

Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.

The Rat as a Model Animal for Digestion in the Dog

A thesis presented in partial fulfilment of the requirement for the degree of
Master of Science in Nutrition at Massey University

Kugappiriyai Sritharan

1998

ABSTRACT

The suitability of the laboratory rat as a model animal for studying protein digestion in the dog was investigated. The work was conducted in two experiments.

In the first study ileal and faecal endogenous excretion of amino acids and nitrogen was measured in adult rats and dogs. Two groups of five adult dogs (two females and three males) and two groups of six adult rats (three males and three females) were fed either a protein-free (PF) or enzyme hydrolysed casein (EHC)-based diet, containing Cr_2O_3 as an indigestible marker. After an 8-10 d equilibration period, 4½ h after the start of hourly feeding, the animals were euthanased and the ileal content was collected from the terminal 20 cm of the ileum and freeze-dried. Faecal digesta samples of the rats and dogs fed the PF diet were obtained one day before digesta sampling from the terminal ileum. The freeze-dried digesta collected from the EHC fed animals were ultrafiltrated before analysis. The amount of endogenous amino acids and nitrogen excreted per gram of dry matter intake at the end of the ileum for the PF and EHC fed animals and over the entire digestive tract for the PF fed animals were determined. Data were analysed using ANOVA with species, diet and the interaction between species and diet as variables. There was no interaction between species and diet on the endogenous ileal excretions of any of the amino acids or nitrogen. Significant ($P < 0.05$) higher endogenous amino acid and nitrogen excretions were found in the dogs compare to the rats when fed the PF and EHC-based diet. Faecal endogenous excretions were higher than ileal endogenous excretion in both species for all amino acid. The pattern of endogenous amino acid excretions was similar in both species with the endogenous excretions of amino acids measured by the ultrafiltration method significantly ($P < 0.05$) higher than the PF method in both species.

In the second experiment the digestibility of a commercial dry dog food was compared between the rat and the dog. A group of five adult dogs (three females and two males) and six adult rats (three females and three males) were fed a commercial dry dog food, containing Cr_2O_3 as an indigestible marker for 10 and 8 days, respectively. On the final day, 4½ h after the start of hourly feeding, the animals were euthanased and the ileal content was collected and freeze-dried. A faecal sample was collected from each animal

one day before ileal digesta sampling. The diet and digesta samples were analysed for amino acids, nitrogen, organic matter and the apparent digestibility of dry matter, organic matter, nitrogen and amino acids were determined at a faecal and ileal level. The true ileal digestibility of nitrogen and amino acids were calculated and all the data were analysed using ANOVA. In the dog, the apparent faecal digestibility of aspartic acid, threonine, serine, proline, glycine and total nitrogen was significantly ($P < 0.05$) higher than the apparent ileal digestibility values whereas for methionine the apparent ileal digestibility value was significantly ($P < 0.05$) higher than the apparent faecal digestibility value. Apparent and true ileal digestibility for most amino acids were significantly ($P < 0.05$) higher in the dog when compared to the rat. Regression analysis showed that there was a significant ($P < 0.001$) linear relationship between the apparent and true ileal digestibility of amino acids between the rat and the dog. Ileal digestibility of amino acids in the dog (Y) could be predicted from respective rat values (X). The following equations were obtained for apparent digestibility: $Y = 0.32 + 0.65 X$ and true digestibility: $Y = 0.45 + 0.53 X$.

The present study showed that the rat may be a useful model for studying protein digestion in the dog. However, to make a more general conclusion regarding the use of the rat as a model animal to study protein digestion in the dog, a wider range of dog foods need to be investigated to determine the “strengths” of the regression equation shown above.

ACKNOWLEDGEMENTS

First and foremost, my indebtedness and sincere thanks are extended to my supervisor Dr Wouter Hendriks for his excellent supervision, understanding, invaluable advice, constructive criticism and endless patience throughout my studies. Special thanks to Dr John Pluske for proof reading the thesis.

I would also like to thank the staff of the Small Animal Production Unit, Massey University and the staff of Jenners Mead Farm, Fielding, for the help during the animal trials. I also extend my thanks to Dr. K. Ankenbauer-Perkins and Dr. B. Flacek for euthanasia of the dogs.

Thanks are also due to the staff of the Nutrition Laboratory, Department of Animal Science, Massey University, for their help with chemical analyses, especially to Mr. Shane Rutherford for his help in analysing the samples for amino acids and for his invaluable advice.

I acknowledge Mr. M de Weerd and K. Weidgraaf (practical training students from The Netherland) for their assistance with the animal trials.

I am very grateful to my husband for his endless patience, encouragement and support and my children for their understanding throughout my studies.

