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NUTRITIVE VALUE AND BIOAVAILABILITY OF PROTEIN FEEDSTUFFS FOR BROILER CHICKENS

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NUTRITIVE VALUE AND BIOAVAILABILITY OF PROTEIN FEEDSTUFFS FOR BROILER CHICKENS

THESIS

A thesis submitted in partial fulfillment of the requirements for the Degree of Master of Science at Universiti Pertanian Malaysia

by

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LIST OF ABBREVIATIONS

AAA	amino acid availability
AAAA	apparent amino acid availability
ADF	acid detergent fibre
ADL	acid detergent lignin
AME	apparent metabolizable energy
BE	bioavailable energy
CF	crude fibre
CP	crude protein
DCP	digestible crude protein
DM	dry matter
EE	ether extract
(FE + UE)	excreta energy
(FEn + UEn)	excreta energy corrected to zero nitrogen balance
FFM	Federal Flour Mill
(FN + UN)	faecal and urinary nitrogen
FSM	fish meal
(FmE + UeE)	Metabolic faecal plus endogenous urinary energy
(FmEn + UeEn)	nitrogen corrected energy excretion of unfed bird
g	gram
GE	gross energy
IE	energy input
IN	nitrogen input
kcal	kilocalorie
kg	kilogram
ME	metabolizable energy
MJ	megajoule
N	nitrogen
NDF	neutral detergent fibre
NE	net energy
NFE	nitrogen free extract
SBM	soybean meal
SS	Soon Soon
TAAA	true amino acid availability
TME	true metabolizable energy
TMEn	TME corrected to zero nitrogen balance

ABSTRACT

An abstract of the thesis presented to the Senate of Universiti Pertanian Malaysia in partial fulfilment of the requirement for the Degree of Master of Science.

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Three experiments were conducted to evaluate the nutritive value and biological availability of nutrients in proteinaceous feedstuffs for broiler chickens. These include Thai fish meal (FSM), Peruvian FSM, China soybean meal (SBM), two locally-processed SBM, Federal Flour Mill (FFM) and Soon Soon (SS), respectively, and single-cell protein "Pruteen".

In Experiment 1, the nutritive values of these feedstuffs were subjected to the following chemical analyses: proximate, minerals, detergent fibre, amino acids and *in vitro* digestibility. Crude protein (CP) contents of fish meals (on dry matter basis) were

54.17% for Thai FSM and 60.98% for Peruvian FSM. Ash content in Thai FSM was higher (25.86%) than Peruvian FSM (15.51%). Gross energy in Peruvian FSM (4, 488 kcal/g) was higher than Thai FSM (3,781 kcal/g), attributing mainly to higher fat content in the Peruvian FSM (10.37%) than in the Thai FSM (7.59%). *In vitro* evaluation of fish meals showed that the digestible CP (DCP) was higher for Thai FSM (42.2%) than the Peruvian FSM (40.0%). SBM of China origin showed highest protein content (44.41%) followed by FFM SBM (43.09%) and SS SBM (41.04%). However, the amino acid profiles showed that China SBM had the lowest total amino acid value (42.81%) and SS the highest (44.08%). *In vitro* evaluation showed that China SBM had the highest DCP (38.33%) and that of the two locally-processed SBM were comparable (35.15 and 35.64%). Pruteen had a high CP value (71.94%) and DCP (61.0%), but low in crude fibre (/ 1%), and high in gross energy (4,527 kcal/g).

Experiment 2 consisted of two trials. In the first trial, the effects of Thai FSM (5 to 32%) and Pruteen (3 and 5%) inclusion in the diets on digestibility and performance by broiler chickens were studied. The results showed that diets containing FSM exhibited higher nutrient digestibility and superior performance than the control diet without added FSM. Optimal performance was obtained at 10 and 15% FSM inclusion. In the second trial the inclusion of Peruvian FSM (28/22%) was inferior to Thai FSM (32/25%) in nutrient digestibility and performance. Pruteen gave comparable nutrient digestibility and performance as those on FSM-based diets, although it was observed that there was growth depression and low feed intake at higher levels of Pruteen inclusion. The second trial studied the effect of type and level

of SBM-based diets on the digestibility and performance by broiler chickens. The data showed that digestibility and performance were superior at lower level (20%) of SBM inclusion in diets containing FSM than higher level (44/35%) of SBM with no added FSM. This study revealed that SS SBM had relatively lowest quality among the three SBM.

