

Institution: Cardiff Metropolitan University		
Unit of Assessment: UOA03: Allied Health Professions, Dentistry, Nursing and Pharmacy		
Title of case study: Innovation in gluten-free product development and compliance with food safety manufacturing standards for coeliac disease and cereal allergies		
Period when the underpinning research was undertaken: 2008 - 2016		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s): Prof Arthur Tatham	Role(s) (e.g. job title): Professor in Food Science & Nutrition, Food Industry Centre (FIC)	Period(s) employed by submitting HEI: 2005 - present
Period when the claimed impact occurred: August 2013 – December 2020		
Is this case study continued from a case study submitted in 2014? No		
1. Summary of the impact (indicative maximum 100 words)		
<p>Cardiff Metropolitan University's Food Industry Centre (FIC) has been at the forefront of gluten-free (GF) product innovation, reformulation and development, and safeguarding food safety standards in small and medium sized enterprises (SMEs) in the GF industry. Underpinned by research into Coeliac Disease (CD) and cereal allergies (CA), FIC knowledge transfer activities and interventions have resulted in 10 SMEs achieving increased or retained turnover of £19.6 million, 30 food quality awards, and 23 accrediting body food safety standard certifications. Three SMEs alone brought 47 new GF products to market between 2014 and 2020. This has been achieved through innovative ingredient and processing solutions for healthier, safer, and more diversified product ranges, improved product quality and affordability, and compliance with food safety standards for individuals with CD and CAs.</p>		
2. Underpinning research (indicative maximum 500 words)		
<p>Coeliac disease (CD) is an autoimmune condition triggered in genetically predisposed individuals with a specific genetic background (human leukocyte antigens¹ HLA-DQ2 and/or DQ8) when they ingest gluten, specifically the seed storage proteins of wheat, barley, and rye. Since 1990 the incidence of CD in the United Kingdom (UK) population has increased four-fold affecting between 700,000 to 2.1 million people. An additional ¼ million people within the UK suffer from cereal allergies (CAs). The only treatment for CD and CA is a gluten-free (GF) diet, avoiding food containing wheat, barley, rye and for some individuals, oats. Failure to follow a GF diet for those with CD or CA can result in increased incidence of lymphoma, bowel cancer, osteoporosis, malnutrition, and life-threatening anaphylactic reactions. For example, it can result in an 82% increased risk of small bowel disease and 75% increased risk of osteoporosis. Gluten is used extensively in food manufacturing because of its unique properties of viscous flow and elasticity, which are difficult to replicate in GF formulations. UK legislation limits gluten content to ≤20parts per million (i.e., 20mg per kg) in products labelled 'gluten-free'. However, GF product cost, availability and range can influence adherence to a GF diet, with reported compliance to GF dietary recommendations varying widely (17-80%).</p>		

¹ Human Leukocyte Antigens (HLAs) are a group of related proteins located on cell surfaces and are responsible for the regulation of the immune system, e.g. they recognise foreign peptides and proteins and elicit an immune response.

Tatham's research into the role of gluten proteins and epitopes that trigger CD spans 38 years and has been integral to GF product reformulation and development. The immunological basis of CD is associated with HLA DQ2 and/or DQ8. Research by **Tatham** and colleagues in 2008 [R1] showed that the pattern of gluten-derived peptides that were recognised by HLA-DQ8 differed from HLA-DQ2 and that the molecular mechanism of the disease also differed. These findings contributed to greater understanding of the number of epitopes (and gluten proteins) that trigger the disease in susceptible individuals.

Subsequent research [R2] identified the CD triggering epitopes present in gluten were derived from wheat, barley and rye. CD patients in remission were fed either wheat, barley or rye, and T lymphocytes (white blood cells that determine the specificity of an immune response to an antigen - in this case gluten) were isolated from patients' blood and reacted with synthetic peptides derived from the available gluten protein sequences. Synthetic peptide mapping established (a) the immunodominant peptides; (b) the hierarchy of stimulatory peptides (i.e., some sequences are more active than others in stimulating the disease); and (c) a basis for cross-reactivity between wheat, barley and rye. These findings led to enhanced understanding of the epitopes that trigger the disease, and their distribution and prevalence in the different gluten proteins. Collectively, the research has contributed to enhanced understanding of current technologies, including genetic-modification and traditional crop-plant breeding, to produce, for example 'coeliac-safe' wheat [R3].

Responses to inhaled or ingested allergens in wheat and related cereals are less well understood, but symptoms can include urticaria, atopic dermatitis and anaphylaxis. **Tatham's** [R4,R5] reviews of the allergens in wheat and related cereals suggested that a wide range of gluten proteins appear to be associated with ingested forms of allergens, addressed by a GF diet. The major allergen associated with wheat dependent exercise induced anaphylaxis, identified by Tatham and co-workers, is now used as a diagnostic test for ingestion-related cereal allergies [R6].

