

Impact case study (REF3)

Institution: University of Nottingham		
Unit of Assessment: 6; Agriculture, Veterinary and Food Science		
Title of case study: Transforming Pipers Crisps into a science led company acquired by PepsiCo		
Period when the underpinning research was undertaken: 2012 – 2018		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s): Ian Fisk	Role(s) (e.g. job title): Professor of Flavour Chemistry	Period(s) employed by submitting HEI: 2010 - present
Period when the claimed impact occurred: 2016 – 2019		
Is this case study continued from a case study submitted in 2014? N		
<p>1. Summary of the impact Researchers at the University of Nottingham (UoN) have played a key role in the expansion of a regional UK-based savoury snack company. Pipers Crisps (PC) have embedded UoN discoveries into their production processes enabling them to extend product shelf-life, reduce ingredient costs, improve flavour stability and reduce sodium levels whilst increasing consumer acceptance. As a result, PC have expanded their export market into 42 countries and introduced 2 new products to the market. This has led to the creation of new jobs within PC and total attributable benefit of [redacted], which comprises new product sales in the UK of [redacted], export sales of [redacted] and cost savings of [redacted]. Consequently the adoption of a science-led approach resulted in the rapid growth of PC and acquisition by the global food manufacturer PepsiCo International for approximately GBP20,000,000.</p>		
<p>2. Underpinning research Professor Ian Fisk, in the School of Biosciences at the University of Nottingham (UoN) has a growing body of research using fundamental flavour chemistry and seasoning technology. This impact case study surrounds Fisk's research regarding optimisation of snack foods.</p> <p>Initial work in this area began in 2012, optimising the flavour potential of seasonings in snack foods. The results showed a significant proportion of the crisp's seasoning is not perceived when the crisp is exposed to normal eating patterns and would result in the consumption of an excess of salt (sodium) in the diet, and significant expense by the food industry in "over-seasoning" snack foods. This is due to poor adhesion of seasoning particles and poor hydration of particles in the mouth (1). Fisk's lab developed unique approaches to measure salt concentration in the saliva and showed that saltiness perception peaked after the time frame for normal consumption. This further reinforced the concept that most of the salt applied to the crisp is undissolved and unperceived. This presented the opportunity to optimise the physical properties and dissolution rate of salt crystals during consumption. Fisk showed modification of salt crystal size altered the sensory perceived saltiness (2) and that oral processing affected sodium bioaccessibility (3). Further work developed a fundamental understanding of how the relative composition of carbohydrate, lipid and protein in seasoning carriers affected flavour release (4). Together these findings indicated that the salt content of crisps could be optimised, and seasoning carriers could be modified, without compromising flavour providing scope to transform approaches to crisp manufacture.</p> <p>Piper's Crisps (PC), was a regional company based in Lincolnshire (UK) who manufactured kettle-style potato crisps using locally sourced potatoes on a relatively small scale. The company had a strong local brand with ambition for growth, but limited technical understanding of ingredients, products and manufacturing processes, and consequently limited opportunities through export and UK growth. In 2012, representatives of PC attended the UoN Food Flavour Course, the leading UK flavour course for industry professionals, and subsequent discussions led to two Knowledge Transfer Partnership (KTP) projects which aimed to extend shelf-life, optimise flavour application, understand consumer choice and enhance consumer liking.</p> <p>PC produce a unique style of kettle batch-fried potato crisps from unwashed, sliced potatoes. In this type of crisps, some of the characteristic flavours and texture are believed to be associated with the elevated levels of surface lipids entrapped in the free starch</p>		

coating. Whilst this creates its unique texture and flavour, it is in itself problematic, because the elevated surface lipids contribute to instability due to increased lipid oxidation during storage (5). Fisk, in collaboration with PC, showed that the fatty acid profile and ratio of free to bound fatty acids in the frying oil were key quality limiting factors for these unique crisps and that products fried in high oleic sunflower oil (HOSO) were more stable than those fried in regular sunflower oil. Furthermore flushing end user packaging with nitrogen gas slowed down the oxidation rate and stabilised the crisps, HOSO was also more stable during multiple frying cycles and resulted in a significant increase in predicted shelf life; this has previously not been shown for crisps with a high free starch content (5). Further work showed that the key negative sensory attributes during product ageing were associated with oil rancidity and flavour staling and that a controlled oxygen environment and the inclusion of certain proteins in the flavour mix act as antioxidants and significantly improves seasoning stability over shelf life (6).

