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**INFLUENCE OF BIRD TYPE, DIETARY FIBRE AND  
PARTICLE SIZE ON APPARENT ILEAL DIGESTIBILITY OF  
NUTRIENTS AND ENERGY UTILISATION**

A thesis presented in partial fulfilment of the requirements for the degree of

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## List of abbreviations

AA	Amino acid
ADF	Acid detergent fibre
AID	Apparent ileal digestibility
ALA	Alanine
AME	Apparent metabolisable energy
AMEn	Nitrogen-corrected apparent metabolisable energy
ANOVA	Analysis of variance
ARG	Arginine
ASP	Aspartic acid
°C	Celsius
Ca	Calcium
CAID	Coefficient of apparent ileal digestibility
Cu	Copper
CYS	Cysteine
d	days
DDGS	Distiller's dried grains with solubles
DF	Dietary fibre
DM	Dry matter
FI	Feed intake
g	Gram

GE	Gross energy
GIT	Gastrointestinal tract
GLM	General linear model
GLU	Glutamic acid
GLY	Glycine
GMD	Geometric mean diameter
GSD	Geometric standard deviation
h	hours
HCl	Hydrochloric acid
HIS	Histidine
ICP-MS	Inductively Coupled Plasma-Mass Spectrometry
ICP-OES	Inductively Coupled Plasma-Optical Emission Spectroscopy
ISO	Isoleucine
K	Potassium
Kcal	Kilo calories
kg	Kilogram
kJ	Kilo joule
LEU	Leucine
LSD	Least significant difference test
LYS	Lysine
MET	Methionine

Mg	Magnesium
MJ	Mega joule
mm	Millimetre
Mn	Manganese
N	Nitrogen
Na	Sodium
NDF	Neutral detergent fibre
NE	net energy
NRC	National research council
P	Phosphorus
<i>p</i>	Probability
pH	Power of hydrogen
PHE	Phenylalanine
PRO	Proline
SAS	Statistical analysis system
SEM	Standard error of mean
SER	Serine
SID	Standardized ileal digestibility
THR	Threonine
Ti	Titanium
TID	True ileal digestibility

VAL	Valine
Zn	Zinc
μm	microns

# CHAPTER 1

## General introduction

Poultry require dietary nutrients including amino acids, minerals and vitamins for body maintenance, growth and egg production. Feed represents the major cost item in poultry production accounting for 60 to 70% of the total production cost. The ever-increasing cost of raw materials has placed more emphasis on the use of alternative feed ingredients in order to reduce the costs of production. As a result, there has been an increased interest in exploring new approaches to improve nutrient digestibility in poultry. A major growing area on poultry nutrition research has been the use of digestible amino acids (Huang et al., 2006b) and other nutrients instead of total nutrient contents in feed formulations. The use of digestible nutrient contents of feed ingredients would enhance the economics of production by meeting the bird's nutrient requirements more closely. Besides other factors including sex (Doeschate et al., 1993; Batal and Parsons, 2002; 2003), age (Huang et al., 2005; Garcia et al., 2007), genotype (Ravindran et al., 1999b; Rideau et al., 2014) and dietary nutrient composition (Parsons et al., 1997), type of birds, level of dietary fibre (DF) and particle size of the diet are possible factors that can affect the nutrient digestibility in poultry.

There are several published data on the amino acid digestibility of feed ingredients for broilers, but studies comparing the nutrient digestibility in different bird types are scant. However, there is some available information concerning the effect of bird type on the digestibility of amino acids in feed ingredients (Huang et al., 2006b; 2007). Huang et al. (2007) showed higher apparent ileal digestibility of most amino acids in maize for broilers compared to those for layers. Huang et al. (2006b) found higher apparent ileal digestibility of amino acids in soybean meal for layers compared with those for broilers. Adedokun et al. (2009) showed higher apparent ileal amino acid digestibility of maize (0.891) and lower digestibility of meat and bone meal (0.647) in broilers than those in layers (0.714 and 0.750, respectively). Huang et al. (2000a)

reported lower protein digestibility in sorghum (0.764) and higher digestibility of soybean meal (0.889) in layers than broilers (0.815 and 0.852, respectively). Huang et al. (2000b) showed greater protein digestibility for canola meal in broilers (0.780) than those in layers (0.740). The observed influence of bird type on the nutrient digestibility in different feed ingredients suggests that the use of nutrient digestibility values generated with one type of bird may not be appropriate for other types of birds.

