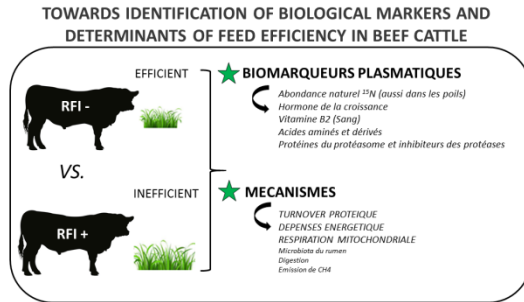


# UMR Herbivores

## Feed values, ingestion, digestion, and nutrients Team (Dinamic)

### Towards identification of biological markers and determinants of feed efficiency in beef cattle



For sustainable livestock systems, animal productivity should be associated with an improvement of the animal's ability to transform feed into animal products (i.e. feed efficiency; FE). The mean FE for a given diet is relatively well characterized thanks to the new updated feeding systems for ruminants, however there is still a high between-animal variability around this mean which should be evaluated in order to i) improve genetic selection on this trait et ii) match the type of diet to the individual's potential (i.e. precision feeding system). Different candidate biomarkers of FE have been identified from easy-to-access samples in fattening young bulls fed diets rich in fiber. Some of these biomarkers suggest a key role of protein (turnover) metabolism in the between-animal variation of FE, whereas the study of rumen microbiota and determination of diet digestibility showed a significant but weak relationship. These experimental results agree with our comprehensive review concluding that digestive components of FE, unlike metabolic ones, have a weak contribution to the between-animal variability of FE.

Ruminants have the extraordinary ability to transform human-inedible feeds (e.g. grasses, forages and by-products rich in cellulose) into high-quality human-edible food (e.g. meat, milk). The efficiency of this conversion is low but highly variable between animals (Saviotto et al., 2014), providing an opportunity to select for increased feed efficiency. For measuring animal feed efficiency, a strict control of individual intake and weight gain over a long period is needed. This is not possible to do in field conditions and on large numbers of animals. Consequently, biological markers should be explored as proxies for feed efficiency.

Also, the reasons why comparable animals reared in similar conditions have such different abilities to transform feed into food is a topical issue for the beef industry. Indeed the insights we can gain on the biological determinants underlying the animal-to-animal variation in feed efficiency (Richardson et al., 2004) will i) provide information on the undesirable side effects of selection for feed efficiency and ii) reveal novel management strategies to improve performance of feed inefficient animals and better match diets to individual animal requirements. These issues are being addressed in a French national program called BEEFALIM 2020, which has in part been conducted at the INRA Herbivores Research Unit over the last three years. This programme aimed at exploring low-invasive biological markers of feed efficiency in animals fed high-forage diets as well as studying biological mechanisms underlying the between-animal variation in feed efficiency.

Different candidate biomarkers from easy-to-sample matrices have been identified in fattening young bulls fed high-forage diets (Meale et al., 2017; Cassar-Malek et al., 2018). They concern the natural <sup>15</sup>N abundance in plasma proteins (bulk N but also in specific amino acids), the plasma (blood) concentration of the growth hormone and vitamin B2, as well as other metabolites and proteins revealed by metabolomics and proteomics. A common metabolic pathway has been identified from some of these biomarkers, suggesting that protein turnover (the continuous synthesis and degradation of tissue proteins) may have a role in explaining the between-animal variability in feed efficiency in beef cattle. These results agree with i) higher weights of viscera observed in less efficient animals (Meale et al., 2017) and ii) the tight relationship between protein turnover and energy expenditure, both likely to be the true determinants of the between-animal variation in feed efficiency (from a recent review coordinated by our team; Cantalapiedra-Hijar et al., 2018). Although significant differences were also observed across individuals ranked as high or low efficient in terms of total tract apparent digestibility (De la Torre et al., 2016, 2018) and rumen microbiota biodiversity (Meale et al., 2016) they were judged as minor and partly related to the associated changes in feed intake usually observed across high vs low efficient animals (Cantalapiedra-Hijar et al., 2018).

The candidate biomarkers are currently being validated and completed using large size experiments (n ≈ 400 growing heifers and 560 young bulls). In addition the ability of some biomarkers to rank animals for feed efficiency at an early stage is being tested and results for the natural abundance of <sup>15</sup>N in plasma proteins are promising. In the medium and long-term, plans are to use the validated biomarkers to assist the precision feeding of animals fed high-forage diets. The relative contributions of the digestive and metabolic mechanisms supposed to drive the between-animal variations in feed efficiency will be specifically investigated in a starting experiment (Effi-Science, a project of BEEFALIM with 100 young growing-fattening bulls) with a particular focus on the role of the protein turnover. Concentrate and Forage rich diets will be compared to test the hypothesis that the biological determinants may differ with the type of diets. The expected outcomes of this new project will contribute to define better balanced genetic programs on feed efficiency.

#### Valorisation

Cantalapiedra-Hijar G., M. Abo-Ismael, G. C. Carstens, L. L. Guan, R. Hegarty, D. Kenny, M. McGee, G. Plastow, A. Relling, I. Ortigues-Marty. 2018. Review: Biological determinants of between-animal variation in feed efficiency in growing beef cattle. *Animal*. <https://doi.org/10.1017/S1751731118001489>

Cassar-Malek I., G. Cantalapiedra-Hijar, A. Delavaud, M. Bonnet. 2018. A candidate proteomic signature from the plasma of Charolais bulls to phenotype feed efficiency. 10th International Symposium on the Nutrition of Herbivores. Clermont-Ferrand FR, 2-6 Sept 2018.

De La Torre A., D. Andueza, R. Baumont, G. Renand, S. Rudel, L. Genestoux, G. Cantalapiedra-Hijar, P. Nozière. 2016. Differences in digestibility between ruminants contribute to differences in feed efficiency regardless of the diet. Communication orale. 67th Annual Meeting of the European Federation of Animal Science. Belfast UK, 29 Aug – 2 Sept 2016

De La Torre A., D. Andueza, G. Renand, S. R. Baumont, G. Cantalapiedra-Hijar, P. Nozière. Digestibility contributes to between-animal variation in feed efficiency in beef cows. *Animal* (submitted Sept 2018)

Meale, S. J., Morgavi, D., Cassar-Malek, I., Andueza, D., Ortigues-Marty, I., Robins, R., Schiphorst, A.M., Migné, C., Pétéra, M., Laverroux, S., Graulet, B., Boudra, H., Cantalapiedra-Hijar, G. 2017. Exploration of biological biomarker of feed efficiency in young bulls. *Journal of Agricultural and Food Chemistry* 65:9817-9827

Meale S.J., M. Popova, G. Cantalapiedra-Hijar, D. Morgavi. 2016. Relationship between ruminal and cecal microbial signatures and feed efficiency in growing cattle. 10th Joint Symposium INRA-Rowett. Clermont-Ferrand FR, 20 – 23 June 2016.

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