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Overview

Data capture through Australian beef cattle and meat sheep value chains: opportunities for enhanced feedback to commercial producers

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Abstract. Technologies for capturing and transmitting data from different points in livestock value chains are developing very rapidly, and interest is growing in how best to use such technologies. While new data-capture technology comes with the promise of producers and others being more informed about a system, what usually results is large and complex datasets. A key challenge is to make use of the data or information. The present paper initially outlines the data-capture points and flow of information that occurs throughout the Australian beef cattle and meat sheep value chain. The avenues through which feedback can be delivered to commercial producers are briefly summarised, along with the value of this feedback and the factors that affect its value. Finally, practical principles for effective feedback systems are provided. While data capture is occurring throughout the value chain, the main focus of the paper is on carcass- and eating-quality feedback from processors to commercial producers. There is significant variation in the volume, nature and quality of data collected, and also the flow of information among members of the chain. Further, there appears to be an inconsistency in the levels of demand or desire for the feedback. The value of feedback ultimately depends on the producer's ability to make better business decisions as a result of having that data or information. Increasing market specifications and compliance will result in greater profitability for the producer, as well as processor. The value of feedback also depends on several other factors, including its accuracy, its granularity, whether or not it can be connected to other data, and what options the producer has to use that information in the future. Feedback must be interpretable and enable better business decisions. The value of feedback will also increase if extended further upstream along the supply chain for genetic evaluation, provided there is enough information on genetically informed animals and their identifications can be tracked across the supply chain. For efficient feedback systems, every member in the chain needs to see value in the feedback, and there needs to be a mutual commitment and shared vision between all value-chain partners. Further, feedback must be provided in an efficient and practical manner, so as to increase the willingness of the information providers to deliver the feedback. Producers should be involved in any attempts to enhance feedback systems. Since there is variability in the needs, wants and capabilities of processors and producers, multiple dynamic and flexible feedback systems are required. An incentive to enhance feedback systems is to provide a value proposition by calculating the monetary value of the feedback to all members of the chain. Better objective measurements and Meat Standards Australia for lamb is likely to also contribute to better feedback value propositions. Communication and fostering of relationships among supply-chain members will always remain critical. While data permissions add a complication to information sharing across the chain, benefits can be gained by not only the commercial producer, but the entire industry.

Additional keywords: feedback systems, information sharing, livestock value chains, supply chain.

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Introduction

Technologies for capturing data from different points in livestock value chains are developing very rapidly. They range from remote-sensing technology for weight and body condition measurements of grazing livestock, to food traceability phone apps on eating quality for consumer feedback. In the processing chain, technologies for objective livestock measurement are currently being investigated in the *Advanced Livestock Measurement Technologies* (ALMTech) project (Brown *et al*. 2017). The objective of the ALMTech project is to provide Australian beef, sheep and pig producers with more accurate descriptions of the key attributes that influence the value of their

livestock, including lean meat yield, eating quality and compliance to market specifications. One obvious opportunity for the use of such data-capture technologies is to provide commercial producers with useful feedback on attributes of the animals they sell, which can be used to enable better business decisions and on-farm management. Feedback information can also be beneficial for animal-selection decisions.

While new data-capture technology comes with the promise of producers and others being more informed about a system, what usually results is large and complex datasets. Raw data then are sometimes converted or transformed to usable information. A key challenge is to make use of these data or information. To obtain maximum benefit and value from the information generated from the captured data, feedback must first be relevant to a commercial producer's business and be delivered in a timely manner. This feedback must also be presented in a way that is understandable and usable by producers. In addition to usability of information, appropriate procedures must be in place to assist flow of feedback data and information. The present paper initially outlines the data-capture points and flow of information that occurs throughout the Australian beef cattle and meat sheep value chain. The avenues through which feedback can be delivered to commercial producers are briefly summarised, along with the value of this feedback and the factors that affect its value. Finally, practical principles for effective feedback systems are provided. While data capture is occurring throughout the value chain, the main focus of the paper is on carcass- and eating-quality feedback from processors to commercial producers.

