

marine products, particularly fishmeal and fish oil, to being mainly based on terrestrial products. One of the most important on-going strategies for feeding aquaculture is continually refining feeds to ensure they remain sustainable. This is especially the case for intensive aquaculture systems that rely on formulated manufactured aquafeeds. Ingredient screening and development underpin this and sit alongside other strategies to improve animal performance and increase how efficiently feeds are used.

Aquaculture has global reach and offers aquaculture systems that are appropriate in different regions depending on environmental, cultural and socio-economic factors. For Atlantic salmon, off-shore and land-based systems are being discussed. Location-specific integrated multi-trophic aquaculture provides one direction with great promise, it also reflects the 3000 year old history of aquaculture that achieved an elegant solution through integrated polyculture.

**Funding source(s):** N/A.

#### References

1. FAO. 2014. Yearbook of Fishery Statistics - Summary Tables and Data Query [Online]. Rome: Food and Agriculture Organisation of the United Nations. Available at: <http://www.fao.org/fishery/statistics/global-commodities-production/en> [Accessed 18 May 2014]

#### AUSTRALIAN NATIVE SHRUBS: DELIVERING BENEFITS TO LIVESTOCK, SOIL, PLANTS AND PEOPLE

D.K. Revell<sup>1,2,3</sup>, P.E. Vercoe<sup>3,4</sup>, A.C. Kotze<sup>2</sup>, J. Emms<sup>3,5</sup>. <sup>1</sup>Revell Science, Duncraig, WA, Australia; <sup>2</sup>CSIRO Agriculture Flagship, Australia; <sup>3</sup>Future Farm Industries CRC, Floreat, WA, Australia; <sup>4</sup>The University of Western Australia, Australia; <sup>5</sup>SARDI, Adelaide, SA, Australia  
E-mail: [Dean.Revell@csiro.au](mailto:Dean.Revell@csiro.au) (D.K. Revell)

**Background:** Grazing ruminants – which are capable of supplying high-quality protein for human consumption from landscapes and environments that are not always amenable to crop production – are, in essence, their own nutritionists. They are required to select forages that best meet their requirements, with the challenge of coping with temporal and spatial variability in plant species, forage abundance and chemical composition of the plants. Ruminants select their diets based on expected nutritional rewards and post-ingestive feedback that links nutrient supply to metabolic requirements. To successfully adapt to a variable nutritional environment, animals require dietary choice. Under conditions of low nutrient supply, such as during a seasonal drought, a heterogeneous environment with a variety of forage types leads to higher levels of animal productivity.

**Why Australian shrubs?** In grazing systems of southern Australia based on annual pasture species, there are often ‘feed gaps’ in autumn when feed quantity and quality limit animal production. The ‘Enrich’ research project has explored the potential for Australian shrub species to contribute to the diet of grazing livestock to partially fill these ‘feed gaps’, improve the management of natural resources, and increase farm profitability. Another potential benefit, which is less recognised, is a possible improvement in the nutritional quality of the meat produced from animals that consume a more diverse range of plants.

**On-farm benefits, including nutrition and health of livestock:** From over 100 Australian shrub species tested, we identified those that: (i) produced adequate levels of edible biomass and re-grew after moderate-heavy grazing; (ii) provided green feed in autumn when annual plants were senesced (dead); (iii) possessed a nutritional composition that complemented other pasture species, principally by providing adequate to high levels of crude protein and minerals, and moderate levels of digestible energy (1); (iv) grew well with companion pasture species; (v) were selected by livestock as part of a mixed diet, particularly when grazing management allowed animals to learn about the attributes of the novel forages (1); (vi) had desirable characteristics when fermented by rumen microbes *in vitro*, including high levels of volatile fatty acids and/or reduced methane production (2); and (vii) reduced development of gut parasites *in vitro* (3). At the farm-system level, we found that grazing shrubs in autumn allowed farmers to defer the grazing of other pastures on the farm, thereby increasing whole-farm productivity and better managing vegetation cover. We also found an improvement in the microclimate of shrub-based paddocks, which would help conserve soil moisture and provide a more suitable thermal environment for livestock, potentially reducing maintenance energy requirements.

