

**Institution:**  
**Glyndŵr University**

**Unit of Assessment:**  
**13: Electrical and Electronic Engineering, Metallurgy and Materials**

**Title of case study:**  
**Modification of hydrocolloids to produce novel and enhanced food products**  
**[13/2]**

**1. Summary of the impact** (indicative maximum 100 words)

Research into the characterisation, functional properties and applications of hydrocolloids which improves the stability of beverage products has been transferred to end users through the University's Phillips Hydrocolloids Research Centre. The associated development of industry standards for acacia gum supply has resulted in more than 44 companies since 2008 directly using the University's analytical services or adopting its methodologies, enabling improvements in productivity, product stability and costs. The Gum Arabic Board of Sudan invited the University to assist in improving gum arabic industry practices and methodologies for processing, storage and traceability from source in supply of consistent and quality materials, producing benefits in terms of volume of business.

**2. Underpinning research** (indicative maximum 500 words)

A key challenge in the University's research into the characterisation, functional properties and applications of hydrocolloids is to control the built-in variation present in natural hydrocolloids, necessary for the production of consistent product/s and the development of new formulations. The emphasis of current research is to develop processes for the modification of hydrocolloids to meet specific industrial requirements.

Gum Arabic (*Acacia senegal*) is the most widely used emulsifier in beverage emulsion but suffers from natural built-in variation which can be influenced by many factors such as location, climate and age of the tree.

A key paper (**Paper 1**, 1993) giving an insight on the structure function relationship of gum arabic was produced by Williams (Director of the University's Centre for Water Soluble Polymers) and colleagues. Hydrophobic fractionation of gum arabic revealed the presence of three different fractions with different molecular weight and protein content. Furthermore, they were able to identify the main fraction responsible for emulsifying oil in water emulsions typically used in the beverage industry.

Subsequent research carried out from 1998 – 2005 to further identify the difference between various samples obtained from various locations as well as the effect of processing (e.g. spray drying) led to establishing a routine method for the characterisation of gum arabic by gel permeation chromatography linked to multi angle laser light scattering, refractive index and UV detectors. As a result it was possible to determine the variation in crude and processed samples of gum arabic and clearly identify the effect of processing. (**Paper 2**).

By linking the structural characteristics of the main fractions present in gum Arabic, as well as the effect of processing, a new process was invented in 2007 by Al-Assaf (**Paper 3**), enabling the modification of these hydrocolloids without using chemical reagents and maintaining the biocompatibility. The method is based on increasing the proportion of the active ingredient responsible for emulsification. A process described as maturation treatment increases the proportion of the active emulsifying component and essentially mimics the natural process by which the active component builds up naturally in the plant.

Al-Assaf and colleagues have further confirmed the mechanism (**Paper 4**) of aggregation by direct comparison with another patented process [US Patent 6,610,810 B2] we developed which relies on introducing C-C bond between two polymeric chains.

The detailed emulsification mechanism of a range of natural food emulsifiers was examined by Al-Assaf and Catellani of the Institut National de la Recherche Agronomique (INRA), France and others. The University's ability to provide well characterised natural food emulsifiers and modified forms was combined with the measuring the interfacial properties at both air/liquid and liquid/liquid interfaces and was described in series of collaborative papers. The results were interpreted jointly to correlate the interfacial properties with the structural parameters to specifically identify the mechanism of emulsification for a wide range of food emulsifiers which assisted the design of new or improved formulations (**Paper 5**).

The maturation technology together with the understanding of the molecular and interfacial properties of hydrocolloids was applied to corn fibre gum (**Paper 6**). The results indicate that our process is applicable to other proteinaceous hydrocolloids and also show that organisation such as US Department of Agriculture is interested in applying this technology to materials currently produced in 1000MT quantity and treated as a waste product because it could not be used without our process.

Professor Peter Williams – Professor of Hydrocolloids (1978 – present)

Professor Saphwan Al-Assaf – (2007 – present) (PDRA from 1998)

### 3. References to the research (indicative maximum of six references)

Available on request if not available to the REF panel as open access publications

1- Osman, M. E., Menzies, A. R., Williams, P. A., Phillips, G. O., and Baldwin T. C. (1993), 'The molecular characterisation of the polysaccharide gum from *Acacia senegal*', *Carbohydrate Research*, Vol.246, No.1, pp.303-318.

2- Al-Assaf, S., Glyn O. Phillips, G.O., and Williams, P.A. (2005), 'Studies on Acacia Exudate Gums. Part I: The Molecular Weight of Acacia senegal Gum Exudate', *Food Hydrocolloids* Vol.19, pp.647-660.

3- Al-Assaf, S., Phillips, G.O., Aoki, H. and Sasaki, Y. (2007), 'Characterization and properties of Acacia senegal (L.) Willd. var. *senegal* with enhanced properties (Acacia(sen) SUPER GUM™) Part 1: Controlled maturation of *Acacia senegal* var. *senegal* to increase viscoelasticity, produce a hydrogel form and convert a poor into a good emulsifier', *Food Hydrocolloids* Vol.21, pp.319-328. DOI: 10.1016/j.foodhyd.2006.04.011.

4- Al-Assaf, S., Sakata, M., McKenna, C., Aoki, H. and Phillips, G.O. (2009), 'Molecular associations in acacia gums', *Structural Chemistry* Vol.20, pp.325-336. DOI: 10.1007/s11224-009-9430-3.

5- Castellani, O., Al-Assaf, S., Axelos, M., Phillips, G.O. and Anton, M. (2010), 'Natural Hydrocolloids with Emulsifying Capacity. Part 2 – Adsorption Properties at n-Hexadecane – Water Interface', *Food Hydrocolloids* Vol.24, 121-130. DOI: 10.1016/j.foodhyd.2009.07.006.