Data capture along the value chain

The value chain can be pictured as comprising sectors that range from the seedstock breeder, commercial producer, processor and retailer levels, to the consumer level. Figure 1 (an extension of the data generation and flow in the lamb supply chain provided by Williams *et al*. 2013) is a simplified schematic of the data captured on animals, the flow of animals and the flow of data and information that occur throughout the domestic market value chain for beef cattle and sheep industries. While the present paper provides an overview of what is typical for each sector, business models vary, and so the degree of information captured can differ among species and enterprises.

The seedstock sector is responsible for providing genetics to the commercial sectors. To objectively evaluate the genetic merit of animals of seedstock, multiple measures of performance are collected from each animal and their relatives, as well as information on systematic effects (for example, age of measurement) and how they were managed. The recording of matings and relationships among animals (through pedigree records, or genomic testing) is generally accurate and complete in the seedstock sector. For example, cattle are required to have full pedigree for registration through breed societies, so as to

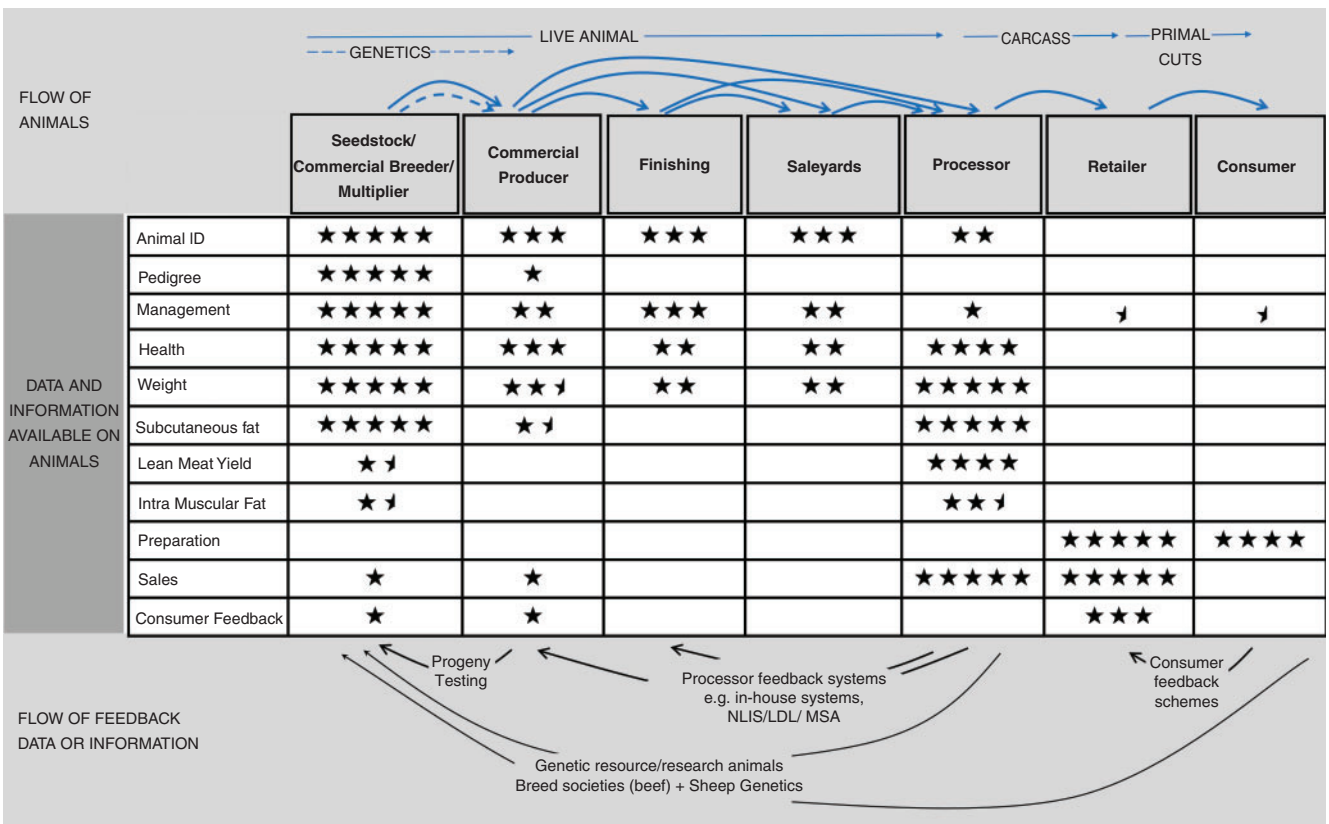

Fig. 1. Simplified schematic of the flow of animals, data and information available (higher degree denoted by more stars), and the flow of data and information in the domestic beef and sheep value chain (extended from Williams *et al*. 2013).

obtain estimated breeding values. There appears to be more variability in data recording among sheep breeders, with between 44% and 91% of sheep in the LAMBPLAN and MERINOSELECT database with complete pedigree records in 2015 (Collison *et al*. 2018). Commercial breeders choose genetics from seedstock herds, and multiply animals via commercial breeding programs. It is common within the Australian cattle and sheep industries that the seedstock breeder, commercial breeder and commercial multiplier can exist within the same enterprise.

Commercial producers can grow animals and finish them to a specific market weight, and sell them on as prime sales at the saleyards, or sell over the hooks directly to a processor. Alternatively, animals can be sold for finishing to feedlots, forage irrigators or stubble graziers. Producers tend to collect data on performance (such as live weight, fat depth and muscle depth) and management procedures (such as husbandry, nutrition and administration of medication). Performance is generally measured only once, if at all. However, there is considerable variation in the level of detail collected at the individual animal level. While animals may have individual identification (ID), pedigree is frequently not recorded. It is also important to note that, in Australia, all animals must be permanently identified using a National Livestock Identification System (NLIS)-accredited device before being moved off a property. In cattle, the NLIS IDs can be in the form of a visual ear tag or rumen bolus, and must be electronic radio frequency identification (RFID). Meanwhile, in sheep, no such requirements for RFID exist, except for in Victoria after January 2017.

