NDS Synchrony Index

Rev. 1 of 5/12/2022 EN

Synchronizing N and Carbohydrates sources: refreshing an old concept in NDS

The CNCPS allows the calculation of nutrient supply to meet the requirements for various production levels. Factors such as feeds, feeding regimen, quantity, and the ratio of nitrogen (N) and energy-yielding substrates to rumen microbes, nutrients degradation pattern in the rumen, rumen environment, rumen outflow kinetics, and urea recycling into the rumen all influence the synthesis and growth of rumen microbes. This, in turn, affects N utilization by the animal together with a supply of digestible undegraded protein and metabolizable energy (ME). There have been significant advances in our knowledge of the effects of various combinations of these factors on microbial yield, but there is still the need to identify and control some interactions that affect rumen fermentation, N capture by microbes, and the extent of reflection of rumen fermentation status, which contributes to animal production performance.

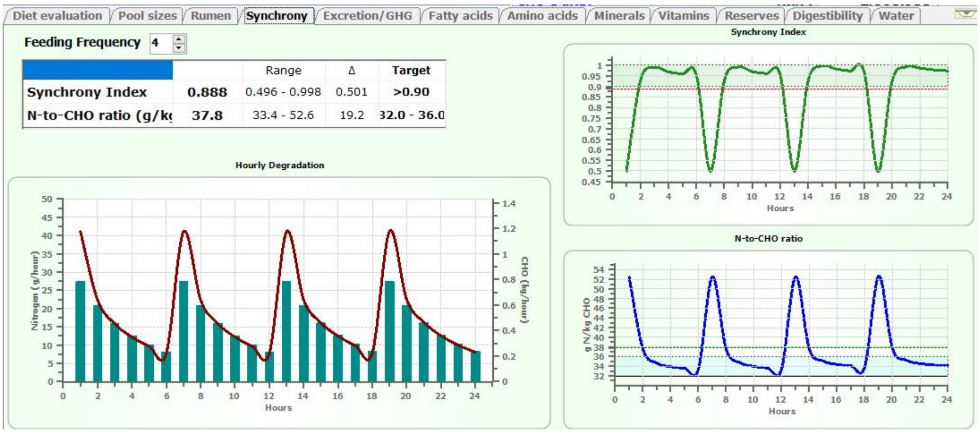
Balancing and synchronizing the supply of N- and energy-yielding substrates to ruminal microbes has been proposed as a mechanism for maximizing the capture of ruminally degradable N (**RDN**), optimizing microbial growth rate, and efficiency in ruminants and consequently reducing N waste in the environment. In particular, the synchronizing release of energy at the same rate as N sources would be required for efficient N utilization by ruminants. In the 90s there has been much effort to evaluate the synchronizing hypothesis that microbial efficiency and synthesis will be maximized by synchronizing the availability of RDN and fermentable energy in the rumen. Sinclair *et al*. (1993) proposed an index (0 to 1) originally calculated from an equation using *in situ* degradability data of N and carbohydrates sources and specific passage rates, describing the degree of synchrony between N and fermentable energy supplies in the rumen throughout the day. An index of 1.0 means perfect synchrony of energy and protein availability in the rumen for MP synthesis and an index close to 0.0 means a very asynchronous rumen environment. Following this calculation, several researchers had tested the synchrony hypothesis and had reported that the improvements in microbial metabolism due to upgrading rumen synchronicity resulted in greater improvements in animal performance (Sinclair *et al*. 1993; Aldrich et al., 1993; Witt *et al*. 1999; Fadel Elseed 2005; Mitani *et al*. 2005), mainly due to N retention. However, some have disputed that ruminal synchronization between N and energy release improves microbial yield and animal performance (Kolver *et al*. 1998; Kim *et al*. 2000; Valkeners *et al*. 2004).

As described in a review on microbial synthesis by Dewhurst *et al*. (2000), research into the synchronization efficacy has produced results confounded by factors such as intake response to experimental diets, the dietary proportion of DN and fermentable carbohydrates, rumen degradation kinetics with N and OM, fluctuation of both RDN and energy supply to rumen microbes in a specific feeding regimen including ruminal infusion procedures. Additionally, the results of those studies are difficult to interpret due to the presence of confounding factors relating to variation of experimental approach (ruminal infusion or feeding), feeding regimen (restricted feeding vs. voluntary feeding), the composition of ration (silage based or dried forage-based, or forage-to-concentrate ratio), nutrients degradation nature in the rumen (rapid- or slow degradation) and physiological status of the animal and ruminant species. Therefore, the contradictory findings may be the result of different experimental methods and animals. More likely, successful implementation of nutritional synchrony requires the ability to quantitatively predict the outcome of the ruminal interplay of dietary protein and

