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IN VITRO RUMEN AND RABBIT CECUM DIGESTIBILITIES: IV. SELECTED RABBIT DIETS

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Abstract

In vitro cecal and rumen fermentation trials were conducted to study the relationships between in vitro rabbit cecal fermentation, in vitro rumen fermentation and in vivo rabbit digestibility of nutrients in selected rabbit diets. In vitro trials were conducted on samples of four diets differing in fermentability. The diets, which had been previously used in two digestion trials conducted with weanling New Zealand White rabbits, included those containing (a) low fermentable carbohydrate - low protein (LFC-LP), (b) low fermentable carbohydrate - high protein (LFC-HP), (c) high fermentable carbohydrate - low protein (HFC-LP), (d) high fermentable carbohydrate - high protein (HFC-HP) and two Oregon State University doe herd diets, (e) OSU 47 and (f) OSU 58. In vitro rumen dry matter digestibility (IVRDMD) and in vivo rabbit dry matter digestibility (VIVODMD) of the diets were higher than their in vitro rabbit cecal dry matter digestibility values. VIVODMD values were lower than IVRDMD values for the low fermentable carbohydrate diets while the reverse was the case for the high fermentable carbohydrate diets. In vitro and in vivo digestibilities of the diets increased with increasing levels of fermentable carbohydrate irrespective of dietary protein and fiber levels. In vitro rumen digestibility was a better predictor of in vivo digestibility than in vitro cecal digestibility. In vitro cecal digestibility represented only about 70% of in vitro rumen digestibility values. In vitro cecal and rumen digestibility studies could serve in preliminary evaluation of the nutritive values of rabbit diets and could be used to predict in vivo rabbit digestibility.

Introduction

Various research reports (Aderibigbe et al., 1992[a,b,c,d,e]) have shown that in vitro cecal digestibility studies could be used to evaluate the nutritive value of feeds and feedstuffs for rabbits similarly to the use of in vitro rumen digestibility studies in ruminant nutrition. Aderibigbe and Church (1983) observed that in vitro enzymatic and rumen digestion studies could be used effectively to predict in vivo digestibilities of dry matter, organic matter, crude protein and gross energy in ruminant diets. Aderibigbe et al. (1992[e]) pointed out the need for more research studies in the area of the relationship between in vitro cecal digestibility and in vivo digestibility of rabbit diets, with an

ultimate goal of predicting in vivo utilization of diets from in vitro studies. The objective in the research reported herein was to study the relationships between in vitro rabbit cecal fermentation, in vitro rumen fermentation and in vivo rabbit digestibility of selected rabbit diets.

Materials and Methods

In Vivo Digestion Trials With Weanling Rabbits

Feed samples were used from two digestion trials which had been conducted previously with weanling New Zealand White rabbits (Aderibigbe et al., 1992a,b). The general nature of the diets, and the diet numbers to be referred to in this paper, are:

1. OSU #47, a high fiber diet
2. OSU #58, a high fiber diet
3. Low fermentable carbohydrate, low protein (LFC-LP)
4. Low fermentable carbohydrate, high protein (LFC-HP)
5. High fermentable carbohydrate, low protein (HFC-LP)
6. High fermentable carbohydrate, high protein (HFC-HP)

The ingredient composition and analyzed chemical composition are given in Table 1. The in vivo digestibilities were reported earlier (Aderibigbe et al., 1992a,b).

In Vitro Cecal and Rumen Digestion Trials

Diets from the in vivo studies (six diets) were used as substrates for in vitro rabbit cecal and cattle rumen digestion studies. Each diet was ground through a Wiley mill (20-mesh screen). Five samples (1 g dry basis) from each diet were used as substrates for the in vitro studies. Closed in vitro incubations were conducted for 48 h using the methods described by Aderibigbe et al. (1991c).

Statistical Analyses

The percent in vitro cecal and rumen dry matter digestibilities and organic matter digestibilities were compared with in vivo digestibilities using a two-way analysis of variance as described by Neter and Wasserman (1977). Means were compared using the Duncan's Multiple Range test as outlined by Steel and Torrie (1980).

Results and Discussion

The % in vitro cecal or rumen dry matter digestibilities and in vivo dry matter digestibilities of the experimental diets are shown in Table 2. In vivo rumen dry matter digestibility (IVRDMD) and in vivo rabbit dry matter digestibility (VIVODMD) values were higher ($P < .05$) than in vitro cecal dry matter digestibility (IVCDMD) values for

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Table 1. Ingredient components (%) and chemical composition of selected rabbit diets used as substrates for in vitro cecal and rumen, and in vivo rabbit digestion studies.