**Benefits to people:** Bio-economic modelling showed that the addition of Australian forage shrubs could increase whole-farm profit or maintain whole-farm profit with reduced risk (4). We propose a further advantage to people beyond farm economics: bioactive plant compounds for health. Plants growing in challenging environments, especially those that have not been selected for use in agricultural monocultures, often use bioactive phytochemicals as part of their defence or survival mechanisms. We have shown bioactivity in some Australian shrub species in terms of effects on microbial activity and gut parasite larvae, yet a relatively unexplored area is the potential for beneficial levels of plant-derived compounds in the meat of animals that consume these plants. Meat from sheep grazing saltbush (*Atriplex spp.*) contains elevated concentrations of vitamin E<sub>5</sub>, and we suggest there are likely to be other phytochemicals that may enhance the nutritional value of meat from animals selecting a diverse diet that includes bioactive plants. By altering the range of plants consumed by animals, a broader assessment of meat traits, including ‘extra-nutritional’ factors, would seem warranted.

**Funding source(s):** Future Farm Industries Co-operative Research Centre and Meat and Livestock Australia.

#### References

1. Revell DK, Norman HC, Vercoe PE, Phillips N, Toovey A, Bickell S, Hughes S, Emms J. Australian perennial shrub species add value to the feedbase of grazing livestock in low-medium rainfall zones. *Anim Prod Sci.* 2013;53: 1221-30.  
2. Durmic Z, Hutton P, Revell DK, Emms J, Hughes S, Vercoe PE. In vitro fermentative traits of Australian woody perennial plant species that may be considered as potential sources of feed for grazing ruminants. *Anim Feed Sci Technol.* 2010;160: 98-109.  
3. Kotze AC, O’Grady J, Emms J, Toovey AF, Hughes S, Jessop P, Bennell M, Vercoe PE, Revell DK. Exploring the anthelmintic properties of Australian native shrubs with respect to their potential role in livestock grazing systems. *Parasitology.* 2009;136: 1065-80.  
4. Monjardino M, Revell D, Pannell DJ. The potential contribution of forage shrubs to economic returns and environmental management in Australian dryland agricultural systems. *Agric Systems.* 2010;103: 187-97.  
5. Fancote CR, Norman HC, Vercoe PE, Pearce KL, Williams IH. Grazing saltbush (*Atriplex spp.*) during summer improves vitamin E concentration in muscle and colour stability of retail meat cuts. Proceedings of the 62<sup>nd</sup> Annual Meeting of the European Association of Animal Production, Stavanger, Norway. 2011; p.48.

#### Plenary 4: “new” plant foods

##### NEW CEREALS AND PSEUDOCEREALS IN AUSTRALIA – HYPE OR REAL NUTRITIONAL BENEFIT?

A.R. Bird<sup>1</sup>. <sup>1</sup>CSIRO Food and Nutrition Flagship, Adelaide, SA, Australia  
E-mail: [tony.bird@csiro.au](mailto:tony.bird@csiro.au)

Pseudocereals, such as buckwheat, amaranth and quinoa, are broadleaf plants whose seeds have a gross structural anatomy and culinary applications akin to those of the grains of (true) cereals. Indeed, they are promoted as alternatives to the more familiar cereals, especially ones containing gluten, and are being increasingly sought as ingredients in bakery items and other commercial food products. Pseudocereals are also garnering attention on websites and in the popular press where they are lauded as ‘superfoods’ on the basis of their nutritional credentials, especially the presence of unique antioxidant compounds, and many presumed health benefits.

But the claims are overstated and not well grounded in evidence. Individual differences aside, the nutrient profile of most pseudocereals and conventional cereals is not markedly different. Both are rich in essential minerals and B group vitamins. The germ and outer layers of grains from both groups of cereals are also abundant in dietary fibre, phenolics and other bioactives, although fibre diversity tends to be greater for cereals. Typically, processed pseudocereal and cereal grain products contain little resistant starch and have moderate to high glycaemic indices.

Whereas the evidence linking regular consumption of wholegrain cereals and cereal fibre with reduced risk of several major diseases is well documented, there is little empirical data on the health benefits of