A flavour profiling tool, combining analytical techniques coupled with chemometrics, was developed at the UoN. Validation studies showed this tool could characterise the aroma volatiles and accurately predict maturity of commercial Cheddar cheese (7). This offered a rapid and detailed flavour profiling tool for PC to screen different flavour and seasoning carrier combinations, assess quality and accelerate product development.

3. References to the research

University of Nottingham UoA6 staff are **bold**.

Underpinning references:

1. Xing, T., **Fisk, I.D.** (2012) Salt Release from Potato Crisps. *Food & Function* 3, p 376-380. DOI: 10.1039/C2FO10282J
2. Rama, R., Chiu, N., **Da Silva, M.C., Hewson, L., Hort, J., Fisk, I.D.** (2013) Impact of Salt Crystal Size on in-Mouth Delivery of Sodium and Saltiness Perception from Snack Foods. *Journal of Texture Studies*, 44, p 338–345. DOI: 10.1111/jtxs.12017
3. **Fisk, I.D., Da Silva, M.C., Tian, T., Soukoulis, C., Mooney, S., Sturrock, C.** (2015) Investigation of tastant delivery through control of oral processing and structural properties of snack foods. In: Taylor AJ and Mottram DS, eds., *Flavour Science: Proceedings of the XIV Weurman Flavour Research Symposium* Context Products Ltd. Cambridge, UK. ISBN: 9781899043705, pg 413-418.
4. **Fisk, I.D., Boyer, M., Linforth, R.** (2012) Impact of protein, lipid and carbohydrate on the headspace delivery of volatile compounds from hydrating powders, *European food research and technology* 235, no. 3, pp. 517-525 DOI: 10.1007/s00217-012-1776-x
5. Marasca, E., **Greetham, D., Herring, S.D., Fisk, I.D.** (2016) Impact of nitrogen flushing and oil choice on the progression of lipid oxidation in unwashed fried sliced potato crisps. *Food Chemistry*, 199, p 81-86. DOI: 10.1016/j.foodchem.2015.11.136
6. **Agarwal, D., Aldridge, E., Mottram, R., Lim, M., Mckinney, J., Fisk, I.D.** (2018) The impact of nitrogen gas flushing on the stability of seasonings: volatile compounds and sensory perception of cheese & onion seasoned potato crisps. *Food & Function*, 2018, DOI: 10.1039/C8FO00817E
7. Gan, H., Yan, B., **Linforth, R., Fisk, I.** (2016) Development and validation of an APCI-MS/GC-MS approach for the classification and prediction of Cheddar cheese maturity. *Food Chemistry*, 190, p442-447. DOI: 10.1016/j.foodchem.2015.05.096

Underpinning grants:

- G1. Novel approaches to reduce dietary sodium. Sponsor: BBSRC, BBSRC/UoN Doctoral Training Grant, 2011-2015, BB/F017014/1. GBP69,599. Supervisor: Ian Fisk.
- G2. Increasing the shelf life of potato crisps (to optimise the frying process to get the best possible most healthy crisp and increase shelf life). Sponsor: Innovate UK, KTP with Piper's Crisps, 2013-2015, 508816. GBP125,564. PI: Ian Fisk.
- G3. Understanding flavour instability in snack foods. Sponsor: Innovate UK, KTP with Piper's Crisps, 2015-2017, 509505. GBP143,742. PI: Ian Fisk.