TABLE OF CONTENTS

	Page
ABSTRACT	i
ACKNOWLEDGEMENTS	iii
TABLE OF CONTENTS	iv
LIST OF TABLES	vii
LIST OF FIGURES	ix
GENERAL INTRODUCTION	1
<u>CHAPTER 1</u> REVIEW OF LITERATURE	3
1.1 Introduction	3
1.2 Determination of the digestibility of dietary protein and amino acids	4
1.2.1 Faecal digestibility	4
1.2.2 Ileal digestibility	6
<i>1.2.2.1 Limitation of ileal amino acid digestibility</i>	8
<i>1.2.2.2 Factors influencing ileal digestibility values</i>	10
<i>1.2.2.3 Faecal verses ileal digestibility</i>	12
1.2.3 True digestibility	13
<i>1.2.3.1 Apparent verses true digestibility</i>	13
<i>1.2.3.2 Methods developed to measure endogenous losses of amino acids and nitrogen</i>	14
<i>1.2.3.3 Factors affecting endogenous losses</i>	18
1.3 The rat as a model animal	18
1.3.1 Reasons for the rat as a model animal	18
1.3.2 Comparative anatomy and physiology of the digestive tract of the rat and the dog	19
<i>1.3.2.1 Mouth cavity</i>	20
<i>1.3.2.2 Oesophagus</i>	21
<i>1.3.2.3 Stomach</i>	21
<i>1.3.2.4 Small intestine</i>	22
<i>1.3.2.5 Large intestine</i>	25

1.3.2.6 <i>Conclusions</i>	25
1.4 Endogenous gut secretion of protein in the dog	25
1.4.1 Salivary secretions	26
1.4.2 Gastric secretions	27
1.4.3 Pancreatic secretions	27
1.4.4 Bile secretions	28
1.4.5 Intestinal secretions	28
1.5 Inferences from the literature review	30
<u>CHAPTER 2</u> ENDOGENOUS AMINO ACID AND NITROGEN FLOW AT THE TERMINAL ILEUM AND AT THE END OF THE DIGESTIVE TRACT OF THE ADULT RAT AND DOG DETERMINED BY FEEDING A PROTEIN-FREE AND ENZYME HYDROLYSED CASEIN-BASED DIET	31
2.1 Introduction	31
2.2 Material and Methods	32
2.2.1 Animals, housing and diets	32
2.2.1.1 <i>Study 1</i>	32
2.2.1.2 <i>Study 2</i>	34
2.2.2 Chemical analysis	34
2.2.3 Data analysis	35
2.3 Results	36
2.4 Discussion	40
<u>CHAPTER 3</u> COMPARISON OF THE AMINO ACID DIGESTIBILITY OF A COMMERCIAL DRY DOG FOOD BETWEEN THE ADULT RAT AND DOG	44
3.1 Introduction	44
3.2 Material and Methods	45
3.2.1 Animals, housing and diet	45
3.2.2 Chemical analysis	47
3.2.3 Data analysis	47
3.3 Results	48

3.4 Discussion	55
<u>CHAPTER 4</u> GENERAL DISCUSSION	58
<u>CHAPTER 5</u> LITERATURE CITED	62

LIST OF TABLES

Table	Page
Chapter 1	
1.1 The differences between apparent faecal and ileal digestibility (%) of amino acid for the growing pig	12
1.2 Faecal and ileal crude protein digestibility measured in different animals	13
1.3 Comparative enzymology of salivary secretion in the dog and the rat	20
1.4 Mucosal surface area of different segments of the small intestine in the rat and the dog	23
1.5 The mucosal surface area of the small intestine (SI) of the rat and the dog	24
1.6 Essential amino acids in digestive enzymes of monogastric animals	26
Chapter 2	
2.1 Ingredient composition of the experimental diets	33
2.2 Mean (\pm SEM) endogenous amino acid and nitrogen excretion at the terminal ileum of the adult rat and dog fed either a protein-free (PF) or enzyme hydrolysed casein (EHC) based diet	37
2.3 Mean (\pm SEM) endogenous amino acid and nitrogen excretion at the end of the digestive tract of the adult rat and dog fed a protein-free diet	38
2.4 Statistical significance of ileal (protein, species and interaction between protein and species as variables) and faecal (species as variable) endogenous excretion of amino acids and nitrogen	39
Chapter 3	
3.1 Ingredient composition of the dog food	46
3.2 Mean (\pm SEM) apparent ileal and apparent faecal amino acid, nitrogen, dry matter and organic matter digestibility coefficients in rats and dogs fed a commercial dry dog food	49
3.3 Statistical significance between apparent ileal and faecal digestibility of amino acids, dry matter, organic matter and nitrogen of dogs fed a commercial dry dog food	50

3.4	Statistical significance of the apparent ileal digestibility of amino acids, dry matter, organic matter and nitrogen between the rat and the dog fed a commercial dry dog food	51
3.5	Mean (\pm SEM) true ileal amino acid and nitrogen digestibility coefficients in the rat and dog fed a commercial dry dog food	52
3.6	Actual apparent and true digestibility values of amino acids of a dog food in adult dogs and predicted values using the laboratory rat	53

LIST OF FIGURES

Figure	Page
Chapter 3	
1 Apparent ileal digestibility of a commercial dry dog food in the rat and the dog and the linear regression equation	54
2 True ileal digestibility of a commercial dry dog food in the rat and the dog and the linear regression equation	54