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

The underpinning research comprises five international peer-reviewed journal outputs [R1, R2, R3, R4 and R6] and a key text [R5]. As an indicator of the quality of the outputs, the journal *Immunity* [R1] is ranked 3/158 in the field of Immunology; *Science Translational Medicine* [R2] is ranked in the top 20 journals in the field of Medicine; *Clinical and Experimental Allergy* [R4] is ranked in the top 10 journals in the field of allergy; and the *Journal of Biological Chemistry* [R6] is ranked 41/456 in the Biochemistry subject area.

- [R1] Henderson KN, Tye-Din JA, Reid HH, Chen Z, Borg NA, Beissbarth T, **Tatham A**, Mannering SI, Purcell AW, Duduk NL, van Heel DA, McCluskey J, Rossjohn J & Anderson RP (2007). A structural and immunological basis for the role of human leukocyte antigen DQ8 in celiac disease. *Immunity* 27:23-34. DOI: 10.1016/j.immuni.2007.05.015
- [R2] Tye-Din JA, Stewart JA, Dromey JA, Beissbarth T, van Heel DA, **Tatham A**, Henderson K, Mannering SI, Gianfrani C, Jewell DP, Hill AVS, McCluskey J, Roosjohn J & Anderson AP (2010). Comprehensive, quantitative mapping of T-cell epitopes in gluten. *Science Translational Medicine*. 2:41-51. DOI: 10.1126/scitranslmed.3001012
- [R3] Shewry PR & **Tatham AS** (2016). Improving wheat to remove coeliac causing epitopes but maintain functionality. *Journal of Cereal Science* 67:12-21. DOI.org/10.1016/j.jcs.2015.06.005
- [R4] **Tatham AS** & Shewry PR (2008). Allergens to wheat and related species. *Clinical and Experimental Allergy* 38:1712-1726. DOI: 10.1111/j.1365-2222.2008.03101.x

- [R5] **Tatham AS** (2016). Food Grains: Intolerance, Allergy and Diseases. In: *Encyclopedia of Food Grains*, 2nd Edition. Wrigley CW, Corke H, Seetharaman K & Faubion J eds, pp72-76. Academic Press, Oxford, UK. ISBN: 9780123944375
- [R6] Matsuo H, Morita E, **Tatham AS**, Morimoto K, Horikawa T, Osuna H, Kaneko S, Kohno K & Dekio S (2004). Identification of the IgE-binding epitope in omega-5 gliadin as a major allergen in wheat-dependent exercise induced anaphylaxis. *Journal of Biological Chemistry* 279:12135-12140. DOI: 10.1074/jbc.M311340200

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

Between 2014 and 2019 the UK 'free-from' food and drink retail market more than doubled in value to an estimated **£934 million**. Of the 14 allergen groups that comprise this market, **GF has over 50% market share**, with UK sales estimated at **£517 million** in 2019. Gluten is also the only allergen that is subject to specific legislation, which has important implications for product development and production. **Tatham's** research in, and knowledge of, cereal science and CD has led to Cardiff Metropolitan University's Food Industry Centre (FIC)'s increased engagement with the GF sector. In common with other food sectors, the GF market is characterised by low profit margins and low levels of technical expertise. **Tatham's** knowledge of hydrocolloids and their functional replacement of gluten in bread and pastry products, as well as in testing for gluten contamination, has had significant impact on food companies through FIC's knowledge transfer activities and interventions [E1, E2, E3].

The impact of **Tatham's** research on the FIC's GF interventions is threefold, namely: (a) product innovation, reformulation, and development; (b) ensuring compliance with food safety standards and legislative requirements (including food labelling); and (c) increased sales/turnover. Since 2014 the impact of the FIC's work with, and support of the sector has been evidenced for **10 SMEs** as well as multinational conglomerates (e.g., 3M). Collectively, the FIC has contributed to the **10 SMEs** achieving a reported retained and increased turnover of **£19.6 million**, **30 food quality awards** (e.g., Great Taste, Butcher Shop of the Year), and **23 third party food safety standard certifications** (e.g., British Retail Consortium - BRC²) certification. The extent of the FIC's impact on the GF market is illustrated through its work with three of these SMEs [company names redacted].

With the support of the FIC and underpinned by **Tatham's** research, the three companies have benefitted from the development of **47 GF products** that were launched to new global markets and supplied nationally to major retailers [E4, E5, E6]. For example, [company name redacted] supplied Marks & Spencer (including the majority of products for Marks & Spencer's 'Made without Wheat' range), Tesco, Waitrose and Greencore, while [company name redacted] supplied Tesco and Asda, and [company name redacted] supplied products for Premier Foods, one of the UK's largest food producers [E4, E5, E6]. The quality of the products resulted in the companies achieving several awards. [company name redacted] achieved multiple **Great Taste awards** (Punjabi cholay chickpea curry, mixed vegetable samosa, and maple and date with tamarind chutney, 2019) and [company name redacted] achieved the **Chef's Choice Award for Innovation** (choux pastry mix, 2018) and the **Supplier Excellence Award for Sustainability** (suet, 2015) [E7].

