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FROM BREEDING TO MARKET: OPPORTUNITIES WITHIN A DISRUPTED FOOD CHAIN

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SUMMARY

Food production and traditional agricultural systems are in a state of change due to increasing consumer demands and technological advances. In this paper, we outline international food trends as a background for creating discussion for supporting the positioning of future animal breeding programmes. We then present at a high-level, two case studies of programmes where breeding indexes could, or have been altered, to achieve changes in traits previously unselected for. We complete the paper with some discussion on the challenges of being closely aligned with industry and what that means for developing capabilities of young scientists.

THE FAST CHANGING WORLD WE LIVE IN

"Beware of the incumbent's chortle" was a line given in response to a discussion about disruption. It is of course, quite probable that the Blockbuster's former CEO chortled at the concept of live-streaming, when they turned down the opportunity to buy Netflix.

Disruption is a term in regular use and the food industry is not immune. Insect-based proteins, synthetic and plant-based meat and milk products, greenhouse gas (GHG) minimisation and consumer beliefs associated with animal welfare are challenging traditional agriculture food production systems. So too are these challenges creating opportunities and we, as scientists and technologists, have an important role to play in working closer with industry to take full advantage of them.

INTERNATIONAL FOOD TRENDS

Consumer power. Food brands have long-been established through clever marketing campaigns and product positioning. However, consumers' rising distrust of the food industry and their ability to promote or undermine companies via social media has led to a change in the balance of power. Because of this, consumers need to be at the forefront of research and development strategies of companies and industries.

For companies and industries striving to differentiate themselves from commodity producers, a sticker or label on packaging is not enough to denote where a product is from and how it has been produced. Layers of evidence as to how food has been grown and produced, fulfilling ethical, welfare and environmental considerations, and a connected value chain are critical for commanding premium food prices.

Food and health. A significant international food trend is the relationship between food and health. This is led by Chinese consumers who have been described as "the world's most health conscious," based on a long tradition of food-based medicines. In China, 73% of consumers are willing to pay a premium for healthier products (12 points higher than the global average), preferring products which treat common ailments, boost energy and strengthen immune systems (Boston Consulting Group 2014).

Aligned with the food and health trend is an increasing interest in the concept of personalised-food, and not just for humans. "Just Right by Purina" allows dog owners to order personalised-food formulations for their dogs. The formulations are derived according to the dog's breed, activity levels, coat and skin condition and the state of their stools. Similarly, for humans, Soylent is an example of formulated foods designed for specific human nutritional needs. Large food companies, such as Nestle with their “Choose Wellness,” programme, are investing significantly into this area.

The changing face of food retail. The way we buy food is changing which is important for the delivery of foods in a personalised form. Factories and big companies are out of vogue. Consumers want to feel a connection to growers and the rise in popularity of Farmers’ Markets is testament to this. There are increased quantities of high-end food products being sold on-line directly, or via meal-kit companies such as Blue Apron (United States) and My Food Bag (New Zealand). This ability to directly market and sell to consumers means that smaller companies can offer niche products profitably, opening-up opportunities for artisan growers.

Food as an experience. Younger consumers are increasingly seeking authentic and novel food experiences, in preference to more traditionally sought fine-dining experiences. This creates opportunities for producing novel food products derived from less traditional livestock cuts, such as offals and from other species such as crickets. It is worth noting that *Acheta domesticus* -the humble domestic cricket, is far better at converting ingested food into protein than cattle and crickets also have far greater fecundity (1,200–1,500 offspring per female).

The concept of food as an experience, also generates opportunities associated with food-tourism, of relevance to both Australia and New Zealand’s significant tourism industries which are connected to our landscapes.

“You know things are changing in the food sector when you get gourmet nosh from a food truck, when your beer comes bolstered with protein, and McDonald’s introduces a kale-enhanced breakfast” (Keown and Brendish, 2015).

LIVESTOCK AS A SOURCE OF PROTEIN

Protein consumption is rising internationally, especially in emerging economies. Annual meat production is projected to increase from 218 million tonnes in 1997-1999 to 376 million tonnes by 2030 (World Health Organisation). In response, emerging economies are fast-developing their own sources of protein with livestock production programmes growing in efficiency and volume throughout Asia and Africa.

In parallel, the role of ruminants in the food chain is increasingly being questioned as awareness around climate change grows. In the future, we may see political trade ramifications for high-carbon products (Ciochetto, 2016) and food producers will become more vulnerable to negative campaigns, be they political or social.

Thirty per cent of Earth's land surface is already devoted to livestock production, a practice that accounts for nearly 15% of global greenhouse-gas emissions (reviewed in Heffernan, 2017). Cows are the seen as the worst environmental culprits, not only because they emit a lot of methane, but because the production of beef uses vast quantities of water: 15,415 litres for a kilogram of beef (reviewed in Heffernan, 2017).

Alternate protein may lead to a reduction in protein sourced from livestock but it is unlikely to become an either/or situation. Livestock producers that position their products at the high-value end of the spectrum will not be as challenged by alternate proteins as those who operate in the commodity space. Fully-housed livestock, produced in commodity-style with high health and feed inputs, will increasingly be shunned by consumers.

