The use of $\delta^{13}C$ to determine passage kinetics of feed in dairy cows

***Warner Daniel**, Dijkstra Jan, Pellikaan Wilbert Frans*
Animal Nutrition Group, Wageningen University

Dairy cows need to be fed according to their requirements in order to reach their maximum performance and reduce the loss of waste products into the environment as well as nutrient-related disorders. The behaviour of feed particles in the digestive tract, namely the passage of feed nutrients from the rumen (rumen fractional passage rate; $\boldsymbol{K_p}$), is essential to predict absorption and excretion of nutrients and is, therefore, an essential part of modern feed evaluation systems for dairy cows. Yet, knowledge about K_p is limited. On the one hand, common feed evaluation systems, such as the DVE/OEB system in use in Belgium and The Netherlands, assume fixed K_p values dependent only on the feed source (forages vs. concentrates). On the other hand, their K_p values were commonly derived from external tracers like chromium-mordanted fibre (Cr-NDF), which are not intrinsic to the feed and cannot distinguish differences in passage between various feed fractions (e.g., starch vs. fibre). The use of stable isotopes as passage tracers in feed research is recent. They have the advantage to be inherent to the feed and were shown to adequately describe passage of grass silage fibres (Pellikaan et al., 2012).

A series of experiments were conducted to assess K_p values of carbohydrate fractions (structural fibre and starch) for different feed types commonly fed to dairy cows: concentrates (Exp. 1), maize silage (Exp. 2) and grass silage (Exp. 3). In Exp. 1, the difference in natural ^{13}C abundance between maize bran (C_4 origin) and a concentrate mix (C_3 origin) was used, whereas in Exp. 2 and 3 continuously enriched forage (maize and grass silage) above natural ^{13}C abundance was used to dose the tracer into the rumen. Passage kinetics were assessed based on the ^{13}C:^{12}C ratio determined in the dry matter (^{13}C-DM) and structural fibre (^{13}C-SF) in faeces, and ^{13}C-DM and starch (^{13}C-ST) in the omasal digesta. The internal $\delta^{13}C$ tracer gave lower K_p values than the commonly used external tracer Cr-NDF for forages but considerably higher values for concentrates (Table 1). The K_p values of Cr-NDF were similar among feed types, whereas $\delta^{13}C$ was more sensitive to changes in type of feed. The K_p values based on $\delta^{13}C$ were also considerably lower than the assumed values of the DVE/OEB system, except for starch (data not shown). The passage behaviour of fibres differed among forage types with a larger difference between ^{13}C-DM and ^{13}C-SF for the grass silage compared to the maize silage.

Table 1. Fractional rumen passage rates (K_p, %/h) for different feed types determined by an external tracer (Cr-NDF) and the internal tracers $\delta^{13}C$.

Feed	Cr-NDF	^{13}C-DM	^{13}C-SF	^{13}C-ST	s.e.m.
Concentrate	3.80	5.51	6.17		0.502
Maize silage	4.20	2.32	2.08	4.23	0.960
Grass silage	4.84	3.29	1.58*		0.348

DM: dry matter; SF: structural fibre; ST: starch. *Pellikaan et al. (2012; *Animal*).

The use of ^{13}C isotopes is a useful tool to determine passage and enables distinction between passage of various feed types and carbohydrate fractions. Passage of protein fractions for grass silage based on ^{15}N isotopes should be addressed in future research. The use of stable isotopes as a digesta passage tracer should be further developed to assess passage of isolated carbohydrate fractions (e.g. cellulose, hemicellulose) to obtain a more detailed insight into the passage behaviour of plant fibres in dairy cows.