The information collected at the finish stage include performance records on growth and managerial procedures. Morbidity and mortality rates may also be available on the individual-animal level (Perkins 2013). The genetic background and history of the animal is commonly not known. Saleyard records usually include animal movements and sale prices. Further information is collected by the National Livestock Reporting Service (NLRS) of Meat and Livestock Australia (MLA), where livestock market officers report weekly or monthly on saleyard markets, capturing data on age, live weight, muscle scores, fat scores and estimated carcass weights and prices (Meat and Livestock Australia 2016*a*).

In the processing sector, carcass information is recorded on an individual or mob basis. The recording capability and data collection can vary among processors, as documented for sheep processors by Goers and Craig (2008). Carcass traits typically recorded include hot standard carcass weight (HSCW), fat depth (P8 rump fat for beef or girth rib fat score for sheep), dentition and bruising (beef only). Lean meat yield can be predicted using carcass weight and fatness. For the 105 beef processors that are Meat Standards Australia (MSA) eating quality participants (Meat and Livestock Australia 2018), MSA-accredited graders use a data-capture unit to record measurements such as hump height, eye muscle area, ossification, AUS-MEAT and MSA marbling score, meat colour, fat colour, rib fat, pH and temperature (Polkinghorne *et al*. 2008). Some of these key attributes (MSA marbling, hump height, ossification and rib fat) are combined with other information to form an MSA index value (out of 80), which predicts the eating quality potential of the whole carcass. Health observations are recorded for product safety for human consumption, and for surveillance and monitoring of disease in general (for example, the National Sheep Health Monitoring Project; Animal Health Australia 2017) as well as targeted diseases (for example, the National Arbovirus Monitoring Program (Animal Health Australia 2018).

In the retailer sector (including independent butchers and supermarket chains), information is collected through sales, and consumer preferences are gauged using various consumer-feedback schemes (for example, The Bunch by Woolworths, https://bunch.woolworths.com.au/home, accessed December 2017) and through social media.

While there is much variation within each sector, the amount of data captured is increasing with new technologies. There are, therefore, opportunities to utilise these data, and to relay information back along the chain.

