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A SIMULATION MODEL TO EVALUATE SUPPLEMENTATION OF TROPICAL FORAGE DIETS FOR DAIRY COWS

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Abstract

A dynamic model of digestion kinetics has been built to evaluate dairy cattle diets based on tropical feeds and to estimate the potential of tropical forages for milk production associated with available supplements. Results of simulation were very consistent showing that grazed elephant grass alone can supply nutrients for cow maintenance and yield of 7.10 kg milk/day. Nevertheless, to produce 25 kg/day on grazed elephant grass, a dairy cow would need to be supplemented with 5.85 kg/day of a mixture of cottonseed meal (50%) plus ground maize (50%), while on maize silage it would be necessary 4.15 kg of the same supplementation. On the other hand, for the same amount of milk, a cow fed a sugarcane/urea-based diet would need 5.87 kg of the above mixture. As far as feeding cost is concerned, to reach the potential production of 25 kg of milk/day, a cow would expend US$ 1.19 on grazed elephant grass-based diet, as compared to US$ 1.40 on sugarcane- and maize silage-based diets. The present model showed to be an useful tool for assessing, pre-experimentally, the potential response to supplementation of dairy cows fed tropical forages.

Keywords: milk production, elephant grass, sugarcane, maize silage, supplements, feeding cost, simulation model, digestion kinetics

Introduction

Mathematical simulation models have been used to integrate and apply current knowledge of digestion kinetics in ruminant nutrition (France et al., 1998). Such models are useful tools for assisting dairy cattle feeding programmes in the tropics by pre-selecting potential sources of forage to be tested in the field.

A simulation model has been built to study supplementation of sugarcane for dairy cows in Brazil (Dijkstra et al. 1996). The model was able to predict nutrient flows through the gastrointestinal tract of Holstein-Zebu crossbred steers fed sugarcane-based diets. Furthermore, for dairy cows fed tropical forages, predictions of milk production by the model were very consistent (Kebreab et al., 2000; Rodrigues et al., 2000). The objective of this study is to use the model to assess the potential response of dairy cows fed tropical forage-based diets in association with increasing levels of locally available supplements.

Material and Methods

The gastrointestinal tract of a ruminant is represented in the model by three main compartments, namely: stomach - comprising rumen, reticulum, omasum and abomasum; small intestine - duodenum, jejunum and ileum; and large intestine - caecum, colon and rectum. Basically, the stomach contains twelve ruminal pools or state variables, namely:

undegradable protein, insoluble degradable protein, soluble protein, ammonia, undegradable fibre, potentially degradable fibre, water soluble carbohydrates, volatile fatty acids, insoluble starch, lipids, microbes and endogenous protein. Amino acids, ammonia, glucose and lipids reaching the small intestine are represented as zero-pools, plus a full pool formed by endogenous protein from the stomach and small intestine. In the large intestine, six full pools - microbes, dietary protein, endogenous protein, fibre and starch - and two zero pools - ammonia and volatile fatty acids - are represented. Minerals and vitamins are not considered and assumed to be non-limiting. A complete description of the model structure and dynamics have already been reported elsewhere (Dijkstra et al.,1996).

The predictive ability of the model has been validated against experimental and literature data (Dijkstra et al., 1996; Oliveira 1990; Matos 1991; Kebreab et al., 2000; Rodrigues et al., 2000). In the present work, a version of the model, written in Continuous Simulation Modelling Program-CPSM for microcomputer, is used to simulate the potential response to increased levels of supplements of a dairy cow fed different sources of tropical forages. A simulation set of three types of forages - grazed elephant grass, fresh chopped sugarcane and maize silage - with four levels – 0: 2; 4 and 6 kg (dry matter basis) - of a mixture of cottonseed meal (50%) and ground maize (50%) was carried out. Individual feed characteristics are shown in Table 1, including production cost of forages and market price of supplements. Forage intake was fixed at 12.5 kg of dry matter (DM) for a 500-kg Holstein-Zebu crossbred cow with a potential milk production of 25 kg/day at the peak of lactation.

Results and Discussion

Predictions of milk production from a 500-kg dairy cow fed forage-based diets with different levels of concentrate mixture are shown in Table 2. Despite being the cow potential set at 25 kg of milk per day, maize silage plus 6 kg of supplement diet was able to supply nutrients for up to 33 kg of milk. In this case, the cow genetic potential was limiting milk production.