	Diet #					
	1	2	3	4	5	6
Component (%)						
Alfalfa meal	74.0	54.0	9.9	9.9	9.9	9.9
Wheat mill run	21.0	26.0	68.3	56.7	21.7	3.1
Ryegrass straw	-	-	1.0	1.6	9.8	10.3
Almond hulls	-	-	9.8	5.0	5.0	5.0
Cane molasses	3.0	3.0	6.0	6.0	6.0	6.0
Maize	-	1.25	-	-	33.4	33.4
Soybean meal	-	15.0	-	15.7	8.8	26.4
Vegetable oil	1.25	-	2.9	3.1	3.4	3.9
Limestone	-	-	1.5	1.4	-	-
Dicalcium phosphate	0.25	0.25	-	-	1.4	1.4
Vitamins	*	*	0.3	0.3	0.3	0.3
Trace minerals	0.5	0.5	0.3	0.3	0.3	0.3
Chemical composition						
Dry matter (DM, %)	91.4	89.5	89.5	89.6	89.5	89.5
Organic matter (OM, %)	81.2	80.5	81.0	81.1	82.9	82.7
Analyses, % of DM:						
Crude protein (CP)	17.2	18.2	16.4	22.0	15.7	21.6
Acid detergent fiber (ADF)	29.8	24.4	15.5	13.7	13.5	12.9
Cell contents (CC)	54.9	57.2	61.9	65.2	67.4	71.1
Ash	10.2	9.0	8.5	8.5	6.6	6.8

* Diet 1 contained 0.9 kg $CuSO_4$, 11.1 kg permapel (pellet binder) and 1.8 kg methionine per ton; Diet 2 contained 7 million IU vitamin A and 20,000 IU vitamin E per ton.

the OSU 47, LFC-LP and LFC-HP diets with no differences (P > .05) between their IVRDMD and VIVODMD values. Dry matter digestibility of OSU 58 diet followed the order: IVRDMD > VIVODMD > IVCDMD (P < .05). Digestibility of dry matter for the HFC-LP and HFC-HP diets followed the order VIVODMD > IVRDMD > IVCDMD (P < .05). These results showed that (a) IVRDMD and VIVODMD of rabbit diets were higher than their IVCDMD values, (b) IVRDMD was a better predictor of rabbit VIVODMD than IVCDMD and (c) VIVODMD values were lower than IVRDMD values for the low fermentable carbohydrate diets while the reverse was the case for the high fermentable carbohydrate diets. IVCDMD and VIVODMD of the experimental diets followed the order: HFC-HP = HFC-LP > LFC-HP = LFC-LP > OSU 58 = OSU 47 (P < .05), while IVRDMD followed the order: HFC-HP = HFC-LP > LFC-HP = LFC-LP > OSU 58 > OSU 47 (P < .05). These suggest that once the minimum dietary protein and fiber requirements are met, in vitro cecal and rumen, and in vivo rabbit digestibility of diets would increase with increasing levels of fermentable carbohydrate, irrespective of dietary protein and fiber levels.

Table 2. In vitro cecal and rumen dry matter digestibilities versus in vivo dry matter digestibilities of selected rabbit diets.

Diet #	In Vitro Cecal Dry Matter Digestibility (IVCDMD, %)	In Vitro Rumen Dry Matter Digestibility (IVRMD, %)	In Vivo Rabbit Dry Matter Digestibility (VIVODMD, %)	IVCDMD as Percentage of VIVODMD	IVRDMD as Percentage of VIVODMD
1	$36.7^{a,d}$	$56.3^{b,d}$	$54.5^{b,d}$	67.3	103.3
2	$36.6^{a,d}$	$60.3^{c,e}$	$55.2^{b,d}$	66.3	109.2
3	$47.2^{a,e}$	$63.5^{b,e,f}$	$64.0^{b,e}$	73.8	99.2
4	$48.9^{a,e}$	$64.6^{b,f}$	$67.3^{b,e}$	72.7	96.0
5	$53.1^{a,f}$	$68.9^{b,g}$	$73.2^{c,f}$	72.5	94.1
6	$50.7^{a,c,f}$	$70.0^{b,g}$	$74.4^{c,f}$	68.1	94.1

^{a,b,c} Means in the same row with different superscripts differ (P < 0.05).

^{d,e,f,g} Means in the same column with different superscripts differ (P < .05).

Table 3 shows the % in vitro cecal or rumen organic matter digestibilities and in vivo organic matter digestibilities of the experimental diets. Organic matter digestibility of OSU 47, OSU 58, LFC-LP and LFC-HP diets followed the order: in vitro rumen organic matter digestibility (IVROMD) > in vivo rabbit organic matter digestibility (VIVOOMD) > in vitro cecal organic matter digestibility (IVCOMD) (P < .05). IVROMD and VIVOOMD for the HFC-LP and the HFC-HP diets were higher (P < .05) than their IVCOMD values with no differences (P > .05) between the IVROMD and

VIVOOMD values. Thus, the organic matter digestibility results were similar to those observed for dry matter digestibility. IVCOMD of the experimental diets followed the order: HFC-HP = HFC-LP = LFC-HP = LFC-LP > OSU 58 = OSU 47 ($P<.05$), while IVROMD followed the order: HFC-HP > HFC-LP = LFC-HP > LFC-LP = OSU 58 > OSU 47 ($P<.05$). VIVOOMD of the diets followed the order: HFC-HP = HFC-LP > LFC-HP = LFC-LP > OSU 58 = OSU 47 ($P<.05$), indicating a similar trend as that observed for IVRDMD.

Table 3. In vitro cecal or rumen organic matter digestibilities versus in vivo organic matter digestibilities of selected rabbit diets.

