Reducing CP levels in dairy cow diets, what can be achieved?

Dairy cows are fed crude protein (CP) in order to meet their nutritional protein and amino acid requirements, to maintain bodily functions and to produce milk. However, dairy cows are not very efficient at utilizing the nitrogen (N) supplied by CP. Indeed, some 75% of N is excreted in faeces and urine. There are significant environmental concerns as a result of this N excretion. For example, increases in nitrous oxide emissions from urine patches, leaching of nitrates from soil, leading to eutrophication of waterways and the topical issue at present in NI, ammonia emissions. Preliminary research has shown that by feeding lower CP diets, as well as reducing dietary cost, N efficiency can be improved, leading to reductions in urinary N excretion thereby reducing ammonia emissions from dairy cow housing and from slurry storage and spreading. Due to the above reasons, there is increasing interest in feeding lower protein diets, but doing so without compromising performance.

In reducing dairy cow dietary crude protein intake, the aim is to balance dairy cow diets for metabolizable protein (MP), in conjunction with dietary energy requirements while minimizing nitrogen excretion. It is important to remember although CP is the quoted metric, when feeding dairy cows it is the rumen that must be fed first which has a requirement for N, in the form of ammonia and amino acids. A number of studies on dairy cow crude protein requirements have been conducted around the world in recent years in what is an increasingly important issue from an environmental perspective.

USA research

In 2003 a study in the US examined the feeding of three different CP levels, along with three different energy levels in dairy cows. The three CP (% DM) levels were 15.1, 16.7 and 18.4%. Production results from the study (Table 1) found that at a CP of 18.4% dry matter intake (DMI) was greatest. However, there was no substantive improvement in milk yield or milk quality in moving above a total CP of 16.7%. From an environmental perspective, N intake along with fecal/urinary N outputs reduced significantly as CP levels declined. This study concluded that irrespective of diet energy content, a CP content of 16.7%

was sufficient to support milk production, in conjunction with improvements in N use efficiency.

Table 1. Dry matter intake (DMI), milk yield, milk composition N outputs from diets containing three CP levels

	Crude protein (as % of total dry matter intake)		
	15.1	**16.7**	**18.4**
Dry matter intake (kg/day)	21.1	22.1	22.6
Milk yield (kg/day)	33	34.1	34.1
Fat (%)	3.51	3.66	3.60
Protein (%)	2.99	3.03	3.02
N intake (g/day)	512	593	666
Fecal + urinary N (g/day)	376	457	509

Adapted from Broderick & others 2003

Another American study in Wisconsin examined the effect of feeding low CP diets to late lactation cows, i.e. 224 days in milk (DIM) ±54 days. A total of four different CP levels were fed, these being 16.2, 14.4, 13.1 and 11.8%, (DM basis). As CP levels reduced DMI decreased (Table 4). It is interesting to note at 16.2 and 14.4% CP, milk yield was relatively stable, however at 13.1% and 11.8%, milk yields declined. This finding is similar to AFBI's, in terms of no significant milk yield loss at 14.4% CP. Marginal increases in NUE occurred as CP levels declined.

Table 2. Effect of dietary CP content on late lactation cow performance & N efficiency

	Crude protein (as % of dry matter intake)			
	16.2	**14.4**	**13.1**	**11.8**
Dry matter intake (kg/day)	24.2	23.8	23.8	22.7
Milk yield (kg/day)	31.8	31.4	29	25.5
Fat (%)	4.24	4.13	4.41	4.34
Protein (%)	3.58	3.45	3.52	3.33
N intake (g/day)	624	547	497	429
N use efficiency (%)	28.2	30.4	30.7	30.2

Adapted from Barros and others 2017

The CP of the diets in the previous studies appeared to be conducted without the addition of any rumen protected dietary additives. The evidence would suggest that production performance of dairy cows can be maintained on lower CP diets along with increased N efficiency. It is important to remember if any MP deficiencies are identified in the diet, this can have a negative effect on production performance i.e. milk and protein yields. Therefore, it may be necessary to include additional rumen protected products or essential amino acids.