All forage sources have shown linear response to increased level of concentrate, as follow:

$$Y_{EG} = 7.101 + 3.058x, \qquad R^2 = 0.989 \qquad (1)$$

$$Y_{SC} = 0.936 + 4.103x, \qquad R^2 = 1.000 \qquad (2)$$

$$Y_{MS} = 5.906 + 4.603x, \qquad R^2 = 0.999 \qquad (3)$$

where:

Y_{EG} = simulated milk production on grazed elephant grass-based diet (kg/cow/day)
Y_{SC} = simulated milk production on sugarcane-based diet (kg/cow/day),
Y_{MS} = simulated milk production on maize silage-based diet (kg/cow/day), and
x = concentrate level (kg DM/cow/day).

Response of forage sources to supplementation can be assessed by equations 1, 2 and 3. Without supplements, 12.5 kg DM of maize silage and grazed elephant grass-based diets contain sufficient nutrients for cow maintenance plus 5.91 and 7.10 kg of milk per day, respectively, while sugarcane was only enough for maintenance and less than 1 kg of milk. On grazed elephant grass without supplementation, cow performance (7.10 kg) was very similar to that found under grazing conditions (Valle et al., 1987), though other studies have reported values between 11 and 12 kg (Embrapa, 1997). Experimental factors like fertiliser level, forage quality, cow genetic potential, trial duration and between-animal variation could be responsible for such a large difference. On the other hand, cow fed maize silage has shown an average response to supplementation (4.60 kg of milk/kg concentrate DM) greater than sugarcane (4.10 kg milk/kg DM) and elephant grass-based (3.06 kg milk/kg DM) diets.

In order to attain the potential milk production of a crossbred cow, set at 25 kg/day, grazed elephant grass would need to be supplemented with 5.85 kg DM of concentrate mixture, while sugarcane and maize silage with 5.67 and 4.15 kg, respectively. Furthermore, total feeding cost per cow was calculated for each forage-based diet (Table2). Although maize silage had the greatest response to concentrate (4.60 kg/kg) and grazed elephant grass the least (3.06 kg/kg), total cost of silage-based diet (US$ 1.40/cow/day) was 18% greater than the elephant grass one (US$ 1.19). Sugarcane-based diet stood in an intermediary position for both response (4.10 kg/kg) and cost (US$ 1.40/cow).

In conclusion, despite its low response to concentrate, grazed elephant grass-based diet could afford a greater margin over feeding cost than sugarcane and maize silage ones. The results from this study have strongly indicated the ability of the model for assessing potential response to supplementation of dairy cows fed forage-based diets.

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Table 1 - Chemical composition [(1)], degradation rates [(1)] and production cost [(2)] or market prices [(3)] of feeds used in the simulation trial.

Item[(4)]	Grazed elephant grass	Fresh chopped sugarcane	Maize silage	Ground maize	Cottonseed meal
DM (%)	19.60	29.12	30.45	80.51	85.00
OM (% DM)	90.00	95.64	94.30	97.74	98.20
CP (% DM)	12.90	2.44	8.00	9.93	42.40
DP (% CP)	83.21	52.83	12.86	60.71	84.67
N Sol (% N Total)	5.65	48.56	45.00	24.80	13.44
WSC (% DM)	14.28	42.02	22.86	0.00	2.02
ST (% DM)	1.59	2.10	15.24	69.60	18.18
EE (% DM)	1.23	1.03	3.20	6.94	6.60
NDF (% DM)	60.00	50.15	45.00	11.27	29.00
PD NDF (%)	73.74	46.78	75.36	66.99	66.08
Kd CP (% / h)	4.40	2.94	9.00	3.95	7.60
Kd NDF (% / h)	4.20	2.47	4.00	8.45	6.50
Kd ST (% / h)	-	-	12.50	40.00	12.50
Cost (US$ / kg DM)	0.0228	0.0394	0.0608	-	-
Price (US$ / kg DM)	-	-	-	0.14	0.17

[(1)] Source: Assis et al. (1999).
[(2)] Source: Tupy et al. (1999).
[(3)] Source: FNP (2000).
[(4)] **DM:** Dry matter; **OM:** Organic matter; **CP:** Crude protein; **DP:** Rumen degradable protein; **N Sol**: Nitrogen solubility; **WSC:** Water soluble carbohydrates; **ST:** Starch; **EE:** Ether extract; **NDF:** Fibre in neutral detergent; **PD:** Potential degradability; **Kd:** Degradation rate.

Table 2 - Simulated response of a 500-kg dairy cow fed forage-based diets [(1)] to increased levels of concentrate [(2)] and feed cost (US$) of this cow fed three different forage-based diets to attain a potential production of 25 kg of milk per day.

	Diet based on		
	Grazed elephant grass	Fresh chopped sugarcane	Maize silage
Concentrate (kg DM/cow/day)	Milk production (kg/cow/day)		
0	7.09	0.00	5.57
2	13.23	10.00	15.50
4	19.34	18.44	24.55
6	25.44	24.54	33.24
Diet component	Feed cost (US$/cow)		
Forage	0.285	0.493	0.760
Concentrate	0.907	0.909	0.643
Total	1.192	1.402	1.403

[(1)]Forage intake set at 12.5 kg DM/cow/day.
[(2)]Mixture of cottonseed meal (50%) and ground maize (50%).

