High Sugar Ryegrass for Sustainable Production of Ruminant Livestock and Reduced Environmental N Pollution

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Mike Theodorou is head of Plant Animal and Microbial Sciences (PAMS), which is one of three research departments at the Institute of Grassland and Environmental Research (IGER). He trained as a microbiologist and spent the last twenty five years working on microbial ecosystems and how plants are degraded by micro-organisms in the rumen. Latterly, he has become involved in research relating to sustainable agriculture focusing on how farming practice will change in Europe as a consequence of reform of the European Common Agricultural Policy (CAP).

Ruminant livestock are effective at extracting energy from food that monogastric animal are unable to use (e.g. energy from plant fibres). However, they are relatively inefficient in using feed proteins, meaning that a large proportion of the nitrogen that is consumed by cattle and sheep is excreted onto the land rather than being incorporated into useful products such as meat and milk. Increasing the efficiency of feed protein utilisation can be achieved by balancing the diet with supplementary energy sources, such as cereal grains. However, this is expensive compared to grazed grass, and can be difficult to achieve with grazing livestock. Recent advances in grass breeding have led to the development of perennial ryegrass varieties that express high levels of water-soluble carbohydrates (sugars), to balance the proteins in the grass, allowing the animal to make more efficient use of the plant nitrogen.

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Ruminant nutritionists have known for some time of the fundamental problems associated with the microbial fermentation of dietary components in the ruminant fore-stomach. Over the last 50 years, they have devised many ways of enhancing the conversion of dietary proteins into microbial proteins (or the by-passing of this fermentation) in order to increase delivery of amino acids for absorption in the small intestine and hence for growth and/or milk production. Often, this has involved addition of large quantities of protein to the ruminant diet and paradoxically because of intrinsic conversion inefficiencies, animals are oversupplied with protein, leading to environmental pollution, making some ruminant feeding strategies unattractive and distinctly unsustainable.

Prior to considering mechanisms for altering/enhancing N-conversion efficiency in the forage-fed ruminant, it is first necessary to understand some of the basic concepts associated with the digestion of plant proteins in the rumen. Although it is generally assumed that plant proteins are broken down in the rumen is a process mediated by microbial enzymes, there is increasing evidence to suggest that both plant and microbial proteases are active in ingested fresh forage. After fresh plant biomass enters the rumen and prior to extensive plant cell-wall degradation, there is often a phase of rapid proteolysis in excess of that needed to maintain the rumen microbial population and we now believe that plant enzymes largely mediate this initial proteolysis. An understanding of the mechanisms that underlie these processes is essential if we are to devise plant-based strategies to manipulate them.

Regardless of underlying mechanism(s), ruminant production systems are inefficient because of an imbalance in nutrient supply, i.e. asynchronous release of nitrogen and energy for microbial fermentation. Two possible ways of increasing the capture of forage protein during microbial fermentation are firstly increase readily available energy during initial fermentation (the concept behind IGER's breeding programme for high sugar ryegrasses) and secondly to protect plant proteins in order to reduce the rate at which they become degraded.

Whilst there are many challenges ahead in developing livestock agriculture according to the sustainability concept advocated by scientific policymakers, there are a number of areas relating to ruminant nutrition where consideration of crop quality would seem to provide opportunities. Firstly, enhancing N-use efficiency in ruminants would not only increase the productive efficiency of ruminant enterprises but also reduce environmental burden. Secondly, exploring and exploiting protein protection mechanisms in plants could result in more natural mechanisms of parasite control and a reduction in anthelmintics drug usage. And finally, linking quality in ruminant products to health benefits in humans could contribute in helping to position these enterprises within the context of a healthy lifestyle. In our view, the key to success in these endeavours are two-fold and relates to (a) obtaining a better understanding of digestive tract function within the context of the whole animal and (b) elaborating new criteria to breed

forage plants that are pre-disposed to behave in a particular way, or to cause a particular behaviour(s), during their degradation and passage through the ruminant digestive tract.

This workshop will seek to demonstrate the principles behind the way in which the high sugar grass varieties exert their effects. These relate to the fact that a better balance of energy and nitrogen in the diet of animals will contribute to reduce the concentration of ammonia in the rumen and lead to reductions in the excretion of nitrogen in urine. This is achieved through increased intakes of high sugar ryegrass and/or the improved partitioning of nitrogen in their rumen towards ruminant products and away from wasteful excretion.

The workshop will consider how ruminant livestock can milk or grow as well on these high sugar ryegrasses as they can on traditional grass pastures, while using the grass proteins more efficiently, resulting in the production of less environmental pollution in farming systems using these animals. We will discuss the implication of results from proof-of-principle research, which show that the efficiency of utilisation of feed nitrogen was increased in beef and dairy cattle, and that this was related to rumen fermentation.

In addition to proof-of-principle studies, which are carefully controlled to investigate underlying mechanisms and conducted on a relatively small scale, some of our research investigates milk and meat production from high sugar ryegrass on a larger scale, and includes production from grass silage as well as from fresh grass. We will also consider how the benefit of these research results can be achieved in conventional farming practice.

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