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Scientific Expert Panel

Evaluation of the impact of gastrointestinal conditions on the health and welfare of ruminants

1. Introduction

This document is part of a set of documents developed by the IFIF with the support of the IFIF Scientific Expert Panel and adopted by the IFIF Working Group (WG) on' Nutritional Innovation to Promote Animal Health'.

The IFIF WG was launched in 2017 with the objective to have '*animal nutrition solutions contributing to animal health and animal wellbeing **scientifically recognized, clearly understood,** and benefit from a proper regulatory **framework** to be valorized and implemented*'.

Nutritional solutions, now called nutritional strategies are aimed to support the development of animal adequate nutrition.

Adequate nutrition is defined as '*the oral intake of animals of adequate levels of nutrients, substances, microorganisms, and other feed constituents, considering their combination and presentation, necessary to fulfill functions related to their physiological states, including the expression of most normal behavior, and their resilience capabilities to cope with stressors of various type encountered in appropriate husbandry conditions.'* Furthermore, the way to achieve adequate nutrition is described as follows:

- *Optimization of feed composition, manufacturing, presentation, and delivery to animals,*
- *Minimization of the exposure of animals to stressors in feeds,*
- *Coverage of the animal's requirements for maintenance, activity, growth, production, and reproduction,*
- *Support of digestion and physiological functions, body systems, and behavioral expression.*

The purposes of these documents are to provide

- The developers of nutritional strategies with information on the way to evaluate the effectiveness of their strategy for a given purpose
- The evaluation bodies in the different jurisdictions with an approach for the evaluation of the effectiveness of nutritional strategies for a given purpose.

Each document will provide recommendations with a focus on a specific purpose, in relation with microbiome, gut function, exposure control, immunity, physiology, and others. The information provided in the document does not depend on a particular nutritional strategy and may be used to evaluate any nutritional strategy having an impact on rumen conditions.

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The present document is focusing on the impact of the gastro-intestinal conditions (especially ruminal pH and redox potential) on the health and welfare of ruminants.

2. Scope

This document outlines how rumen conditions (pH and redox potential) influence the health and welfare of ruminant animals and the methods for evaluating the interrelationships among them. Since the pH value and redox potential are two interrelated indicators of the rumen physiological condition induced by its microbiological ecosystem (Huang et al. 2017), this document will focus on rumen pH, rather than redox potential.

3. Descriptions of endpoints

As the largest stomach compartment of ruminant animals, the rumen serves as the primary fermentation chamber where complex carbohydrates and nitrogenous compounds are broken down by the microbes it harbors. Recalcitrant carbohydrates such as cellulose and xylans can only be digested in the rumen. The fermentation of carbohydrates produces short chain fatty acids (SCFAs)[1] and lactic acid in the rumen and under optimal rumen conditions, the SCFAs can account for approximately 70% of dietary energy for ruminants (Bergman 1990; Hungate 1975).

An optimal rumen condition depends on the rumen microbiome, which, in turn, depends on what the animal consumes (McGrath et al. 2018). The pH in the rumen fluctuates depending on diet, which in turn, determines the types of microorganisms that dominate the rumen ecosystem (Dijkstra et al. 2020). For instance, under neutral or slightly acidic pH condition (c. pH 6.2-7.0), the rumen functions properly and microbial fermentation of fibrous substrates is optimal, whereas ruminal pH values below 5.6 and 5.2 signal chronic and acute cases of acidosis with an increased concentration of lactic acid, respectively (Owens et al. 1998). This is when the nexus between nutrition, health and welfare is clearly displayed, i.e., inappropriate feeding management leads to significant health issues under acute cases of acidosis, and on-going morbidity and welfare problems under sub-acute acidosis. In addition, changes of diets during transition periods (such as start of lactation, change from backgrounding diet (pasture) to feedlot diets (concentrate)) may also lead to sub-acute or acute acidosis in ruminants.

4. Parameters for the evaluation of the endpoints

There are well established techniques for the measurement of both rumen pH and rumen redox potential. As outlined in Section 3, there is a clear link between rumen pH or rumen redox potential and health or welfare of ruminants. Scientifically, pH measurement is easy and accurate and there are a number of well-established techniques for it.

5. Methods to measure the parameters

There are two broad approaches that are widely used to measure rumen pH (Danesh-Mesgaran, 2020). They all involve the collection of ruminal fluid samples either via a rumen cannulation (RC) (Nocek 1997) or by the insertion of an oral stomach tube (ST) in the rumen (Ramos-Morales et al. 2014; Muizelaar et al., 2020). Although there are a few variations in the way each general approach is used, the common purpose in both approaches involves sampling ruminal fluid over time to see the

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[1] Note that in ruminant nutrition, short chain fatty acids also refer to Volatile Fatty Acids. In this guideline, for consistency reasons, the wording short chain fatty acids will be used.

pH values and evolution in the rumen. Penner et al. (2006) elucidated and validated a number of techniques for the RC approach and Lage et al. (2020) comprehensively compared the RC approach with the ST method in dairy cows.

In practice, there are numerous limitations for both approaches. For the RC method, a number of animals must be operated to install a cannula on their rumen, a procedure requiring specialized expertise for surgery whilst imposing a high level of animal ethics obligations to the user. But the RC techniques generally provide an accurate means of measuring changes in pH over time and monitoring, and hence preventing, the occurrence of ruminal acidosis in ruminants.

The ST approach, on the other hand, removes the necessity of performing surgical procedures on the animal, but the various techniques used under this approach have been suggested to lack accuracy compared with the RC approach in general (Lage et al. 2020).

This leaves the rumen bolus technique (Antanaitis et al. 2020), which is a highly viable, welfare-friendly technology where a protected electrode (the bolus) is orally placed in the rumen of the animal and then continuously monitors the rumen conditions wirelessly.

Today, ready-made “bolus kits’ are easily available from a number of commercial entities around the globe.

6. Conclusions

The pH values in the rumen are a very strong indicator of digestibility efficiency, ruminal health, and welfare of ruminant animals. There are well established techniques for the measurement of rumen pH, but the most accurate methods require the surgical installation of cannula in the rumen. The rumen bolus technique overcomes all the deficiencies of other methods and combined with the commercial availability of rumen bolus kits, it is nowadays the technique of choice for real time, repeated monitoring of rumen conditions with high accuracy and a low long-term cost, applicable under farm conditions.

7. Abbreviations

SCFAs: Short Chain Fatty Acids

RC: rumen cannulation

ST: oral stomach tube

8. References

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9. Glossary of Terms

Endpoints: The measurable impact of a nutritional strategy on the animal, its physiology, or its microbiome.

Health: The state of normally functioning animal, especially the state of being sound, free from physical disease, pain or (symptom of) stress.

Welfare: The physical and mental state of an animal in relation to the conditions in which it lives and dies.