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.

BLOOD METABOLITE AND HORMONE CONCENTRATIONS OF DAIRY CALVES DIFFERING IN GENETIC POTENTIAL FOR MILK FAT PRODUCTION

A THESIS PRESENTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTERATE OF AGRICULTURAL SCIENCE IN ANIMAL SCIENCE AT MASSEY UNIVERSITY NEW ZEALAND

GUO QIANG XING

1985

MASSEY UNIVERSITY

1.* (a) I give permission for my thesis, entitled

Blood metabolite and hormone concentrations of dairy calves differing in genetic potential for milk fat production

to be made available to readers in the Library under the conditions determined by the Librarian.

(b) I agree to my thesis, if asked for by another institution, being sent away on temporary loan under conditions determined by the Librarian.

(c) I also agree that my thesis may be copied for Library use.

2. * I do not wish my thesis, entitled

.....

.....

.....

to be made available to readers or to be sent to other institutions without my written consent within the next two years.

Signed Xing, Guo Qiang

Date 25-2-85

* Strike out the sentence or phrase which does not apply.

The Library
Massey University
Palmerston North, N.Z.

The copyright of this thesis belongs to the author. Readers must sign their name in the space below to show that they recognise this. They are asked to add their permanent address.

Name and Address	Date
Xing, Guo Qiang	25-2-1985
Department of Animal Science	
Beijing Agricultural University	
Beijing	
China	

MASSEY UNIVERSITY
LIBRARY

ABSTRACT

The present study was conducted at the Massey University Dairy Research Unit to investigate the effect of genetic merit for milk fat production on the physiology and metabolism of Friesian calves.

Twenty four Friesian calves divided into four groups namely High Breeding Index (HBI) heifers, HBI bulls, Low Breeding Index (LBI) heifers, and LBI bulls were challenged with four different experimental treatments, ie. fasting, feeding, intravenous arginine infusion, and subcutaneous synthetic corticosteroid injection at ten to eighteen days of age. A total of eighteen blood samples were collected from each calf through an indwelling jugular cannula and the concentrations of plasma glucose, insulin, GH and cortisol were determined.

Some statistically significant differences were found in plasma metabolite and hormone concentrations between the HBI and LBI groups.

1. The basal glucose concentration in HBI group was significantly higher than that in LBI group ($P<0.05$). The basal plasma insulin concentration was also significantly higher in HBI group than in LBI group ($P<0.01$). The basal GH concentration in HBI calves was higher in HBI calves than in LBI calves, but the difference was not quite significance at 5% level ($P=0.059$).

2. Following feeding, plasma insulin and GH concentrations in HBI group were significantly higher than those in LBI group ($P<0.01$, $P<0.05$ respectively).

3. Acute intravenous arginine infusion induced hyperinsulinemia and hypoglycemia in all calves. LBI calves had significantly higher increments of plasma insulin measured as a percentage of basal levels than HBI calves. The response of GH concentration to arginine challenge differed significantly in terms of level and pattern between HBI and LBI groups, with the HBI calves having more prolonged higher GH concentration than LBI calves ($P<0.05$).

4. Subcutaneous injection of synthetic corticosteroid resulted in significant increments in plasma glucose and insulin concentrations, and a significant decrease in endogenous cortisol production in all calves. ($P<0.01$, $P=0.05$, $P<0.01$ respectively). But no significant differences were detected between HBI and LBI groups.

Effects of sex on plasma metabolite and hormone concentrations were also found in the present study. Plasma insulin concentration was consistantly higher in bulls than in heifers and the differences were significant at the time of fasting, after feeding, and after arginine infusion ($P<0.01$). Plasma glucose concentrations following feeding were significantly higher in bulls than in heifers ($P<0.05$). GH concentration was slightly but not significantly higher in bulls than in heifers for most of the experiment.