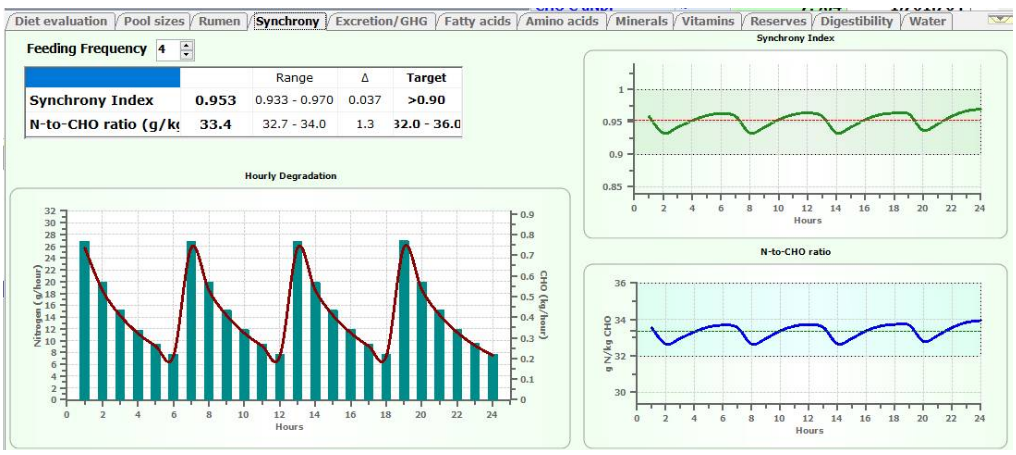
energy to produce microbial products, as well as the factors that affect the partitioning of nutrients by the animal. Both of these areas are today still researched and consideration must be given to the effects of factors external to the diet. Furthermore, all the sources that are not directly derived from the diet can change the temporal pattern of protein availability from that predicted for the diet alone and those sources may not be consistent in their supply. In this light, attempts in vivo to show differences in
the effect on the animal performance of the synchronous and asynchronous provision of nutrients to the rumen may have been fighting an uphill battle against homeostasis, "the tendency of the body to seek and maintain a condition of balance or equilibrium within its internal environment, even when faced with external changes" (Hirsch, 2003). If we use the concept of synchronization, we would need to be aware of fact that rumen microbes can buffer themselves against transient deficits in RDN and energy supply by synthesizing intracellular storage polysaccharides when fermentable carbohydrates are relatively plentiful and by utilizing the cellular storage and recycled urea N when fermentable energy and RDN are deficient within a short period of the feeding cycle (Valkeners *et al*., 2004; Kim *et al*., 1999, 2000).
When looking at the specific number, some (Henning et al., 1993; Richardson et al., 2003) have also postulated that when RDN and energy sources are provided within a day to meet animal requirements with overall balance, there is a certain degree of degradation synchronicity above which no further improvement in animal production can be obtained. This means that for example there would not be real improvement when the index is above a certain "high" synchrony level. This critical point is not known but we can assume with confidence that above 0.90 no further improvements in microbial efficiency and N utilization by host animals are achievable. This would also explain the non-significant results of various studies.
Despite the history of this concept, the RUM&N team believes that the synchronization concept has still great potential as a diet evaluation tool, rather than a rumen environment evaluation tool, it can represent a strong tool to be used by the nutritionist. We as nutritionists always have in fact the goal of creating the ideal environment for the rumen bugs and the concept of synchronization can still be used for such purpose.
Something else that the RUM&N team has noticed is that none of the studies that used the synchrony index had used a precision feeding tool like the CNCPS with the respective feed fractionation system and passage estimations. In recent years we have reached a very accurate measure of DMI that would be needed to determine the total mass of substrate. The CNCPS estimates rates of passage for the various classes of feeds which are needed to estimate the proportions of substrates that will be fermented ruminally. Accurate feed sampling and characterization of feed composition have become routine in many farms and are essential to describing diet fermentation and utilization by the microbes. All this detailed feed characterization system will improve the precision of a synchronization index and its subsequent interpretation. Yet, we are aware that the availability and selection of analyses to make the needed characterizations may also be a challenge (e.g.: protein fractions). It is also obvious that the synchrony index alone will not be able to capture the whole dynamic of the relationship between energy and N available to the rumen bugs and therefore other parameters will have to be used when reading and interpreting such index. What we have done was therefore not only to calculate the index but to show the respective 24-h patterns of the index itself, the released N, and the fermented carbohydrates to have a thorough overview and interpretation of the relationship between N and energy released from fermented carbohydrates. In fact, a high index can still result from a wide daily pattern of asynchronous N and energy availability. According to our guidelines, the objectives would be to have a Synch index of at

least 0.90, while minimizing its variability across the 24 hours and have between 32 and 36 g of N for each kg of fermented carbohydrates.