Feedback of information to producers

The amount of data and information flowing along the value chain can vary depending on the relationships among enterprises. The feedback that producers receive from processors varies in quantity and quality, and can be on an individual or mob basis. The mode in which carcass characteristics and payment for each carcass is provided to producers can vary, from on paper delivered through post or fax, to email or through an online system. Payment to producers is made either on a per head basis, or through carcass-pricing grids for carcass weight and fat depth. Information on condemns and lack of compliance is also provided via penalties; however, this may be only on the consignment level and not at the individual carcass level.

Depending on the state, there are requirements on the information provided by processors for beef cattle through NLIS. In New South Wales, body number, RFID or NLIS ID number, HSCW or liveweight, Property Identification Code (PIC) of consignment and slaughter date are required. However, if processors are located in Queensland, Northern Territory, South Australia and Western Australia, there are no such requirements to provide feedback information on carcass attributes through NLIS (National Livestock Identification System 2014). It should be noted that individual animal traceability during processing occurs only if the NLIS ID is transferred from the ear tag to the carcass, through methods such as hook tracking. For the 131 AUS-MEAT-accredited abattoirs (AUS-MEAT Limited 2018), the minimum feedback that is required to be provided for beef is at the individual carcass level (if payment is based on a weight and fat pricing grid), with feedback on HSCW, P8 fat depth, bruise score and dentition (AUS-MEAT Limited 2016*a*). However, feedback for lamb from an AUS-MEAT-accredited processor does not need to be on an individual basis (AUS-MEAT Limited 2016*b*). Mobs can be defined by fat class, with the number of lambs and the average hot carcass weight provided.

Several studies have examined data-capture techniques and information flow each sector and the feedback systems in the Australian red meat supply chain. Key studies include reviews of sheep feedback systems by Goers and Craig (2008) and Williams *et al*. (2013); a review of technologies and feedback systems for the beef and sheep industries was provided by

Bowler (2014); and the value of feedback through Livestock Data Link (LDL) and future developments for the system was provided by Green *et al*. (2017). Goers and Craig (2008) found differences in data capture and producer feedback among processors and proposed a standard feedback system. Williams *et al*. (2013) highlighted that at each stage of the sheep value chain, 'data islands' form due to the lack of information flow, and most of the information collected remains unused. Bowler (2014) further confirmed that technology is not the limiting factor for improved feedback to producers. Bowler (2014) also states that there is inconsistency in the levels of demand or desire to connect these 'data islands', with some members seeing no value in feedback, while others want as much detail as possible. Both Williams *et al*. (2013) and Bowler (2014) identified feedback and data capture on the individual animal level as a key element of feedback. Green *et al*. (2017) identified LDL as a tool not only for compliance feedback, also as a supporting link to integrate new data sources from across the entire supply chain (for example, genetics, weather and spatial data). The four studies mentioned here identify some common factors that inhibit the effectiveness of feedback systems, including lack of understanding about the value of information, lack of commercial drivers and inconsistent data formats. Clearly, a mutual commitment among supply-chain partners is required in the design, implementation and improvement of feedback systems. However, since the needs, wants and capabilities of producers and processors are so variable, multiple dynamic and flexible feedback systems will exist.

Current feedback systems

Most processors have some form of in-house data-collection, -storage and -reporting system. Some are public, while others are private systems (designed in-house). However, there are three systems that operate at a national level and enable processors to provide feedback to producers, including the following: NLIS, LDL and myMSA.

The NLIS system database is designed to contain records on all movements of cattle, sheep and goats, if moved across properties with a different PIC (National Livestock Identification System 2014). The recorded animal movements can be between producers, or from producers to processors. Carcass feedback for cattle is available through NLIS using a 'carcase feedback query' report. The minimum amount of information provided by processors varies with each state, but can include date of slaughter, NLIS/RFID ID number, body number, vendor's PIC and HSCW or live weight. However, anecdotal evidence suggests that the 'carcase feedback query' on the NLIS website does not appear to be commonly known or used, nor does it appear to be regulated.