TABLE 3: Feeding cost (US$) of a 500-kg crossbred dairy cow fed three forage sources diets to attain the potential production of 25 kg of milk per day.

Forage source	Forage cost/cow	Concentrate price/cow	Total cost/cow
Elephant grass	0.285	0.907	1.192
Sugarcane	0.493	0.909	1.402
Maize silage	0.760	0.643	1.406

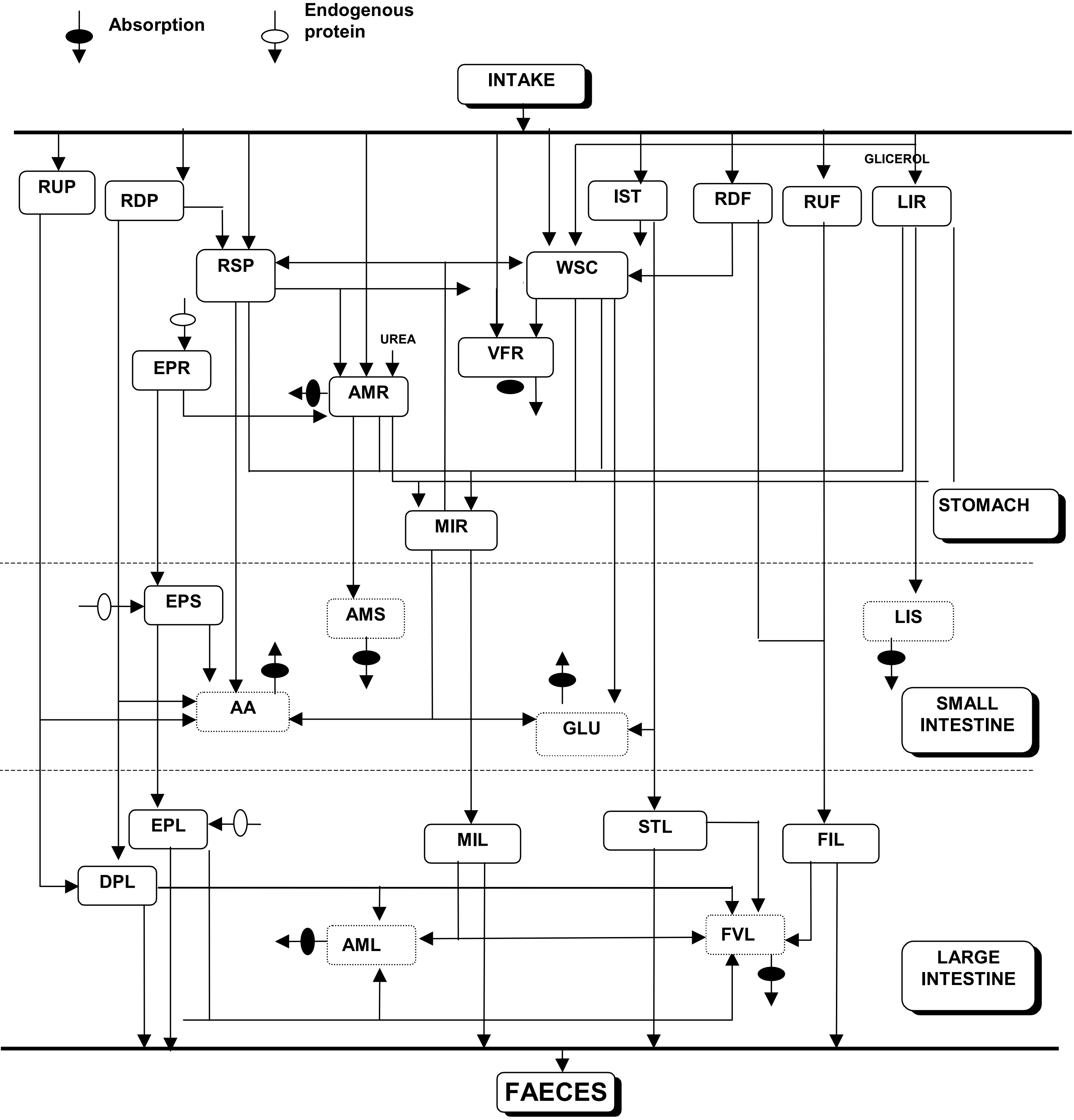

Figure 1: Representation of nutrient kinetics in the gastrointestinal tract of ruminants.