptable to consumers and leads to large financial losses. These losses can now be reduced by the use of this sorghum protein-based edible coating.

Modern food processing technologies for indigenous legumes

The consumption of cowpeas (*Vigna unguiculata*), a drought-tolerant legume, is impaired by the hard-to-cook (HTC) defect, which develops when cowpeas are stored at high temperature and humidity conditions. HTC cowpeas require extended time to cook resulting in poor textural and nutritional quality. A combination of pre-conditioning in a solution containing monovalent (Na^+) cations and micronisation (a high temperature short time infra-red processing treatment) reduces the cooking time of HTC cowpeas by approximately 80%. Preconditioning in monovalent cations improves pectin solubility by converting insoluble pectin to soluble pectin. Micronisation further improves pectin solubility by breaking pectin molecules into lower and more soluble fractions. This results in a decrease in cooking time.

Emerging research about African cereal and legume grains and health

Non-nutritive plant chemicals that may exert protective or disease-preventing effects are described as phytochemicals. Currently, there is increasing interest in the phytochemical content of foods because they are associated with protection from and/or treatment of chronic diseases such as heart disease, cancer, hypertension, diabetes and other medical conditions. Our research in the Department focuses on phenolic compounds in particular. Phenolics are powerful antioxidants and are hypothesised to reduce the risk of developing certain cancers by potentially protecting body cells against oxidative damage caused by reactive oxygen species. In our research, we are interested in the concept of the "phytochemical quality" of foods, which we define in terms of their content of phenolics or any phytochemical compound of interest and their antioxidant activity.

The main objective of this research field therefore, is to study the phytochemicals (principally phenolic compounds) of African grains and their processed foods. We conduct research on various grains including sorghum, finger millet, wheat, cowpeas and marama beans. Specific objectives are the following:-

- Characterisation and quantification of phenolic compounds in African cereals and legumes. We use spectrophotometric methods such as the Folin-Ciocalteu assay for phytochemical screening purposes to determine total phenolic content. High performance liquid chromatography is used to characterise and quantify specific phenolic compounds.
- Determination of *in vitro* antioxidant activity of extracts from African cereals and legumes. We make use of methods such as ABTS and DPPH radical scavenging and the ORAC assay.
- Application of phenolic extracts from African cereals and legumes as sources of natural antioxidants in

lipid food systems such as edible oils.

- Determination of the effect of processing (e.g. milling, extrusion, baking) on phenolic content and antioxidant activity of foods from African cereals and legumes.
- Determination of potential biological effects of extracts from African cereals and legumes and their processed foods. We are interested in effects such as gene expression for antioxidant enzymes in cell tissue cultures, protection against oxidative DNA damage, LDL oxidation and erythrocyte haemolysis.

Chemistry and nanotechnology of indigenous African starches: into the future!

A highly viscous and non-gelling paste is obtained when indigenous African teff starch is pasted with stearic acid. Amylose-lipid complexes have been found to play a role in this phenomenon. These paste properties can be exploited as fat replacers in food systems. Current research in the Department showed it can replace oil in a mayonnaise-type emulsion without any significant change in flow and microstructure. It can also successfully reduce fat in processed mozzarella cheese without affecting the melting properties. Starch-stearic acid complexes also seem to be at the nano-scale and produce nano-crystals, as microscopic examination of the starch-stearic acid paste did not show any micron size complexes. This has lead to the study the nanostructure of the complexes and has started research in the area of food nanotechnology in the Department of Food Science. Hopefully in the next few years, we can produce some starch-stearic acid nano-crystals for commercialisation as fat replacers.

Involvement with industry

The Sensory Evaluation Division (SED) at the University of Pretoria serves the needs of students and the South African food industry in terms of teaching and learning and research regarding Sensory Science. The SED focuses its research on methodologies that are specifically relevant to quality assurance/control and product development activities in food companies (Fig. 4). Two main themes, the prediction of the effect of repeated exposure/consumption to specific food properties or food products (whether novel or presumably undesirable) on consumer perception and preferences, and sensory analysis critical control points (SACCP) are pursued.

The repeated exposure sensory studies aim to predict long-term consumer acceptance of food products and ingredients. Hedonic adjustment potential refers to the extent and direction of changes in acceptance ratings over time as a result of consumption over time. Research on this aspect includes measuring the effect of repeated exposure on consumer preferences for sports drinks containing different acidulants and prediction of consumer liking of novel fruit juices. Current research is specifically aimed at value-addition of southern African underutilised foodstuffs to find the very important link between consumer acceptance of foods and their physico-chemical and sensory properties. Examples include investigations on the relative contribution of physico-chemical properties on sensory attributes and consumer acceptance of sorghum, common beans, and protein enhanced (using legumes) cereal porridges.

Sensory evaluation as a reliable tool in quality assurance/control is very important in the food industry. One such tool, namely the SACCP system, is applied to meat products, frozen vegetables and milk with direct involvement of industry. SACCP can be used to identify and carefully control those production and processing factors which have important effects on sensory quality so that it is possible to accurately predict consumer acceptance of end products. Other research includes a study to determine the sensory quality of deep fat fried potato chips manufactured from potatoes with different physico-chemical characteristics. The sensory group was also involved in an Innovation Fund project to develop a novel microwave pasteurisation system for whole shell eggs. We were particularly responsible to determine sensory properties and consumer acceptance of the eggs.

The Division has developed and regularly presents a series of step approach short courses: 'Six steps to Sensory Evaluation', 'Six steps to training a Descriptive Sensory Panel (DSP)','Consumer Sensory Testing: Step by Step', and 'Seven Steps to Sensory Analysis Critical Control Points'.

For further details about the Department's work, please visit *www.tuksfost.up.ac.za*

Figure 4. A sensory panellist at work in the Sensory Evaluation Division.

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