The case below for example shows a relatively high Synch index (0.89) but with a very wide range (0.49 to 0.99) in the 24 hours and characterized by moments of a very high N availability compared to the energy released. This case presents potential improvements in the diet with likely times during which N could be wasted because excreted and not captured by the rumen bugs. This imbalance between N and energy availability during some of the 24 hours can promote a considerable absorption of ammonia through the rumen wall and the use of amino acids as an energy source. The opposite case is also possible when the fermentation of the dietary carbohydrates reaches its peak, the N supply to the rumen microbes will be markedly deficient, leading to an uncoupling of ATP production and microbial protein synthesis, with fermentation occurring largely with reduced microbial growth.



The case below represents instead an ideal case with a very stable relationship between N and energy released, a very small range of the index (0.93 to 0.97), and a very consistent ratio between g of N and fermented carbohydrates. In this case, synchronizing energy and N availabilities in the rumen has probably the potential to enhance the output of microbial protein from the rumen and the efficiency of ruminal fermentation, thereby improving feed utilization and animal performance.



How to improve the synchronization of a diet

It is possible to improve the synchrony of diets, either by changing dietary ingredients or by altering the feeding frequency or the feeding patterns. The latter approach is an extremely useful one because it allows us to alter synchrony without altering diet ingredients. However, the index itself is not able to capture such a strategy, or at least, while the index does not change much, the respective range may be reduced. The tool in NDS allows for an increase in the feeding frequency and the effect on the index range will be noticeable. Below we show 4 cases that represent real scenarios where the Synchrony tab can be a valuable tool to reformulate and improve the recipes.

Case 1 shows an index lower than the optimal (0.9-1.0) but with a small range of variability (Δ: 0.064), an N to CHO ratio (g/kg) lower than the optimal range but again with a small range of variation (Δ: 2.2). The case depicts a situation in which the N degraded is lower compared to the CHO degraded but the protein fractions seem uniformly distributed when compared to the degraded CHO fractions. The reformulation should in this case aim to replace a concentrate portion with protein sources of various degradability (ex.: soy meal and sunflower, 66:33).

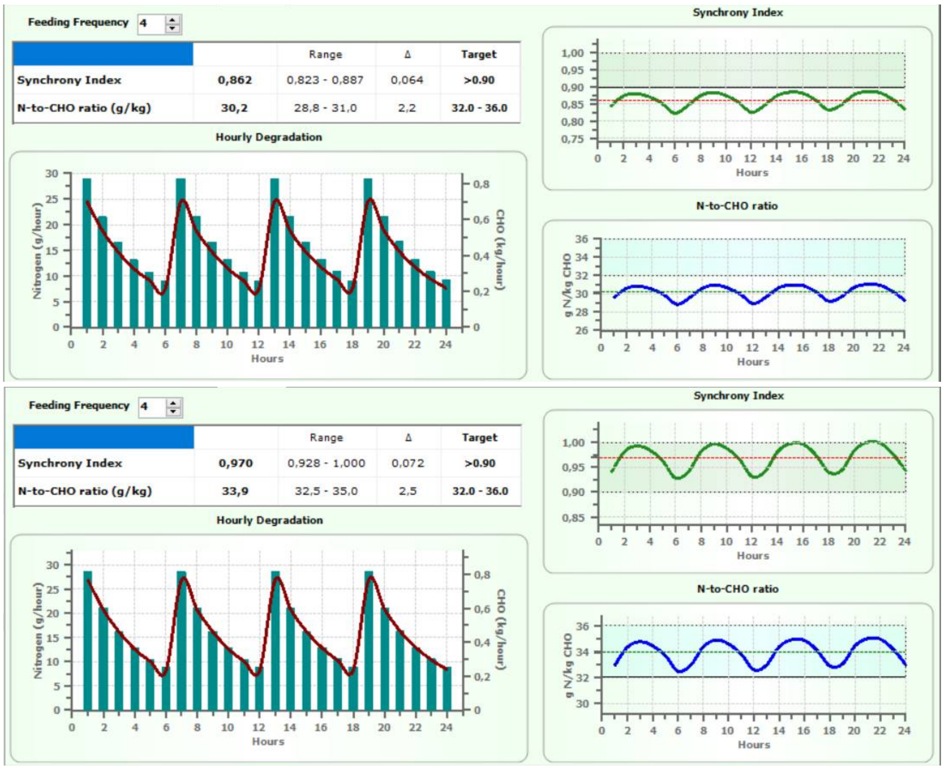


Figure 1. Case study 1 as shown in NDS Professional before and after the reformulation.