Livestock data link is an online web portal that was originally created to provide feedback on compliance and provide a cost of non-compliance from pricing grids (Meat and Livestock Australia 2016*b*). The data currently shared to producers through LDL include carcass traits (HSCW and fat) and non-compliance cost, and has the capacity to report on an individual or mob basis. The frequency of health issues are also available for sheep.

myMSA is an online feedback system on eating quality performance of the carcass, derived using the MSA grading system. This is currently available only for beef, with myMSA for sheep reported to be currently under construction. The implementation of MSA for lamb and feedback into industry supply chains will provide better feedback and value propositions for all parts of the supply chain. The myMSA website provides quick reporting and allows benchmarking, and provides downloadable data. Information provided to producers includes plant, kill date, body number, processor ID, RFID/NLIS number, eating quality scores and MSA index value. However, it has been reported that very few participants have accessed feedback through this system.

Multiple systems are currently available, through which processors can provide producers with feedback on the livestock they supply. However, apart from the minimum legislative requirements for NLIS and information provided for payment, the degree of feedback provided appears to be dependent on individual processors. A further complication to providing carcass feedback to commercial producers arises when livestock are finished by a third party (e.g. feedlot). Since carcass data can be given only to the vendor (or consignment property) who supplied the livestock, a commercial producer is reliant on the third party to pass on the information back to them. In general, so as to maximise the value of feedback, guidelines for the ownership of data and privacy issues must be considered.

Value of feedback to commercial producers

Commercial producers can benefit from feedback from processors, (feedlots), retailers and consumers. Feedback from processors can assist in understanding where their livestock fall short of, or meet, market specifications and compliance. The cost of non-compliance of beef carcasses was estimated at AU $127–AU$164 million per annum (ProAnd Associates Australia 2012). Therefore, feedback can to allow refinement of on-farm management strategies and targeting of specific attributes in livestock to improve compliance and profitability. Carcass health inspections can also assist with decisions affecting disease management. The cost of disease and health conditions in sheep, lamb and goats has been estimated at over AU$110 million per annum (GHD Pty Ltd 2011). Management decisions to increase the health of livestock will ensure production efficiency, and reduce the risk of carcass trim, downgrading and condemnation. Feedback from retailers and consumers may allow producers to better understand desired attributes of products. Provided that the feedback is interpretable and a producer is able to make changes accordingly, the value of feedback ultimately depends on the producer's ability to make better business decisions as a result of having access to that data or information.

The monetary value of feedback to commercial producers has not yet been quantified. So as to quantify the value of feedback, the relative performance of information sharers and non-information sharers can be compared. Measures can be derived to quantify the willingness of the information providers to deliver the feedback, as well as the willingness of receivers to pay for the feedback. The monetary value can

also be based on the extent to which producers know how to, and can afford to, respond by making different decisions on the basis of the feedback.

Feedback from processors can be of additional benefit to producers if it is further distributed to seedstock breeders. Carcass feedback on the progeny or siblings can be used to improve predictions on the genetic merit of breeding stock, provided that information on systematic effects, managerial environments, and genetic information on the animal (through pedigree or genomic testing) are available. Performance data can allow a seedstock breeder to tailor breeding objectives to specific markets, and refine economic values, especially if there is a market signal for specific attributes. To do this, information from the production environment and market requirements of the commercial sectors is needed. Therefore, communication and feedback from the supply chain to seedstock breeders is crucial for genetic improvement. In turn, genetic improvement can help increase profitability for producers and the entire industry. The value of the quantity and quality of information used to evaluate the genetic value of animals and genetic selection could be quantified by comparing response to selection with and without the feedback data. Feedback on health conditions observed on the slaughter floor can also be used for the genetic improvement of health (Gunia *et al*. 2015; Mathur *et al*. 2018). Genetic gains achieved in seedstock populations result in subsequent transfer and realised gain in commercial livestock populations through the sale of rams, bulls or semen. Therefore, there is benefit for commercial producers when feedback information on specific attributes of animals is further relayed to seedstock producers.