4. Details of the impact

Research completed within two Knowledge Transfer Partnerships (KTPs) between Professor Ian Fisk and Pipers Crisps (PC) has enabled the company to develop a robust technical understanding of their products and consumer preferences, and embed new processes and

decision-making tools for new and existing product development. The direct transfer of research outcomes into PC increased the quality and stability of their product, significantly expanded their business through the development of new products and entering the global export market for the first time. The cumulative effect of 6 years of interaction with UoN has resulted in **total attributable cost savings and sales of [redacted]** and the **creation of 6 new roles** (3 technical and 3 skilled manufacturing roles) between **2016** and **2019**. This growth, in addition to the knowledge and understanding transferred into the company and resultant behavioural change in decision making substantially transformed PC and led to the acquisition by PepsiCo for >GBP20,000,000 **(i)**.

The company initially engaged with Fisk in 2013 through a KTP project **(G2)** with the aim of improving understanding of oil stability and rancidity to enable extended product shelf life. The company then employed new technical staff who underwent training through UoN Flavour and Sensory Science short courses and training and mentoring by UoN staff. A second KTP with PC in 2015 **(G3)**, transferred higher level flavour and sensory science knowledge to PC. This led to a mechanistic understanding of flavour and flavour instability in their products and developed product specific sensory protocols and a sensory team. These developments led to improved new and existing product development processes which further extended shelf life and increased product consistency and consequently enabled the development of new, consumer insight led, flavours and seasonings and products.

Enhanced seasoning understanding led to the design and delivery of two new products

Consumer insight research findings from the second KTP **(G3)** led to two new product categories being targeted - vegetarian and gluten free. UoN's development of a rapid flavour profiling tool **(7)** and subsequent factory trials at PC **(b – pg3, q1)**, directly resulted in the development of two new vegetarian products being brought to market. The first product - Atlas Mountains Wild Thyme and Rosemary (WTR) - launched in **2016** was PC's first new flavour in four years **(a – pg2, b – pg3, q1)** and was subsequently awarded UK winner in the [Crisps and Nuts Category 2018 by the Chefs Choice Awards](#) for quality and innovation. The second product – Delicias Jalapeño and Dill (JD) - was launched in **2017** and awarded bronze in the [Savoury Snacks & Crackers category of the Free From Awards in 2019](#).

Attributable sales of each of the new products since launch are shown in Table 1, with cumulative sales between **2016** and **2019** totalling [redacted] **(d)**.

Table 1: Total attributable sales of new products (UK and export), correct as of October 2019. All figures obtained from **(d)**.
[redacted]

An understanding of how lipid oxidation progresses in these products and how flavour binds to components in the seasoning base, specifically carbohydrate, lipid and protein fractions, **(4-6)**, enabled the two new vegetarian products to be formulated without gluten. This fundamental knowledge was combined with the rapid flavour profiling tool developed by Fisk **(7)** to accelerate the re-profiling of all PC flavour and seasoning carrier combinations. In November **2016**, PC announced its complete range had been reformulated to be gluten-free **(j)** which facilitated continued market expansion. The innovative nature of PC's products is directly credited to the new scientific capability embedded within the company via the UoN-PC KTP, with the Founder of PC commenting that they now *'[put] real science behind the things we do ... [allowing] us to develop further new and successful products'* **(a)**. Furthermore, its impact on the company's turnover led to recognition by the Grocers 'Fast 50' due the companies 21.2% annual growth rate between **2015** and **2017** **(c)**.

Greater frying process control led to reduced production costs and improved resource-use efficiency

The quality of all PC products was enhanced through optimisation of frying oil stability during production. This stemmed from a fundamental study on high free starch fried snacks that

identified the optimal frying oil fatty acid profile (5). PC integrated this into all production lines by modifying the fatty acid profile of the frying oil, the ratio of free:bound fatty acids and frying processes in their standard operating procedures (e - pg3-4, q7). As a result of these changes during the first KTP, raw material costs were reduced and product shelf-life was increased from 16 to 26 weeks, resulting in less wastage and the development of a competitive export strategy (e - pg5, q10, 'Exports').

PC reduced their annual raw material costs by [redacted] initially in 2018, and a further cost saving of [redacted] in 2019 (d) making total attributable cumulative savings from enhanced frying oil stability [redacted].