Experiment 3 was carried out to determine the true metabolizable energy (TME) as bioavailable energy, and amino acid availability of protein feedstuffs. The results showed that Thai FSM contained 3.30 kcal TME/g and Pruteen, 3.23 kcal TME/g. The TME for FFM SBM was the highest (2.92 kcal/g) and China, the lowest (2.69 kcal/g) of the SBM. Thai FSM and Pruteen showed high true amino acid availability (TAAA) (average 89.0 and 92.0%, respectively). The TAAA of China SBM was lowest (74.1%) whereas the two locally-processed SBM had the same TAAA (86.7 and 86.4%, respectively).

CHAPTER I

INTRODUCTION

Efficient animal production depends on the availability of feedstuffs of good quality and undoubtly protein quality is an important measure. The quality of protein source is the most variable among feed ingredients and also generally, the more expensive in cost. Therefore, the study of feed protein quality deserves thorough assessment, involving the study of the general quality of feedstuffs, the amino acid composition and the bioavailability of nutrients to the animals.

Chemical analyses provide estimates of the nutritive quality of feedstuffs and play an important part in providing information on the amino acid profiles of feedstuffs. Bioassay, digestibility and performance trials need to be included to assess the nutritive value of feedstuffs adequately. Bioavailable nutrients such as amino acids and energy in feedstuffs are of fundamental importance in determining value. Knowledge of the amount and availability of various nutrients supplied by the feedstuffs is essential in order to avoid inefficient feeding and enormous wastage of feed resources.

The determination amino acid availability is time-consuming and expensive. This has delayed the publication of data on available amino acid requirements and the formulation of diets based on available amino acids. It is desirable to employ a simpler and more rapid method in determining the amino acid availabilities in feedstuffs.

True metabolizable energy (TME), an estimate of bioavailable energy, is important in estimating requirements and formulating rations. A rapid biossary for TME in feedstuffs for poultry has been developed (Sibbald, 1976) and an adaption of the TME procedure

(Likuski and Dorrell, 1978; Sibbald 1979b, c) can be used to assay for amino acid availability (AAA).

Optimal bird performance depends very much on diet formulation of correct amount of the various nutrient to meet accurately the quantitative nutritional requirements. Emphasis is placed on the relationships between compositional attributes and animal performance. Thus, the nutrient content and availability in feedstuffs is becoming important in livestock feeding and needs to be considered for precise diet formulation and preparation.

Feed formulation in Malaysia, at present relies on chemical composition and overseas nutrient availability data. It is not really appropiate to use these value, in view of the variability due to variety, location and methods of production of the locally available proteinaceous feedstuffs. However, work on nutrient availability of the locally available proteinaceous feedstuffs is still very much limited in Malaysia. Consequently, this study seeks to elucidate by chemical and biological evaluation, the quality, the TAAA and the TME of some of the locally available proteinaceous feedstuffs used in broiler diets. These include various fish meals and soybean meals. In addition, the recently introduced single cell protein in Malaysia, designated as Pruteen, produced from Methylophilus methylotrophus by anaerobic fermentation of methanol in the presence of ammonia was chosen for evaluation.

CHAPTER II

LITERATURE REVIEW

A. METHODS OF FEED EVALUATION

Evaluation of feedstuffs in the context of animal production is very important for efficient feeding to improve performance of the animals and to avoid enormous wastage of feed resources. The simplest evaluation of feedstuffs is a comparison of their gross effects as in feeding trials. A further refinement is the chemical analyses of feedstuffs and subsequently, determination of the digestible nutrients and bioavailabilities in the different feedstuffs. These chemical and biological means of evaluating feedstuffs are accepted standardised methods of providing information on composition and/or nutritive values.

1. Chemical Evaluation

Chemistry is very important in predicting the value of feedstuffs. Chemical analyses provide means to determine the common nutrients such as protein and its amino acid profile, fibre, fat, ash, minerals and calorific content. These procedures are described in the book <u>Official Methods of Analyses</u>, published by the Association of Official Analytical Chemists (AOAC, 1975).

(i) <u>Proximate Analysis</u>

The need to develop and quantitative system for classifying and evaluating feedstuffs has long been recognized by animal nutritionists. Henneberg and Stohman, working in the early part of the nineteenth century at the Weende Experimental Station in Germany, introduced the 'Weende' System of feed analysis which describes feeds in terms of their proximate components: moisture, ash, fat, fibre, crude protein and nitrogen-free extract. At present, the proximate analysis is probably the most generally used chemical scheme for describing feedstuffs.