Adding-value to livestock products, should at a very minimum, encapsulate where the product is from, how it is produced, and have sales channels which are different to traditional commodity channels. By shifting more of Australasia’s production systems to this minimum value-add form we would expect increased prices and reduced volatility of those prices. This is because consumers exhibit a lower price sensitivity to products which are more expensive and further processed (Baiardi et al., 2014). A major challenge in making this shift is to ensure that the increased costs of producing a high-value product are a sound investment in the market, because almost by definition, further processing narrows the potential end-use for a product.

WEALTH OF DATA

Throughout the value chain, increasing amounts of data are being generated. Consumers are wearing devices measuring heart rates and sleep patterns. At the other end of the value chain, devices are under development for livestock to wear or be tracked by, and for land-based activities, such as irrigation and nutrient monitoring (reviewed in King 2017).

We will be moving into an era where what we eat will be defined for us by what we have done during the day, informed by internally and externally worn sensors. Similarly, farmers and animal breeders will have access to unprecedented amounts of animal performance data to strive for greater productivity with less impact on environments and creating connections with consumers.

Some of these data will have relevance for how we undertake breeding and genetic evaluation. Scientists will have access to data from greater numbers of animals and for differing traits. Traditional nucleus breeding programmes may be replaced.

In thinking about the types of capability required for positioning our industries for future success, geneticists, as both biologists and mathematicians, are in a prime position to be data integrators: adding value to inherently messy data by asking relevant questions and finding smart solutions to form the base for new technologies and applications.

CASE STUDY ONE: THE POTENTIAL TO INCLUDE GREENHOUSE GAS MITIGATION IN LIVESTOCK BREEDING INDEXES

Many livestock industries around the world are seeking good-news stories relating to environmental impact. An obvious option to reduce absolute GHG levels is to reduce livestock numbers, but this has major implications for production and economic well-being and as such, is unlikely to be taken up, unless there is considerable compliance pressure and/or economic alternatives.

An alternative is to reduce GHG intensity - GHG per unit of product. Under current selection approaches, the drive to improve production efficiencies indirectly lowers GHG intensity year-on-year. So far, modelling data has demonstrated that this is likely to be a positive news story, in that current and historic selection efforts improve livestock production efficiency substantially, and this reduces emissions intensity (Ludemann et al., 2011; Amer et al., 2017a; Amer et al 2017b; Quinton et al., 2017a, Quinton et al. 2017b).

There is a more aggressive option available for reducing GHG emissions intensity of livestock. This involves placing greater than current relative selection pressure on the traits that improve GHG emissions intensity (GHG EI) the most, and correspondingly, less relative selection pressure on traits that do not tend to improve GHG EI (Quinton et al (paper submitted to Animal) and Ludemann et al., 2011). It turns out that these indexes which extract more GHG EI gains than purely farm profit based indexes are typically efficient, in that significant improvements in GHG EI gains can be extracted with only modest reductions in the farm profitability gains expected from selecting on the modified indexes.

There is also a challenge in this approach in that placing more emphasis on the traits that reduce GHG EI the most (for example litter size in sheep (Ludemann et al., 2011) and milk production in dairy (through a dilution of emissions effect) are in reverse (Wall et al., 2010) to a directional shift in breeding goals over past decades towards traits that make animals more functional and easy to farm.

Efforts to develop novel selection criteria to improve GHG EI, including feed intake measurements, and either methane yield per unit of feed, and/or total methane yield per animal may be hampered by genetic antagonisms with functional aspects of animals. Another challenge is the cost of either trait measurement of selection candidates, or the cost of implementing genomic selection schemes, whereby the genotyping costs are more than offset by reductions in phenotyping investment.

Incentives/compliance drivers for uptake. A driver for an increased focus on breeding to reduce GHG emissions might come through audited supply chain systems. Auditing is required, because of the antagonisms and costs discussed above, so that free-riders benefiting from the supply chain story might otherwise skimp on compliance.

Interestingly, choice of breeding males by commercial farmers is potentially easier to audit than many other GHG mitigating technologies and certainly more than any sort of actual farm GHG emissions audit. This is because detailed databases already exist containing a substantial proportion of breeding sector animals. If breeders were to record the commercial farm buyers of breeding males, and/or semen, and submit these to an auditing body, then the ongoing genetic trend of the commercial farm for genetic merit for GHG emissions intensity could be predicted accurately. Occasional, or random checking, via DNA verification or genomic relationship predictions, could be deployed at low cost to ensure accuracy of the system, and miss-reporting of sire purchases. The steps required to develop such a system are quite feasible when compared with what will be required to deploy and incentivise many other GHG mitigating farm technologies.

There are opportunities to link such GHG reduction genetic programmes with national positioning programmes connected to product markets, such as Origin Green. Origin Green is an Irish national sustainability programme implemented by Board Bia, the Irish Food Board and supported by Government and private companies.