UK research

More recently, the University of Reading has completed a study examining the effects of different CP levels to high yielding cows fed maize/grass silage based diets. This study examined the effect of feeding either 14, 16 or 18% CP, i.e. 90%, 100% or 104% of their MP requirement. A total of 215 1st lactation heifers were enrolled on the study and followed through until the end of 3rd lactation. The final report for this study is not yet available, however there are some preliminary findings (Table 3a). The 16% diet appeared to be optimal compared with the other two. The lower protein diets were more N efficient, with increases in nitrogen use efficiency (NUE) at lower CP levels (Table 3b), along with reductions in both urinary nitrogen and slurry ammonia emissions. The financial model suggests that the medium protein ration created the highest net margin. Alternatively, for both high and low protein diets, variable costs increased, i.e. feed costs were highest for high CP group, vet & medicine costs highest for low CP group. However, this study highlighted areas for consideration such as: lower CP diets run the risk of reduced milk yield. There are both economic and animal health implications for diets deficient in MP, particularly for 3rd lactation animals.

Table 3a. DMI, milk yield and milk composition in 1st lactation heifers containing three CP levels

	Crude protein (as % of dry matter intake)		
	14	**16**	**18**
Dry matter intake (kg/day)	21.3	21.3	22
Milk yield (L/day)	28.1	29.6	29.7
Fat (%)	3.79	3.69	3.78
Protein (%)	3.29	3.32	3.34

Adapted from Reynolds & others, 2016

Table 3b. Nitrogen use efficiency (NUE) % across three lactations at different CP levels

	Crude protein (as % of dry matter intake)		
Lactation	**14**	**16**	**18**
1	31.5	29.5	25.5
2	30.7	28.4	24.1
3	31.1	28.4	24.3

Reynolds & others, 2019

It is important to note that this research was conducted with cows fed diets containing forage maize as part of the dietary forage component. The increased proportion of starch in the diet from forage maize compared to a grass silage only diet can influence the quantity of microbial protein flowing from the rumen to the cows lower digestive tracts and have important implications for dietary protein requirements. Further detailed research is needed on the grass silage based diets predominantly fed in N. Ireland.

Local AFBI research

Over 10 years ago AFBI (Hillsborough) examined the effect of feeding different CP levels in dairy cow diets across lactation. The three CP feeding levels were 11.4, 14.4 and 17.3% (dry matter). As shown in Table 2a, increasing CP content resulted in a significant increase of both DMI and milk yield. Cows being fed the lowest CP content had a significantly higher fat content compared to the other CP levels. The three CP feeding levels appeared to have no significant effect on fertility performance. However, 100 day in-calf rate tended to be higher with

animals being fed the 11.4% CP diet compared with both 14.4 and 17.3 % CP diet.

Table 4a. Effects of feeding different CP levels on DMI, milk yield & quality during the first 150 DIM

	Crude protein (as % total DMI)		
	11.4	**14.4**	**17.3**
Dry matter intake (kg/day)	16.5	18	18.6
Milk yield (kg/day)	25.4	31.8	35.4
Fat (%)	4.20	3.83	3.81
Protein (%)	3.14	3.23	3.24

Adapted from Law & others, 2009

This study demonstrated significant reductions in manure N as a result of decreasing CP levels (Table 2b). This is an area which AFBI (Hillsborough) are planning to examine again over the next few years.

Another interesting finding within this study was after 150 days in milk (DIM), reducing the CP content from 17.3 to 14.4% had no significant effect on milk yield or DMI.

Table 4b. Effects of feeding different CP levels on N intake and output

	Crude protein (as % total DMI)		
g/day	**11.4**	**14.4**	**17.3**
N intake	322	445	562
Manure (faeces + urine) N	227	300	380

Adapted from Law & others, 2009

Other important points to consider when lowering crude protein in dairy diets:

-Accurate balancing of protein through the use of rumen un-degraded protein (RUP)

-Adding protected essential amino acids, i.e. methionine and/or lysine.

NB: It is important to note when considering reducing CP levels, dietary advice **should** be sought.

Practical considerations & monitoring

- Delivering a ration consistently and precisely
- Accuracy of forage analysis, i.e. CP content
- Use of computer feeding programs to model the diet to highlight potential deficiencies
- If implemented, monitor herd performance, i.e. milk yield, milk quality, fertility and health

Conclusion

Research is providing increasing evidence that dairy cows can sustain milk production performance with lower CP diets while reducing N excretion. The research questions the production benefit of feeding CP greater than 16.5% in total DMI for high yielding early lactation dairy cows, and with lower levels suggested for later lactating cows. However, this is an area that requires further research, based on grass silage diets and cows fed reduced protein diets over a number of lactations. Producers who are thinking about reducing their overall CP levels, need to give careful consideration to a number of factors as previously highlighted.