Inclusion of insoluble fibre sources in poultry diets has received renewed attention in the poultry research community and their inclusion is currently recommended in the commercial poultry industry (Mateos et al., 2012). It is noteworthy that factors such as type and inclusion rate of fibre sources might contribute to the variation of nutrient digestibility in poultry (Hetland et al., 2004; Mateos et al., 2012). Studies have shown that the extent to which DF improves nutrient digestibility is variable, depending on the bird type (Walugembe et al., 2014; Kimiaetalab et al., 2018). Layers fed diets with increased fibre content reported to have better utilisation of nutrients compared to broilers, suggesting that laying hens have an increased nutrient digestibility capability to the increased DF content compared to broilers (Walugembe et al., 2014). However, despite its importance, there is no clear information regarding optimal amount of fibre sources to be included in the diets of different bird types.

The effects of feed particle size on performance and nutrient digestibility in poultry have been extensively examined in the last two decades. Particle size reduction which is a common practice in commercial poultry feed production, is believed to increase both the number of particles and the surface area per unit volume, allowing greater access to digestive enzymes in the digestive tract (Amerah et al., 2007a). However, recommendations regarding optimum feed particle sizes in poultry diets are contradictory, due to number of confounding factors including feed physical form, grain type, endosperm hardness, grinding method and particle size distribution (Amerah et al., 2007b). Whilst most of research has focused on broiler chickens (Parsons et al., 2006; Amerah et al., 2007a, b; Amerah and Ravindran 2009), the impact of feed particle size on the nutrient digestibility in laying hens has not received much attention.

Despite the practical importance and possible differences in digestibility response of different bird types, studies comparing the effect of DF (Walugembe et al., 2014; Kimiaetalab et al., 2016) and particles size on the digestibility of nutrients in different bird types are limited. Studies have shown that the dietary inclusion of insoluble fibre sources (Hetland et al., 2003; Hetland et al., 2004; González-Alvarado et al., 2010; Mateos et al., 2012) and, medium and coarse grinding (Nir and Ptichi, 2001; Engberg et al., 2002; Dahlke et al., 2003; Parsons et al., 2006; Rougière et al., 2009) of cereals stimulate the development and functionality of the digestive tract and can have a beneficial effect on the dietary nutrient digestibility and utilisation (Pacheco et al., 2013; Ruhnke et al., 2015). However, the extent of beneficial effects of insoluble fibre sources and coarse particles has not been compared in different bird types. Further studies are warranted to investigate the interaction between bird type and DF content or particle size on nutrient digestibility. These studies would help decision making regarding optimum DF level or feed particle size to improve nutrient utilisation in different bird types.

Whilst limited published data are available on the effect of bird type on the nutrients digestibility and the interaction between DF content and bird type on nutrient digestibility, no study has investigated the interaction between dietary particle size and bird type on nutrient digestibility. In the present thesis work, it was hypothesised that the interaction exists in nutrient digestibility responses of different bird types to increased dietary fibre content and particle size, with layers showing better digestion efficiency in high fibre diets and to increased dietary particle size.

The objectives of the experimental research presented in this thesis are,

1. To investigate the influence of bird type (broilers, pullets and layers) and DF content (low fibre and high fibre) on apparent ileal nutrient digestibility and energy utilisation
2. To investigate the influence of bird type (broilers and layers) and maize particle size (fine, medium and coarse) on apparent ileal digestibility of nutrients and energy utilisation

This thesis consists of five chapters. Chapter 1 covers a general introduction to the thesis. Chapter 2 reviews the available data on the effects of insoluble fibre and particle size on nutrient digestibility and utilisation in different bird types. Chapters 3 and 4 present the experimental work conducted. Each chapter includes an abstract, introduction, materials and methods, results, discussion and conclusions.

Chapter 5 covers the general discussion of the summarised experimental research findings and, presents conclusions and suggestions for future research.