Factors affecting value of feedback

Several factors influence the value of producer feedback. These include accuracy, granularity (relative size, scale and level of detail), connectedness with other data (including breeding parameters), and options a producer has to utilise the information. These factors are not independent.

The value of feedback to commercial producers reduces with accuracy of feedback. The feedback provided must accurately describe variation in performance, which is measurable by precision and bias. Any measurements on livestock attributes require a level of repeatability, with minimal operator bias. Any mistrust or perceived lack of fairness can affect the potential use of feedback data. This was shown by Devitt *et al*. (2016), where meat-inspection data were perceived as useful by Irish pork producers. However, these producers also questioned the disease and injury data as animal health and welfare diagnostic tools, because of how feedback was provided and how it was to be used. Therefore, the collection and use of these data must be transparent to producers. To increase trust and credibility, any feedback provided on specific attributes of livestock should be objective, as opposed to subjective, and requires rigorous testing. Measurements of lean meat yield, fat and bone from computer tomography (CT) scan can be considered the ‘gold standard’. However, the high cost of CT scanning has resulted in a search for alternative technologies. A key component of the ALMTech project is to calibrate and demonstrate the accuracy of new technologies, in comparison to CT scan measurements. If the accuracy of measurement technology is high, producers and processors are more likely to have greater confidence in the data and information, which, in turn, increases the value of the feedback. High-quality information has also been found to be an important determinant for the sustainability of relationships across the supply chain (Fischer *et al*. 2008).

The value of feedback also increases when producers perceive the feedback as useable to improve managerial decisions. This includes the ability to utilise the data or information, as well as the desire to use it. The avenue in which it is provided can also influence the value of feedback. Access to feedback needs to be user friendly, and easily interpretable. Further, the feedback is of value only if a producer has the ability to act or make changes according to the feedback, and if the producer can clearly see the likely benefit arising from taking that risk.

The value of feedback can be maximised when it becomes a source for other sectors in the supply chain. The use of feedback for genetic improvement benefits commercial producers indirectly. As mentioned above, if feedback data can be mapped to other data sources such as breeding parameters, this presents opportunities for genetic evaluation. For this to happen, the animals from which these measurements are taken need to be genetically informed, have information available on their contemporary groups (management environments), and have individual unique animal IDs that are either consistent throughout the chain, or that can be traced back. Clearly, not all data are equal or useful. The data required for genetic evaluation, and considerations for how they are recorded, are outlined in guidelines such as by BREEDPLAN (2016) for beef and Sheep Genetics (2005) for sheep. Important aspects to be considered when using commercial carcass data for genetic evaluation include what traits are recorded, method of recording, frequency of recording, accuracy of recordings and the alignment of the carcass to animal ID. The management of the database and guidelines for how traits are recorded also need to be maintained and up-to-date. In addition to this, feedback on traits is valuable only if these traits exhibit genetic variation. For information to be shared, this requires a mutual agreement between producers and seedstock breeders, or between finishing and feedlot enterprises and seedstock breeders. The quantity and quality of information shared has been shown to be affected by trust and shared vision among supply-chain members (Li and Lin 2006).

Another major factor that can influence the value of feedback relates to industry-level choices. Currently, producers are paid on a per head basis, or through weight and fat pricing grids. However, if producers are paid for more specific attributes (such as lean meat yield or saleable meat yield, intramuscular fat or eating quality, and health or compliance and quality) this will increase value of the feedback as it provides a financial incentive to use the feedback. The value of each animal can be increased either through management or genetic improvement. Therefore, a clear market signal will greatly increase the value of feedback.