Diet	In Vitro Cecal Organic Matter Digestibility (IVCOMD, %)	In Vitro Rumen Organic Matter Digestibility (IVROMD, %)	In Vivo Rabbit Organic Matter Digestibility (VIVOOMD, %)
1. OSU 47	$41.4^{a,d}$	$67.6^{c,d}$	$52.4^{b,d}$
2. OSU 58	$40.7^{a,d}$	$70.2^{c,d,e}$	$51.9^{b,d}$
3. Low fermentable carbohydrate - low protein (LFC-LP)	$51.2^{a,e}$	$69.8^{c,d,e}$	$64.1^{b,e}$
4. Low fermentable carbohydrate - high protein (LFC-HP)	$52.4^{a,e}$	$71.6^{c,e,f}$	$67.2^{b,e}$
5. High fermentable carbohydrate - low protein (HFC-LP)	$54.6^{a,e}$	$73.6^{b,e,f}$	$73.6^{b,f}$
6. High fermentable carbohydrate - high protein (HFC-HP)	$53.8^{a,e}$	$75.2^{b,f}$	$74.8^{b,f}$

^{a,b,c} Means in the same row with different superscripts differ ($P<.05$).

^{d,e,f} Means in the same column with different superscripts differ ($P<.05$).

The results of IVCDMD as percentage of VIVODMD, and IVRDMD as percentage of VIVODMD for the experimental diets are shown in Table 2. IVCDMD as percentage of VIVODMD ranged from a low of 66.3 (OSU 58 diet) to a high of 73.8 (LFC-LP diet) with an overall mean of 70.1, while IVRDMD as percentage of VIVODMD ranged from a low of 94.1 (HFC-LP and HFC-HP diets) to a high of 109.2 (OSU 58 diet) with an overall mean of 99.3. Thus, IVRDMD of the experimental diets was a better predictor of VIVODMD than their IVCDMD values. Table 4 shows the results of IVCOMD as percentage of VIVOOMD, and IVROMD as percentage of VIVOOMD for the experimental diets. IVCOMD as percentage of VIVOOMD ranged from a low of 71.9 (HFC-HP diet) to a high of 79.9 (LFC-LP diet) with an overall mean of 76.9, while

IVROMD as percentage of VIVOOMD ranged from a low of 100 (HFC-LP diet) to a high of 135.3 OSU 58 diet) with an average of 113.4. Thus, IVROMD of the experimental diets was also a better predictor of VIVOOMD than their IVCOMD values. Table 5 shows the results of IVCDMD as percentage of IVRDMD, and IVCOMD as percentage of IVROMD for the experimental diets. IVCDMD as percentage of IVRDMD ranged from a low of 60.7 (OSU 58 diet) to a high of 77.1 (HFC-LP diet) with an average of 70.9, while IVCOMD as percentage of IVROMD ranged from a low of 58.0 (OSU 58) to a high of 74.2 (HFC-LP) with an average of 68.6, indicating that in vitro cecal digestibility values represented only about 70% of in vitro rumen digestibility values.

Table 4. In vitro cecal organic matter (IVCOMD) or rumen organic matter (IVROMD) digestibilities as percentages of in vivo organic matter (VIVOOMD) digestibilities of selected rabbit diets.

Diet	IVCOMD as Percentage of VIVOOMD	IVROMD as Percentage of VIVOOMD
1. OSU 47	79.0	129.0
2. OSU 58	78.4	135.3
3. Low fermentable carbohydrate - low protein (LFC-LP)	79.9	108.9
4. Low fermentable carbohydrate - high protein (LFC-HP)	78.0	106.5
5. High fermentable carbohydrate - low protein (HFC-LP)	74.2	100.0
6. High fermentable carbohydrate - high protein (HFC-HP)	71.9	100.5
Overall mean	76.9	113.4

Conclusions

In vitro rumen and in vivo rabbit digestibilities of rabbit diets were higher than their in vitro cecal digestibility values. In vitro rumen digestibility was a better predictor of in vivo rabbit digestibility of diets than in vitro cecal digestibility. In vitro cecal digestibility values represented only about 70% of in vitro rumen digestibility values. In vitro cecal and rumen digestibility studies could serve as preliminary evaluation of the nutritive value of rabbit diets and could be used to predict in vivo rabbit digestibility.

Table 5. In vitro cecal dry matter (IVCDMD) and organic matter (IVCOMD) digestibilities as percentages of in vitro rumen dry matter (IVRDMD) and organic matter (IVROMD) digestibilities, respectively, of selected rabbit diets.

Diet	IVCDMD as Percentage of IVRDMD	IVCOMD as Percentage of IVROMD
1. OSU 47	65.2	61.2
2. OSU 58	60.7	58.0
3. Low fermentable carbohydrate - low protein (LFC-LP)	74.3	73.4
4. Low fermentable carbohydrate - high protein (LFC-HP)	75.7	73.2
5. High fermentable carbohydrate - low protein (HFC-LP)	77.1	74.2
6. High fermentable carbohydrate - high protein (HFC-HP)	72.4	71.5
Overall mean	70.9	68.6

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