Case 2 shows an index within the optimal interval but with a wide range across the day (Δ: 0.188). This indicates that for many hours the synchronization is not optimal and, in this case, lower than the desired minimum. N to CHO is on average within the optimal interval but with a wide range (Δ: 11.3) resulting from an excess of soluble protein (A1+A2). In this case, the highly degradable sources of protein should be partially replaced by lower degradability protein sources (sunflower meal replaced by soybean meal for example) and highly degradable CHO could be introduced (ex. molasses).

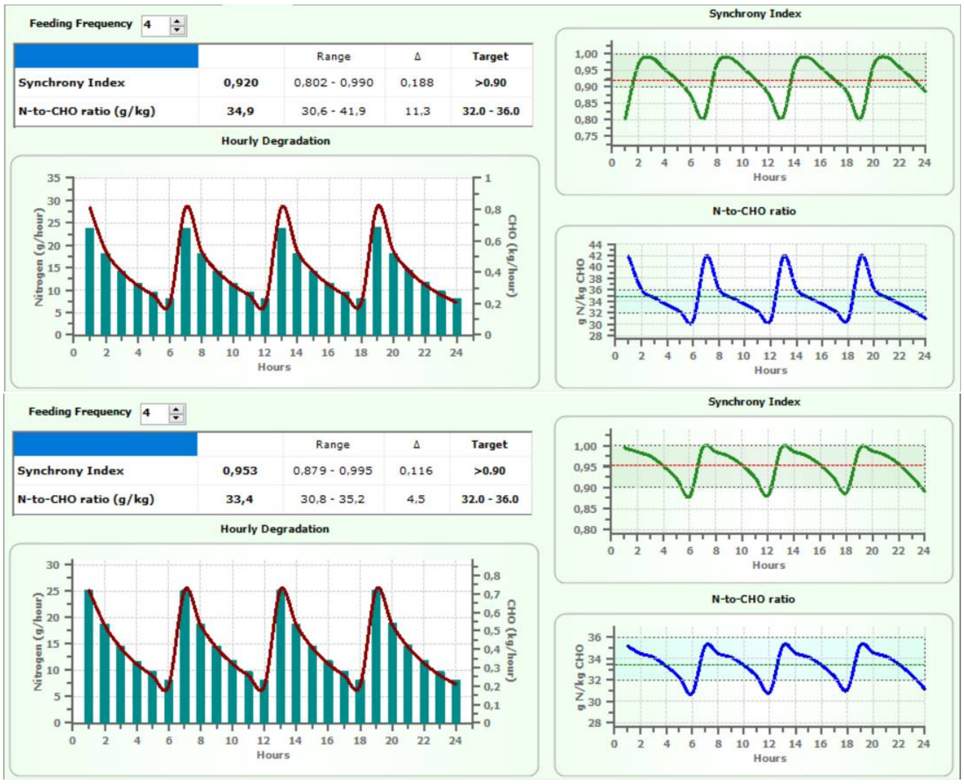
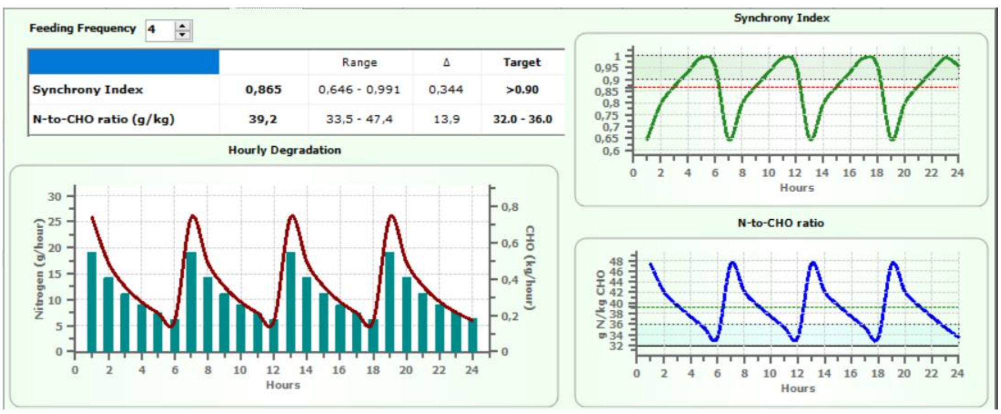


Figure 2. Case study 2 as shown in NDS Professional before and after the reformulation.