Enhanced oil and seasoning stability led to international export

Optimisation of frying oil stability in the first KTP (detailed above) led to a 63% increase in shelf life of products and opened up new export markets, previously inaccessible due to short shelf life. The second KTP determined that the shelf life of the seasoning was further compromised by both poor pack integrity and high ambient pack oxygen content and that nitrogen gas flushing and new packaging materials were required to further improve seasoning stability (6). Furthermore, the finding that certain proteins when in a dry seasoning state (6) can enhance oxidative stability was used to optimise seasoning blends. Implementation of both across all exported product ranges, allowed PC to extend the shelf life from 26 to 40 weeks (b - pg5, q6), enabling expansion and access into 'markets in SE Asia and USA' for the first time (b - pg5, q4).

Initial export sales totalled [redacted] in 2018, which 'was only possible due to the extended shelf life and new packaging technologies implemented in [the KTP] project' (g). In 2019 international sales were [redacted] across 42 countries worldwide (d), making the total attributable cumulative export sales [redacted].

Greater seasoning process control led to reduced seasoning costs

Poor seasoning design, low adhesion rates and ineffective application at PC resulted in excess seasoning being applied and unnecessarily high seasoning costs. Optimisation of seasoning design during the second KTP (6) led to PC investing in new equipment (gravimetric flavour application loop) that increased consistency of flavour application (b - pg2, q1). This resulted in cost savings of [redacted] per year per flavour (d). Currently PC have 9 flavours therefore savings were [redacted] in 2019 (d). Savings in previous years were reported as [redacted] (2017; b - pg9, q13) and [redacted] (2018; g), bringing the total attributable cumulative seasoning savings to [redacted].

Growth driven by knowledge exchange and a step change in skill acquisition and training within the organisation

The initial KTP project resulted in specialist training of 11 members of staff and creation of 2 new jobs in 2015 (e - pg7, q14). The second KTP project built capacity within the organisation through the additional training of 18 members of staff, resulting in media coverage from the BBC (f), and creation of 1 job in 2017 (b - pg9, q14) and 3 subsequent new positions up to September 2019 (d). Since the initial KTP PC has grown from a small snack producer with a turnover of [redacted] in 2015 (e - pg4, q9) to a turnover of GBP11,631,344 (correct as of January 2019) (h, pg11).

The strengthening of skills and competencies of existing staff, creation of new roles and acquisition of new technical capabilities through the KTP has been transformative on PC. Acknowledging the impact of the KTPs, the Managing Director of PC stated: *'the KTPs directly changed the culture of the organisation [...] we are now a science led company that makes informed decision through robust consumer insight testing and a greater understanding of the products and processes that we use. This is entirely due to the transfer of technical knowledge from [Ian Fisk's] research and work processes into the organisation and has enabled the company to grow its UK turnover, develop an international sales programme and become a truly global brand' (g).*

Summary of total attributable impact

The cumulative effect of the 6 years of interaction with UoN has resulted in a total attributable savings/sales to PC of [redacted] (Table 2) and has underpinned the acquisition by PepsiCo for >GBP20,000,000 in February **2019 (i)**.

Table 2: PC cumulative sales and savings between **2016** and **2019**.

[redacted]

5. Sources to corroborate the impact

- a) Pipers Crisps press release; 'Pipers Crisps: when it comes to the crunch, it's all about the science' (July 2017) [PDF]
- b) KTP9857 report (2015-2017) [PDF]
- c) Pipers Crisps press release; 'Pipers Crisps named in The Fast 50' (November 2017) [PDF]
- d) Letter of support from Pipers Crisps Managing Director (Oct 2019) [PDF]
- e) KTP9114 report (2013-2015) [PDF]
- f) BBC East Midlands Today (2nd September 2017) [media file – available on request]
- g) Letter of support from Pipers Crisps Managing Director (December 2018) [PDF]
- h) [Pipers Crisps full accounts, Companies House](#), 1st February 2018 – 31st January 2019 (filed 4th February 2020) [PDF]
- i) [The Times article](#) (November 2018) – Pipers Crisps purchased for >£20M [PDF]
- j) Pipers Crisps press release; 'Pipers Crisps' range is now gluten-free' (November 2016) [PDF]