It was concluded that differences exist in some important metabolic and endocrinological characteristics between HBI and LBI calves, and these differences could become significant under certain physiological conditions and experimental treatments such as those applied in the present study. This study also showed the promise of identifying genetically superior Friesian dairy cattle at an early age by using physiological markers. However this possibility has yet to be tested by carring out measurements on calves for which breeding index value for milk fat production will be determined by methods such as progeny test.

ACKNOWLEDGMENT

I am grateful to my supervisors Professor D.S. Flux and Dr. D.D.S. MacKenzie for their invaluable guidance and encouragement during the period of the project.

I also wish to thank the following :

Dr. G.F. Wilson for help with the cannulation and sampling of the calves.

Mr B. Parlane of the Animal Physiological Unit and farm staff of the Dairy Research and Development Unit for management of the calves.

Mrs.J. Bridges for cortisol assay and Mrs.J. Rumbal for her technical assistance.

Mr. D.J. Garrick for assistance in appling REG programmes for repeated measurments.

Dr. S.N. McCutcheon for consrtuctive discussion.

Miss C.Y.Z. Pang and Miss F.L.H. Chee for typing the thesis.

The Animal Science Department for the fine environment and pleasant atmosphere.

My friends for their support, encouragement, and challenge.

The Chinese Educational Ministry for the financial support which has enabled me to undertake the present study.

TABLE OF CONTENTS

		page
ABSTRACT		ii
ACKNOLEDGEMENTS		iv
LIST OF FIGURES		viii
LIST OF TABLES		ix
CHAPTER ONE :	INTRODUCTION	1
CHAPTER TWO :	REVIEW OF THE LITERATURE	3
2.1	Regulation of plasma insulin, growth hormone and cortisol concentrations	3
2.1.1	Regulation of plasma insulin concentration	3
2.1.1.1	Plasma metabolites and ions	3
2.1.1.2	Enteric and pancreatic hormones	5
2.1.1.3	Other hormones and central nervous system	6
2.1.1.4	Insulin receptor	8
2.1.2	Regulation of plasma GH concentration	9
2.1.2.1.	Hypothalamic control	9
2.1.2.2	Somatomedins	11
2.1.2.3	Glucocorticoids	12
2.1.2.4	Plasma metabolites	12
2.1.2.5	Different physiological stage	14
2.1.2.6	Secretion rhythm of GH	16
2.1.3	Regulation of cortisol concentration	16
2.1.3.1	ACTH and CRF	16
2.1.3.2	Cortisol binding globulin	17
2.1.3.3	Circadian fectors	19
2.1.3.4	Stress	20
2.1.3.5.	Age	20
2.2	Digestive metabolism and glucose homeostasis in young milk fed calves	20
2.2.1	The Digestive Process	20
2.2.2	Blood glucose homeostasis	21
	a) after feeding	21
	b) fasting	22
2.3	Objectives of the present study	23
CHAPTER THREE	MATERIALS AND METHODS	26
3.1	The animals	26

		page
3.2	Rearing of Calf	26
3.3	Reconstituted milk	29
3.4	Procedure for cannulation	30
3.5	Blood sampling	30
3.6	Measurement of Haematocrit	31
3.7	Measurement of Immunoglobulin G1	31
3.8	Glucose assay	32
3.9	Radioimmunoassay of Insulin, GH and Cortisol	32
	1)Hormones used in the RIAs	32
	2) Iodination	32
	3) Antisera	33
	4) RIA procedure for GH, insulin and cortisol	33
	5) RIA Data Transformation	33
	6) Parellelism in RIA	35
3.10	Experimental procedure and statistical analysis	36
	1) Procedure	36
	2) Data analysis	38
CHAPTER FOUR	RESULTS	40
4.0	General results	40
4.1	Before feeding	40
4.2	After feeding	57
4.3	After arginine challenge	60
4.4	After synthetic corticosteroids injection	68
4.4.1	Comparison of pre-injection value with the after-injection value	68
4.4.2	Comparison between calves of different BI and sex	68
4.5	The relationship of BI and plasma metabolite and hormone concentrations	70
4.6	Other physiological traits	73
CHAPTER FIVE	DISCUSSION	75
5.1	General discussion	75
5.2	Effect of fasting, feeding, arginine infusion and synthetic corticosteroid injection on plasma glucose, and hormone concentrations	76
5.2.1	Effect of fasting	76
5.2.2	Effect of feeding	77
5.2.3	Effect of arginine challenge	78
5.2.4	Effect of synthetic corticosteroid injection	79