Basic principles for feedback systems

Taking into consideration the factors that may affect the value of feedback and the limiting factors highlighted by previous studies examining feedback systems, the following are proposed

principles for effective feedback systems. This applies to all interfaces and relationships across the supply chain:

- Every member in the chain needs to see value in the feedback.
- There needs to be a mutual commitment and shared vision among all value-chain partners.
- A commercial driver or financial incentive is likely to be required to motivate use of these systems. This can include payment for specific attributes.
- Feedback systems need to be affordable for both the information provider and information receiver.
- Information receivers must understand the feedback easily, and have the choice to respond to feedback. Receivers must know how to respond, and can afford to do so.
- Since producers are the end-users of the feedback, they should be involved in any attempts to enhance feedback systems.
- Information receivers must have realistic expectations from actions as a result of feedback.
- A practical pipeline to allow data flow among sources is required. Standard data formats can allow easier integration of multiple databases.
- The integrity and security of the data must be maintained. Access to the feedback must be secure.
- There needs to be a certain level of flexibility in what is accessible by the producer. The system needs to be able to cater to those who want just the basic information, as well as those who want more detail.
- If feedback information is being extended to seedstock suppliers for genetic evaluations, individual ID with links to known pedigree, identifiable management groups, and genetic linkages across groups are required.

Future prospects

Several European countries work on cooperative livestock or meat systems. These systems involve coordination and cooperation among partners in the supply chain, which have allowed competitiveness in export markets. One key strength that has enabled these cooperatives to meet demand and remain competitive is the efficient transfer of product-quality information along the production-processing chain (Hobbs *et al*. 1998). This synergy highlights the need for mutual commitment and shared vision among all value-chain partners. The Team Te Mania program is an example of a cooperative network that has formed in the Australian meat industry. This program is a commercial alliance between the Te Mania Angus seedstock suppliers and commercial producers, where participants in the program can lease bulls and have access to semen at cost price (Te Mania Angus, https://www.temaniaangus.com/team-te-mania/program, accessed October 2017). In return, production data and performance records are utilised by the seedstock herd for the refinement of breeding programs. Carcass feedback has been identified as valuable for increasing accuracy of breeding values and more profitable breeding programs (Te Mania Angus, https://www.temaniaangus.com/team-te-mania/program, accessed October 2017).

There are opportunities to enhance production systems through feedback of health conditions routinely recorded in abattoirs. While there are various programs in place for disease monitoring and surveillance, this health data should also be provided to the producers who supply these animals. This can be made possible through programs such as the South Australian Enhanced Abattoir Surveillance (EAS) program (Biosecurity SA PIRSA 2017), which notifies producers of health conditions and provides fact sheets about the issue. There are also on-going developments in LDL reporting capabilities for health feedback. Abattoir inspections for health conditions are a key monitoring tool for diseases, and feedback can be further utilised to improve management decisions on-farm, as well as for the genetic improvement of health.

An alternative that has potential to increase the value of feedback to commercial producers is a centralised database. This may provide more consistency in feedback and spreads fixed costs over a larger scale. For example, the Irish Cattle Breeding Federation (ICBF) established a central database that includes information on animal movements, as well as performance records. Records on the ICBF database include birth registrations (pedigree), fertility data, health events, liveweights and carcass data (Irish Cattle Breeding Federation 2013). Data from specific schemes, such as the Calf Docility and Quality scheme, are included in the database. The ICBF use these data to provide routine genetic evaluations across various breeds and traits, which also allows producers to benchmark their performance. An alternative use of the database is to monitor cattle health events across the country, which can also apply to health inspection of carcasses in abattoirs. However, it should be noted that Ireland has fewer producers, each with relatively small herds. Therefore, the success of such a scheme can be attributed to the smaller scale of the industry in Ireland than in Australia.

Conclusions

While the amount and type of data collected along the supply chain is rapidly increasing with technology, the flow of data and information among members of the chain varies significantly in volume, nature and quality. The value of feedback depends on several factors, such as its accuracy, granularity, and connection to other data. Producers should be involved in any attempts to enhance feedback systems. Since there is variability in the needs, wants and capabilities of processors and producers, multiple dynamic and flexible feedback systems are required. An incentive to enhance feedback systems is to provide a value proposition by calculating the monetary value of the feedback to all members of the chain. Better objective measurements and MSA for lamb are also likely to contribute to better feedback-value propositions. Communication and fostering of relationships among supply-chain members will always remain critical. While data permissions add a complication to information sharing across the chain, benefits can be gained by not only the commercial producer, but the entire industry.

Conflicts of interest

The authors declare no conflicts of interest.

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