In 2019, the Welsh Food and Drink Industry contributed £7.47 billion to the Welsh economy [E3], integral to which was the Welsh Government's commitment to encompassing the uptake of, and compliance with, recognised Food Safety Schemes (FSS) to safeguard the growth of the food and drink industry, and compliance with food safety standards and legislative requirements [E8, E9]. For businesses, obtaining and maintaining food safety standards is key to their sustainability, growth in sales and access to new markets. Since 2014, informed by knowledge transfer activities grounded in **Tatham's** research and from working with the FIC, [company

² British Retail Consortium (BRC) has been replaced by Brand Reputation Compliance Global Standards (BRCGS)

name redacted] gained **British Retail Consortium (BRC) certification** to help the company ensure its GF status was upheld and that food quality and safety policies met legal requirements. Similarly, [company name redacted] maintained a **Hazard Analysis Critical Control Point (HACCP)** and their site in [site location redacted] passed a **Safe and Local Supplier Approval (SALSA)** audit – both of which require GF claims to be evidenced. [company name redacted] gained the highly prized **Coeliac UK Crossed Grain Society certification, the highest level of BRC certification, Responsible Sourced Palm Oil accreditation (RSPO),** and met the requirements of the **Brand Reputation Compliance Global Standards (BRCGS)** GF module [E8].

Their commitment to high quality GF product development for health benefits notwithstanding, increased sales are key to market success for all three companies. As a result of [company name redacted] gaining the quality standards certifications, between 2014 and 2020 the company had GF unit product sales of over **£31 million**, with an increased year-on-year units produced per annum ranging from **500,000 to 1 million**, and **50% increased sales**, which FIC support and **Tatham's** research contributed to. Indeed, such were their sales and profitability in the GF market that in 2018 they were subject to a buyout by the hugely successful [company name redacted], one of the largest ambient cake manufacturers in the UK. Similar, increased sales were reported by [company name redacted], who by the end of 2020, reported a turnover on GF products in excess of £200,000, with increased **units produced per annum** between 2014 to 2020 of over **1500%**, **directly attributed to FIC interventions**. [company name redacted] also increased its **units produced per annum** from 88,000 to 2.6 million, a **2,900%** increase in annual production since 2016, with increased sales of **£5 million** [E10]. In summary, FIC interventions underpinned by **Tatham's** research significantly enhanced company product development, food safety standards certifications, profitability and, importantly, the quality and diversity of the GF product range and availability to sufferers of CD and CA.

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

- [E1] Letter from the Food Division, Welsh Government to confirm the impact of Professor Tatham and Cardiff Metropolitan University's Food Industry Centre (FIC)'s work on the gluten-free market and food industry sector in Wales.
- [E2] Testimonial letter from Chair of the Food & Drink Wales Industry Board - Advisory Board to the Minister for Environment, Energy & Rural Affairs, Welsh Government.
- [E3] Photograph of Lesley Griffiths MS, Minister for Environment, Energy & Rural Affairs, National Assembly for Wales with Professor David Lloyd, Director of the Food Industry Centre, Cardiff Metropolitan University.
- [E4] [Company name redacted]:
 - a) Survey data for GF product units and sales
 - b) Written testimonial from [company name redacted] confirming collaboration with the FIC and the support provided in product innovation, reformulation and development for food industry safety standards.
- [E5] [Company name redacted]:
 - a) Survey data for GF product units and sales
 - b) Written testimonial from [company name redacted] confirming collaboration with the FIC and the support provided in product innovation and development for food industry safety standards.
- [E6] [Company name redacted]:
 - a) Survey data for GF product units and sales
 - b) Video testimonial from the Managing Director of [company name redacted] confirming collaboration with the FIC and the support provided for GF product innovation and

development.

[E7] Evidence of food quality awards:

- a) Great Taste Awards 2019
- b) Supplier Excellence Award for Sustainability 2018
- c) Chef's Choice Award 2015

[E8] Letter of support from 'Brand Reputation Compliance Global Standards' (BRCGS) in recognition of FIC's work in ensuring businesses comply with the global requirement of the BRCGS Food Safety Gluten-Free module

[E9] Testimonial letter from 'Safe and Local Supplier Approval' (SALSA) – food safety certification body, praising the important work of Cardiff Metropolitan University's Food Industry Centre in the 'free-from' food and drink sector.

[E10] YouTube video - Managing Director of [company name redacted]