page

5.3.	Effect of genetic merit for milk production on plasma metabolite and hormone concentration	81
	1) Glucose	81
	2) Insulin	83
	3) GH	84
5.4	Sex effect	85
5.5	Estimation of calf genetic merit by using metabolite and hormone concentrations as gene markers	86
CHAPTER SIX	SUMMARY AND CONCLUSIONS	88
APPENDICES		91
REFERENCES		96

LIST OF FIGURES

Figure		page
1	Control of Pituitary-adrenal function.	18
2	Effects of fasting, feeding, and arginine infusion on plasma glucose concentrations in groups of calves of different BI and sex.	41
3	Effects of fasting, feeding, and arginine infusion on plasma insulin concentrations in groups of calves of different BI and sex.	42
4	Effects of fasting, feeding, and arginine infusion on plasma GH concentrations in groups of calves of different BI and sex.	43
5	Effects of fasting, feeding, and arginine infusion on plasma cortisol concentrations in groups of calves of different BI and sex.	44
6	Effect of synthetic corticosteroid injection on plasma glucose concentrations in groups of calves of different BI and sex.	45
7	Effect of synthetic corticosteroid injection on plasma insulin concentrations in groups of calves of different BI and sex.	46
8	Effect of synthetic corticosteroid injection on plasma GH concentrations in groups of calves of different BI and sex.	47
9	Effect of synthetic corticosteroid injection on plasma cortisol concentrations in groups of calves of different BI and sex.	48
10	Relationship between breeding index of calves and the basal concentration of glucose, insulin, GH, and cortisol in the plasma within BI and sex group.	72
11	Effect of arginine infusion on plasma glucose cocentrations in individual calves of different BI and sex group.	61
12	Effect of arginine infusion on plasma insulin concentrations in individual calves of different BI and sex group.	62
13	Effect of arginine infusion on plasma GH concentrations in individual calves of different BI and sex group.	63
14	Effect of arginine infusion on plasma cortisol concentrations in individual calves of different BI and sex group.	64

LIST OF TABLES

Table		page
3.1	Number,Breeding Index,sex,date of birth, birth weight,body weight and age at cannulation of calves used in the experiment.	27
3.2	Expected means, standard deviations, ranges and the standard errors in Breeding Index units of the HBI and LBI groups.	28
3.3	General calf rearing procedure.	28
3.4	The amount of milk intake of calves at each meal.	29
3.5	Summary of experimental procedure.	37
4.1	Analysis of variance of repeated measurements of basal glucose concentration between groups of calves of different BI and sex.	49
4.2	Analysis of variance of repeated measurements of basal insulin concentration between groups of calves of different BI and sex.	49
4.3	Analysis of variance of repeated measurements of basal GH concentration between groups of calves of different BI and sex.	50
4.4	Analysis of variance of repeated measurements of basal cortisol concentration between groups of calves of different BI and sex.	50
4.5	Analysis of variance of repeated measurements of after-feeding glucose concentrations between groups of calves of different BI and sex.	51
4.6	Analysis of variance of repeated measurements of after-feeding insulin concentrations between groups of calves of different BI and sex.	51
4.7	Analysis of variance of repeated measurements of after-feeding GH concentrations between groups of calves of different BI and sex.	52
4.8	Analysis of variance of repeated measurements of after-feeding cortisol concentrations between groups of calves of different BI and sex.	52
4.9	Analysis of variance of repeated measurements of glucose concentrations in response to arginine challenge between groups of calves of different BI and sex.	53

Table page

4.10 Analysis of variance of repeated measurements of insulin concentrations in response to arginine challenge between groups of calves of different BI and sex. 53