Case 3 shows an average index lower than the optimal one with very large variability, and with the hourly index frequently below the optimal range (Figure 3). The N to CHO ratio is rather high and almost always above the value considered to be the higher optimal limit (36 g N/kg RDCHO). The hourly range is also very large (13.9) with many values situated above the higher limit. The scenario describes a situation in which the N degraded is constantly above the hourly CHO amount degraded. In this case, the intervention required would need to be quite drastic with changes relative to the N degraded (to be reduced, especially for the highly degradable fractions), with the possible introduction of highly fermentable CHO.



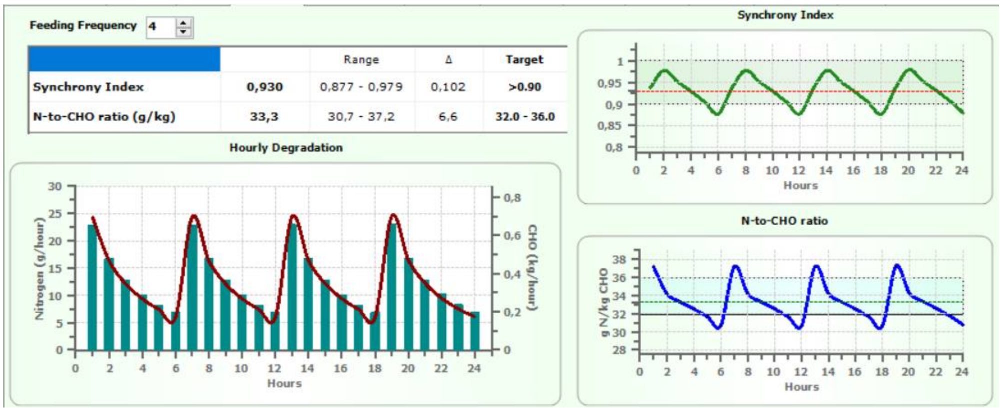


Figure 3. Case study 3 as shown in NDS Professional before and after the reformulation.

Case 4 presents a very high index (0.98), constantly within the recommended interval, and hourly variations are rather minimal. The N to CHO ratio is also constantly within the recommended range, even at its extreme values. This scenario describes optimal fermentation synchrony between protein and carbohydrates where no re-formulation interventions would be needed.

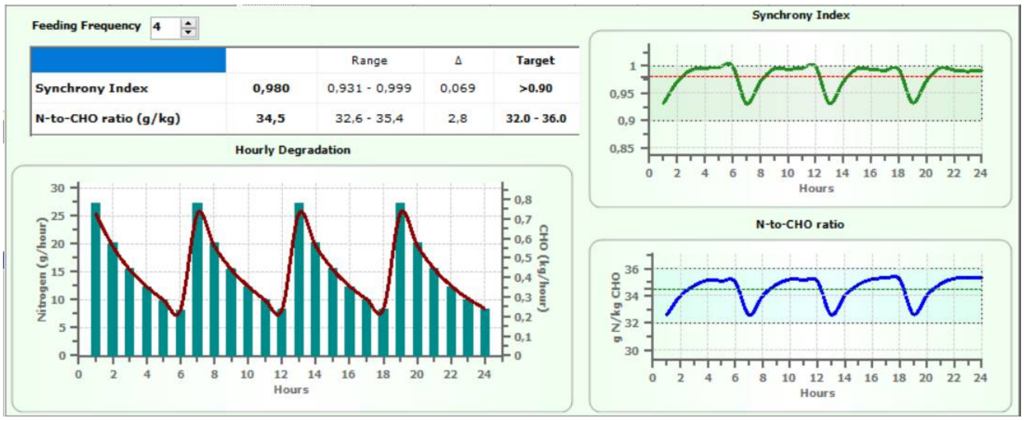


Figure 4. Case study 4 as shown in NDS Professional.

Conclusion and implications

The index and the other parameters utilized can represent a valid decision-making tool if associated with the CNCPS fractionation and prediction system. It is however well known that, like all models, the CNCPS has several areas for possible improvement, and we well know that feed characterization is not well defined for all fractions. Furthermore, the animal will have in place a system to temporarily manage the lack or surplus of either N or CHO. We as nutritionists have however the objective of creating the ideal fermentation environment with the available feeds and tools, like the ones described above. The tool presents however the potential to be improved with the prediction for example of the recycled N influx and the effects of low pH on fiber degradation across the 24 h. We also urge the users to always use the other tools present in NDS while apporting changes to the recipe to satisfy the synchrony of the diet.