The Weende analysis does not define the nutrient content of feedstuffs. It is an index of nutritive value only because the fractions that it isolates are correlated with some of the properties of feeds that have nutritional significance. Consequently, it is a useful descriptive device in establishing the characteristics of feedstuffs.

Although the Weende analysis is inadequate as a measure of the chemical composition, it provides useful information on the nutritive value of feedstuffs in general and is still retained as a routine method of analysis. In addition, most laboratories supplement the data obtained from proximate analysis with more detailed analyses carried out by modern techniques.

The general principles of proximate analysis are given below:-

(a) Crude Protein (CP) - This is approximate by multiplying the Kjeldahl nitrogen value by the factor 6.25. Depending on the type of feedstuff, a greater or lesser part of the nitrogen is present as true protein while the remainder is inorganic nitrogen salts, amides, etc.

(b) Ether Extract (Crude Fat)(EE) - This is measured as diethylether or petroleum ether extracted material. It includes not only oils and fats but fatty acids, resins, chlorophyll, etc.

(c) Crude Fibre (CF) - This refers to organic matter insoluble in hot dilute sulphuric acid and dilute sodium hydroxide solution. It is noted that the CF in many cases is a misleading indication of the digestibility and nutritive value of a feedstuff as has been shown by the development of methods for partitioning the fibre fraction (Van Soest, 1967).

(d) Ash - This is determined by igniting samples until they are free of carbon.

(e) Nitrogen Free Extract (NFE) - This is the difference between the sum of the other constituents and the original dry weight. In other words, it is what remains after the other groups of components have been detected by analysis. NFE includes sugars, starches, etc.

(ii) Gross Energy

The animal obtains energy from its feeds. The energy present in the feed is measured by converting it into heat energy and determining the heat produced. The conversion is carried out by oxidizing the feed by oxidizing the feed by burning it; the quantity of heat resulting from the complete oxidation of unit weight of a feedstuff is known as the gross energy or heat of combustion of that feedstuff.

(iii) Minerals

It is important to know mineral contents of feedstuffs because of the great inherent variability. Macro-elements like calcium (Ca), phosphorus (P) and magnesium (Mg) may be measured. The ashed samples are digested in acids and analysed for the minerals. Ca and Mg are determined by atomic absorption, and P is determined by colorimetric method, involving the vanadomolybdate complex.

(iv) Fibre Analysis

Crude fibre has been and remains a common means of evaluating fibre content in feedstuffs.

However, the need for better methods of the fibre analysis arises due to the deficiencies of crude fibre analysis and associated proximate analysis (Van Soest, 1977). The weaknesses of the CF method have been known for a long time but have only recently become widely recognized. The error of the CF assay stems from its failure to recover lignin and other fibre components (Van Soest, 1975).

Fibres are variable in their composition and properties, and it is not possible to describe the characteristics and amount of fibre with a single value. They will require analysis for components including lignin, cellulose and hemicellulose.

The Detergent System of Fibre Analyses

The objective of the detergent system of analyses is to fractionate feeds of plant origin relative to their nutritive availability and fibre content. The cell wall components of feed are recovered in the neutral detergent fibre (NDF), while the acid detergent fibre (ADF) divides these into fractions soluble and insoluble in IN acid. The acid soluble fraction includes the hemicellulose and cell wall protein while the residue (ADF) recovers cellulose and lignin which is the least digestible non-carbohydrate fractions. Improved systems for fibre analysis (Goering and Van Soest, 1970) have been widely accepted in research laboratories as replacements for the older crude fibre trechnique.

Studies have been conducted in the use of the detergent fibre analyses in formulating broiler rations (Strong and Holder, 1978). The study concluded that ADF is a more accurate and repeatable analysis for fibre than is CF. Thus, when data are available, ADF might be preferable to CF in formulating poultry diets.

(v) Amino Acid

The crude protein value does not distinguish between protein and non-protein nitrogen and assumes that all protein contains 16% nitrogen and is of equal biological availability. It gives no indication of the content of amino acids which constitute the protein and which are required by the animal. The amino acid composition and levels are useful in predicting the potential nutritive value of the protein to the animal.

The amino acid composition and levels can be determined accurately by ion-exchange chromatography of protein hydrolysates.

(iv) *In Vitro* Evaluation

In vitro evaluation provides a means of rapid assessment of nutrient bioavailability. Procedures have been developed and modified to imitate the action of the animal digestive system and are used