4.11 analysis of variance of repeated measurements of GH concentrations in response to arginine challenge between groups of calves of different BI and sex. 54

4.12 analysis of variance of repeated measurements of cortisol concentrations in response to arginine challenge between groups of calves of different BI and sex. 54

4.13 Analysis of variance of repeated measurements of glucose concentrations in response to synthetic corticosteroid injection between groups of calves of different BI and sex. 55

4.14 Analysis of variance of repeated measurements of insulin concentrations in response to synthetic corticosteroid injection between groups of calves of different BI and sex. 55

4.15 Analysis of variance of repeated measurements of GH concentrations in response to synthetic corticosteroid injection between groups of calves of different BI and sex. 56

4.16 Analysis of variance of repeated measurements of cortisol concentrations in response to synthetic corticosteroid injection between groups of calves of different BI and sex. 56

4.17 Analysis of covariance of repeated measuements of glucose concentration in response to feeding between groups of calves of different BI and sex. 58

4.18 Analysis of covariance of repeated measurements of insulin concentrations in response to feeding between groups of calves of different BI and sex. 58

4.19 Analysis of covariance of repeated measurements of GH concentrations in response to feeding between groups of calves of different BI and sex. 59

4.20 Analysis of covariance of repeated measurements of cortisol concentrations in response to feeding between groups of calves of different BI and sex. 59

Table page

4.21 Analysis of covariance of repeated measurements of glucose concentrations in response to arginine challenge between groups of calves of different BI and sex. 66

4.22 Analysis of covariance of repeated measurements of insulin concentrations in response to arginine challenge between groups of calves of different BI and sex. 66

4.23 Analysis of covariance of repeated measurements of GH concentrations in response to arginine challenge, between groups of calves of different BI and sex. 67

4.24 Analysis of covariance of repeated measurements of cortisol concentrations in response to arginine challenge between groups of calves of different BI and sex. 67

4.25 Mean plasma glucose, insulin, GH and cortisol concentrations of calves on day one before, and on day two after synthetic corticosteroid injection, together with the statistical significance of the difference. 69

4.26 Correlations between BI and concentrations of glucose, insulin, GH and cortisol in calf plasma sampled at four different stages of the experiment. 71

4.27 Mean values of birth weight, IgG1 concentration and haematocrit in calf groups of different BI and sex. 74

CHAPTER ONE: INTRODUCTION

The Usefulness of physiological markers in dairy cattle breeding

It has long been desired ,as recently discussed in several papers (Gorski, 1979; Kiddy 1979; Linstrom, 1982; Peterson et al,1982; Land et al, 1981) to be able to identify genetically superior dairy cattle from their contemporaries at an early stage of their life by using physiological or biochemical markers which are genetically correlated with milk production.

A dairy breeding system using such markers would have advantages over the conventional breeding technique, progeny test, in several respects:1) reduced breeding cost , 2) more intensive selection of bulls, as a large population of animals can be tested for the marker, 3) shorter generation intervals, due to the early intensive use of the identified bulls in the artificial insemination scheme.

Animal breeding programmes for dairy cattle, so far, have been based on the principles of quantitive genetics. These programmes are expensive and genetic improvement is slow. In New Zealand, contracts are made each year by the Dairy Board with individual farmers to purchase about 150 newborn dairy bulls (including both Friesian and Jersey breeds) for progeny testing. All these bulls are kept in the breeding centre till they are 5 years old, waiting the assessment of their daughters production. Thereafter only a few of the proven bulls are used intensively in the AI scheme while others are culled. Nevertheless this conventional breeding method has proved reliable and rewarding in dairy herd improvement as witnessed by the great improvement in milk production of Friesian cattle both around the world (Jasiorowski et al, 1983) and within New Zealand (Bryant et al, 1981; Davey et al, 1983; Wickham et al, 1978). This provides the opportunity to compare the physiological differences between two groups of genetically diversed Friesian cattle, a study of which may lead to the identification of suitable gene markers which could , in turn, aid in further improvement of dairy cattle production.