6- Cirre, J., Al-Assaf, S.A., Phillips, G.O., Yadav, M.P. and Hicks, K.B. (2013), 'Improved

emulsification performance of Corn Fibre Gum following maturation treatment. *Food Hydrocolloids*, Vol.36, pp.122-128. DOI: 10.1016/j.foodhyd.2013.05.002.

#### 4. Details of the impact (indicative maximum 750 words)

The research resulted in the patenting, development and launch by Japanese food ingredients company San Ei Gen FFI Inc. of the product Supergum™ (**United States Patent 7462710**), prior to 2008. The further impact since 2008 concerns other companies' use of the University's analytical services (enabled by the underpinning research) and the University's support to the Gum Arabic Board of Sudan in its work towards enhancing the quality profile of gum Arabic products for export. The research described above enabled Al-Assaf to develop gum arabic industrial standards: exact protocols to follow in terms of measuring the structural parameters to the model beverage emulsion to stability, with a certificate issued confirming the attributes of the materials tested.

##### a) Use of analytical services

The research into the properties and characterisation of acacia gum enabled Prof Al-Assaf and colleagues to develop new methodologies for fast, accurate and reliable estimate of the structural characteristics associated with good and poor emulsifiers. These include the graphical presentation of key structural characteristics with performance further confirmed by reporting on functionality testing of model beverage emulsion.

Since 2008 more than 44 companies have used the University's analytical service for characterization and properties of acacia gum enabling them to receive detailed and additional information about the raw material's suitability for the intended application and/or new formulations. Examples are: Nestlé, Doehler, Givudan, Kerry Ingredients.

Doehler GmbH, Germany is a technology-based natural ingredients, ingredient systems and integrated solutions for the food and beverage industry. Its external innovation network is supported by the University's Phillips Hydrocolloid Research Centre. The company reports that the support provided by PHRC has resulted in benefits in terms of [text removed for publication]. (**reference a**)

##### b) Supporting the Gum Arabic Board of Sudan in enhancing the quality profile of gum Arabic products for export

The benefits of this research and the associated development of new methodologies for fast, accurate and reliable estimate of the structural characteristics associated with good and poor emulsifiers have also now been extended to supply sources in Sudan, South Sudan and Kenya. This has been done by providing detailed instructions and staff training to ensure consistency of sampling and reliable subsequent supply worldwide. Al-Assaf presented an invited lecture detailing the methodologies and techniques described above at a key workshop organized by the Government of Southern Sudan (Juba 21-23rd July 09) attended by a range of producer organisations, NGOs and governmental bodies (**reference b**). As a result of the workshop the UN Food Agriculture Organisation commissioned Al-Assaf in collaboration with the Netherlands Development Organisation (SNV) to train staff and set up

a centre to enhance the quality assurance of products sourced from South Sudan. Al-Assaf delivered specific workshops and staff training courses to a number of Sudanese companies to specifically improve their operation: Almoawana Development Co Ltd (2009), Valmar International (2010), Massaie Investment Co Ltd (2011); Nopec Development Co Ltd, Sudan (2012), Dangate Danjadede (2012), Albakry Factory (2012), Elanan Trading Ltd (2011) (**reference c**). Subsequently, a workshop (30<sup>th</sup> October 2011) entitled “Good Practice of Gum Arabic collection and Processing” organised by the Gum Arabic Board was delivered to all major suppliers and exporters of gum Arabic in Sudan. Through this work, the University has according to the Gum Arabic Board helped to implement their policy to guarantee the supply of validated and quality material suitable for specific applications (**reference c**). New guidelines were introduced by the Gum Arabic Board to grade the exporters according to facilities and resources they have; this became a condition for renewal of export licences. The Ministry of Trade together with the Gum Arabic Board visited a number of companies to inspect and their comments about level of improvements in the industry have been attributed to the work with the above mentioned companies.

In 2011 Nopec Development Co Ltd established a new technical laboratory in its factory based in Khartoum supported by Phillips Hydrocolloids Research Centre as a Technical Adviser to enhance company’s quality policy aims through implementing a traceability programme. This has enabled the company to achieve improved inspection outcomes and to provide its customers with the high quality of Gum Arabic that meets their needs, and expectations. The company has renewed its agreement with PHRC until December 2014, and sales volume has increased from 4,000 tonnes in 2011 to 8,000 already achieved and could reach to 9,000 tonnes by the end of 2013 (**reference d**).

Similarly, Elanan Trading Co has also established a technical laboratory supported by PHRC to enhance its quality profile (**references e, f**).

San Ei Gen FFI (Japan) and Doehler GmbH use the testing and accreditation methodologies set up by the University and implemented at source with supplier companies in Sudan. Systematic sampling is undertaken on pre-shipment batches. This way it has been possible for the above mentioned users to obtain the same quality from the pre-shipment samples (1Kg) with the subsequent delivered quantities (in MT’s). This has never been the case before (**reference g**).

**5. Sources to corroborate the impact** (indicative maximum of 10 references)

- a) Managing Director and VP R&D, Production & Quality Management, Doehler GmbH
- b) <http://www.snvworld.org/en/regions/world/publications?filter=t.english/j.2009/agriculture&page=1>
- c) <http://news.sudanvisiondaily.com/details.html?rsnpid=201713>
- d) Managing Director, Nopec Development Ltd
- e) <http://www.elananco.com/anan/index.php/quality>
- f) General Manager, Elanan Trading Exports and Imports Company Ltd
- g) Manager, Fifth Production Section, San Ei Gen FFI Inc.