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Problems in Providing High-energy Rations for Pigs and Poultry

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Text not received for publication.

The Relative Values of Available Protein Concentrates for Non-ruminants

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Protein concentrates are expensive and in short supply in relation to the quantities of cereals available for pig and poultry feeding. It is wasteful to include them in rations at more than the minimal levels necessary for the desired rates of performance—with allowance for any contemplated dilution of the ration with grain. In practice these levels can only be determined for the different classes of rations with a few of the possible concentrates or combinations of them. If the individual feeder or compounder happens to be using any of these particular combinations he can fix his formulas with some certainty.

In order to substitute one protein concentrate in a ration for another an estimate has to be made of their relative replacement values, any error in this estimate will either reduce the margin of safety, which would be dangerous, or increase it, which would be wasteful. That protein concentrates are not of equal feeding value is to be expected from the differences in amino-acid composition among proteins.

A scarcity of protein concentrates for feeding non-ruminants can also be relieved by ensuring that the necessary processing causes the minimum damage to the nutritional value of the food and by developing new processes for the recovery of protein from materials at present used only for ruminant feeding or discarded altogether. The adoption of new methods by manufacturers will depend upon the price obtained for the products. This will depend on the opinions of those compounding rations as to how far they can reduce the quantities of protein they require by using sources of higher quality—that is to say on the relative replacement values of these different materials.

Particular concentrates, in addition to their contribution of protein, are also important sources of energy, minerals and vitamins—aspects that are considered in the papers of Duckworth (1954) and Robinson (1954). These properties will, of course, affect their overall value and market price. Further, it is now obvious that much earlier experimental work on the value of different protein concentrates in practical rations was misinterpreted because the materials under test were

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acting to correct deficiencies of vitamins or minerals as well as of proteins. Improved knowledge of individual nutrient requirements and the development of alternative vitamin sources have allowed greater flexibility in the formulation of rations, and the problem of balancing rations has become less one of including ingredients with special properties, such as the use of skim milk in baby chick rations, and more one of quantitative comparison of one material with another. The aim of substitution is not now to get better performance, but to get the same performance more economically. With other deficiencies corrected, even a relatively unbalanced protein source can often be used as the sole protein supplement to cereals if it is fed at a high enough level.

Feeding trials

Very many experiments have been carried out on the value of protein supplements in practical rations, but every reviewer encounters 'great difficulty in evaluating much of the work owing to the great diversity of conditions under which the experiments of the various investigators were carried out' (Hill, 1943–4).

It has, however, been demonstrated that in the young chick animal protein, as such, is not essential for rapid growth, and good practical starting rations have been constructed with all-vegetable concentrates, though generally so as to give a higher total level of protein. The belief that there was little or no difference in the supplementary values of animal and vegetable protein concentrates for laying hens and bacon pigs has been shown to be a misinterpretation of the results of earlier feeding trials (see Carpenter, 1951; Woodman & Evans, 1951), in which experimental animals (whether pigs or hens) were given a series of protein concentrates and did equally well on animal or vegetable ones. However, the levels of protein in these rations were above what are now known to be the requirement levels for most materials, so that although some rations had greater margins of safety than others, none contained less than the critical levels of any of the essential amino-acids. Thus it has been shown by Woodman & Evans (1951) in their determinations of the minimal levels of fish meal and groundnut meal, respectively, required to supplement fully the proteins of a basal ration with barley, bran and grass meal that, although a nearly optimal level of growth could be obtained with groundnut meal alone, the level of protein needed was considerably above the minimum required to obtain the same growth rate when fish meal was the sole supplement. Our own experiments with laying hens (Carpenter, Duckworth & Ellinger, 1954) have given entirely comparable results; furthermore the depressed production with low levels of vegetable protein was obtained even in the presence of added vitamin B_{12}, but was corrected by the addition of the amino-acid, methionine.

An attempt has been made to bring together in Table 1 data for the relative protein valeus (as obtained by different tests) of various concentrates. The results most directly applicable to practice are those of Woodman & Evans for measuring supplementary protein values for the bacon pig. The 'gross protein evaluation' for chicks is also a test of the value of concentrates as supplements to a practical cereal mixture, but the grow resthponse is measured at only one level of supplementation

Table 1. *Supplementary protein value for pigs and gross protein value for chicks and content of lysine, and methionine with cystine, of certain feeding-stuffs*

Supplement	Supplementary protein values for pigs*	Gross protein values for chicks†	Amino-acids (g/16 g N)†	
			Lysine	Cystine and methionine
Casein (chick standard)	—	100	(8.0)	(3·4)
Fish products				
White fish meal (pig standard)	100	91	6·7	4·3
Herring meal	—	95, (98)	7·5	4·1
Condensed fish solubles (from herring)	—	65	3·8	2·1
Whale products				
Whale-meat meal	—	97	9·0	3·6
Grax meal	—	96	9·8	3·3
Condensed whale solubles	—	57	4·7	1·7
Other animal and fermentation products				
Meat-and-bone meal	—	53, (55)	6·2	(2·6)
Liver meal	—	(55)	(6·0)	(3·9)
Dried skim milk	—	(90)	(7·6)	(3·8)
Dried brewer's yeast	100	90	7·6	(3·0)
Oilseed meals				
Cottonseed meal	—	(25)	(4·0)	(3·8)
Groundnut meal	50	45	3·4	2·3
Soya-bean meal	75	75, (76)	(6·2)	(3·4)
Legumes				
Bean meal	—	42	6·6	(2·4)
Pea meal	—	(59)	(6·4)	(2·4)

* These approximate figures are calculated by the author from the results of Woodman & Evans (1951) and Evans (1952*a*, *b*).