Origin Green is ostensibly a marketing effort, but the differentiation comes from the supply chain (Shelman, 2016). The programme so far has seen 90,000 farms audited and carbon footprinted. At manufacturing level, over 470 food and drink manufacturers, which represent almost 95% of their total food and drink exports, have registered to take part in Origin Green. The opportunity therefore, is for Irish producers to be incentivised to use GHG reduction indexes as part of a commitment to Origin Green, striving for a subsequent value-increase for product off those properties.

CASE STUDY TWO: THE OMEGA LAMB PROJECT

Worldwide, there is a large (>$20 billion) and rapidly growing market for omega-3 and omega-3-enhanced products, and a static or declining source of omega-3 from marine fish oils, prompting concerns of shortages. Alternative sources of omega-3s are necessary to meet demand, particularly in continental countries, like China, where there are large populations that do not eat fish regularly. The European Food Safety Authority recommends a dietary intake of 250mg of EPA plus DHA (eicosapentaenoic acid; C20:5n-3, docosahexaenoic acid; C22:6n-3), a day. The estimated average daily intake of EPA and DHA in China for example, is just 49mg. This deficiency has prompted the Chinese Nutrition Society to review its dietary guidelines in order to increase the nation's intake of DHA and EPA fatty acids. As a result, there is now a substantial volume of research investigating the enhancement of omega-3 levels in beef, lamb, pork and chicken using alternative feeds and feed-lot systems. These feed systems use fish, algal or ALA (alpha-linolenic acid; C18:3n-3) rich seed supplements to enrich the omega-3 composition and, recently, small volumes of omega-3 enhanced beef, pork and chicken products have become available in markets.

The Omega Lamb project, led by red meat processing company, Alliance Group and sheep breeding company, Headwaters, was initiated in 2011, with a view to developing a naturally differentiated lamb product. The aim of the project has been to develop value-added lamb products, high in omega-3 and also incorporating other meat quality attributes and environmental-management philosophies. In the early years of the programme, this involved analysing over 300 sire lines and 20 forage lines for their impact on fatty acid composition.

Enhanced omega-3 levels in lamb have been achieved through a combination of selective breeding - using assessment of correlated traits related to intramuscular fat levels - and diet - using a chicory-red clover finishing system. This is the basis for the development of what is now a fully commercial pipeline of products. High-health lamb products are being marketed for their health attributes and have been endorsed as high quality by chefs and independent consumer taste panel analyses. These products are currently being sold for a premium in high-end New Zealand restaurants and in Hong Kong. This season, in the first year to market, product from 30,000 lambs has been processed, with the target of processing 60,000 lambs in year two. From here, key challenges for the programme are associated with quality control and scaling to a larger volume of product.

A key driver for the success of the Omega Lamb Project has been the early involvement of people representing all parts of the value chain. This included scientists, livestock breeders, commercial farmers meat processors and marketers. Early consumer studies in three markets, the United Kingdom, Germany and China, were also important in informing where the value opportunities lay. This big picture and value-chain commitment has been challenging to manage, but has been critical to the programme's success, throughout the research and development phases and now the commercialisation phase.

CHALLENGES OF MARKET-DRIVEN BREEDING PROGRAMMES

There are many examples of market-driven breeding programmes, some of which have had limited success. Green-wash, is a term used to describe products taken to market and sold under an undeserved environmental banner. As we stated earlier, consumers have become cynical and will question the positioning of products by companies. Products and companies that are seen as inauthentic will be quickly brought-down via social media. One of the challenges with connecting breeding programmes to market is to ensure that there is legitimacy behind market claims, for example claims of superior quality. In breeding terms, such legitimacy will come from a concerted and multi-year strategic investment into understanding traits and the time taken in selection to make a measurable difference. When such programmes have failed, a factor has been that the expectations of progress have not been managed from breeder to marketer and marketers have gone out too early with product claims. Additional challenges include those of scaling breeding programmes to produce enough product for profitability, managing quality throughout the value chain and when demand is created in-market, managing year-round supply and or consumer/retailer expectations around product availability.

There are successful programmes that are managing, or in the process of managing these challenges, some additional examples include the Ora King programme (premium eating quality salmon) and Lanaco (wool-based air filtration face-masks). In these programmes, as in the Omega Project, success is underpinned by a willingness to collaborate by geneticists and industry players throughout the value chain.

CAPABILITY

Scientists need to have a genuine interest in solving industry challenges in order to engage successfully with industry. This requires a deep understanding of company and industry drivers. It is hard to develop this in a purely academic environment and scientists should be encouraged to spend considerable time outside of that environment, to the point of spending periods of time embedded in companies or industry organisations. Such time is invaluable for developing relationships and understanding why things are never as simple as they seem in terms of implementation of longer-term research and development strategies.

Performance drivers for scientists within academic environments are often in conflict with such an approach and science organisations need to strive to develop new, or align existing performance measures with such an approach.

Finally, in the experience of these authors, there is tremendous satisfaction at playing a role bringing science and industry together. It is our view that this can be done in a way which maintains scientific valour and integrity and most importantly, makes a considerable impact in taking industries forward in a changing food environment.

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