† These were obtained with U.K. samples (Carpenter, Duckworth, Ellinger & Shrimpton, 1952 and unpublished findings), except for the data in parentheses—obtained under American conditions (chick results, Heiman, Carver & Cook, 1939; Robertson, Carver & Cook, 1940; Draper & Evans, 1944; amino-acid analyses, De Man, 1949).

and with less rigorous control of energy intake (Heiman, Carver & Cook, 1939). However, it has been found a reliable guide to the approximate value of different supplements for chicks. Many more tests have been carried out with synthetic diets on young rats but these results cannot be relied on as a direct index of the value of protein concentrates as supplements to cereals for pigs and poultry.

Amino-acid data

Supplements have to be used in a variety of non-ruminant rations for starting, growing and breeding animals, and in varying combinations with cereals and other feeding-stuffs. It is sometimes suggested that the only relevant information is the full amino-acid composition of all possible components so as to allow of rations being made up to cover the minimal requirements of each class of stock, Certainly a deficiency of lysine or the sulphur-containing amino-acids, methionine and cystine, which are the most commonly limiting factors in practical rations, may explain a low value in feeding trials. But, apart from young chicks, the requirements for each amino-acid by non-ruminant stock are not known. In addition, the detection of high levels of an amino-acid in the test material on analysis does not guarantee its being present in available form, (c.f. Hegsted, Tsongas, Abbott & Stare, 1946; Clandinin, 1949). In other words, amino-acid composition may sometimes predict failure, but cannot predict success. However, used in conjunction with the results of feeding trials, on stock whose amino-acid requirements are known, it can indicate whether a material has its full potential nutritive value, or whether it is worth attempting to improve it by altering the method of processing.

Several groups of workers have found the protein-quality index (Almquist, 1941) of value in assessing how far particular samples of a feeding-stuff have been damaged in processing. It is a simple test suitable for a routine laboratory.

Animal by-products

White fish meal is our largest single source of animal protein; its place in practical rations is well understood, and it has become the measure by which other concentrates are judged. The type of fish (other than dog fish or other elasmobranchs high in urea) has little effect on quality. Fertilizer-grade meals may have a low value (Bender, Miller & Tunnah, 1953), but we have found that meals carefully processed by either flame drying, batch vacuum or continuous steam drying show similar feeding value.

Herring meals can be of equally high protein quality, but condensed herring solubles, prepared from the press-water obtained after cooking and pressing to expel the oil, are a poorer source of protein, as expected from their amino-acid analysis. Preliminary experiments indicate that fish waste can also be stored, without drying, by adding formic acid, without any important loss in feeding value.

Whale-meat meals can be as good as fish meals—unfavourable results in some instances may be explained by failure to correct for their lower content of minerals when balancing rations. Again the whale solubles are of lower value. Slaughter-house products are generally of low quality with the amino-acids only partly available (Serfontein, 1947; March, Biely & Young, 1950; Underwood, Conochie, Reed & Smyth, 1950).

Plant products

Soya-bean meals are, after suitable heat treatment, high-quality supplements, but some incorrectly processed samples are still sold. Groundnut meal has a lower value little affected by the normal range of processing methods (Cama & Morton, 1950; Carpenter & Ellinger, 1951). Sunflower-seed meal has received less attention but has a high content of sulphur amino-acids and proved satisfactory as the sole protein source in both growing and laying trials (Pettit, Slinger, Evans & Marcellus, 1943–4). Sesame meal is intermediate in composition, and can be used as the only supplement for laying rations (Hale & Bolton, 1948). Linseed and cottonseed meals can now be rendered non-toxic on a commercial scale, and may prove important protein sources. The value of pea and bean meals is limited by their relative deficiency in methionine (cf. Richardson, 1947).

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Synthetic and fermentation products

Properly killed brewer's and fodder yeasts can be valuable supplements to rations adequately fortified with minerals (see Table 1) (Temperton & Dudley, 1940–1). Chlorella and bacterial preparations may also be produced commercially in the future.

Synthetic methionine will become important if offered at a price competing with the methionine and metabolizable calories contributed by normal concentrates—it is the amino-acid limiting the value of many practical rations.

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The Use of Synthetic Vitamins and Antibiotics in Non-ruminant Feeding

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Throughout the war, and the years immediately after, the scarcity of feeding-stuffs was of more immediate practical importance to the farmer than the cost, since the latter was related to the prices paid for livestock products. Even though pig and poultry meals now sell at about £37/ton, compared with £15 in 1949, the demand has expanded to a marked degree as a result of the retention of the principle of

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