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Intake of nutrients from pasture by poultry

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EC legislation requires the land to which free-range poultry have access to be 'mainly covered with vegetation', but the nature of this vegetation is not specified. In practice, most free-range land will be grass pasture. Modern poultry nutrition is a highly-developed science, and to house poultry in an environment in which they may consume an unknown quantity of vegetation, itself of unknown nutritive value, introduces uncertainty into a predictable system. In recent years the contribution of grazing to the nutrition of the birds has been considered negligible. However, birds on range appear to ingest a little grass, and therefore the quality of the pasture may affect their performance. If poultry consumed largely grass, then the nutritional value derived from it would be relatively poor. The grass would constitute a source of energy and fibre, but would make little contribution in terms of protein. The likely approach that poultry nutritionists would take is a precautionary one. They would need to know the full nutritive value of the pasture and the likely quantitative intake by the birds, and they would then make adjustments to feed formulations at what they considered to be a 'safe' level, in order to minimise the risks of impairing performance. A small (0–5) percentage contribution is probably the most that could be achieved, but given that feed accounts for about 70% of the variable costs of poultry production, such a contribution is economically important.

Free-range poultry: Pasture: Grazing: Nutritive value

In 2000 the UK poultry industry comprised: $28{\cdot}7\times10^6$ layers, $9{\cdot}9\times10^6$ breeders (the vast majority of these birds being broiler breeders), 797×10^6 broilers per year, 27×10^6 turkeys per year, 19×10^6 ducks and geese per year (Ministry of Agriculture, Fisheries and Food, 2001). The vast majority of these birds are housed indoors and have no access to pasture, but there is a growing market in the UK for free-range poultry products. Of the 28×10^6 laying hens mentioned earlier, approximately 3×10^6 are thought to be housed in free-range systems in which the birds will have access to the outdoors during daylight hours. There is also a growing market for organically-reared meat chickens, although it is much smaller than that for free-range eggs. EC legislation requires the land to which free-range hens have access to be 'mainly covered with vegetation', but the nature of this vegetation is not specified. In practice, most free-range land will be grass pasture.

Modern poultry nutrition is a highly-developed science. Computer formulation matrices are used to evaluate the effect of known dietary components on the nutritional value of a compound feed. Dietary additives such as enzymes are used to elicit small but economically cost-effective improvements in the digestion of carbohydrates and minerals. Synthetic amino acids are added to feeds in order to give the correct protein balance according to the growth and maintenance demands of the genotype in question. Feeds are formulated so that their metabolisable energy value reflects the expected needs of the bird at a certain quantitative ad libitum feed intake, predicted from experimental work and from commercial practice in controlled environments.

To house poultry in an environment in which they may consume an unknown quantity of vegetation, itself of unknown nutritive value, introduces an element of uncertainty into an otherwise orderly and predictable system. However, it is impossible to prevent outdoor-kept poultry from consuming pasture (or indeed inhabitants of the pasture, such as invertebrates), and therefore it is useful to consider how much they might consume and what

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nutritional value they might derive from it. Such data, albeit vulnerable to considerable variation, may then enable practical nutritionists to incorporate small allowances into their feed formulations, and hence make some savings.

Dietary needs and specifications

It is important to examine the specifications of a modern poultry diet in order to establish the potential to replace some of the nutrients found in the compound feed with nutrients from pasture.

The energy needs of poultry are normally met by including oil or fat and a proportion of cereal in the diet. In the UK the cereal component tends to be principally wheat, although barley is also used. The NSP and β-glucan contents respectively of these two cereal types were at one time a limiting factor to their inclusion rate in practical feeds, but the development of dietary enzymes to aid the digestibility of these carbohydrates has improved their utilisation by poultry. It is common for ≥60% of the compound feed (for both meat and egg-laying types) to be cereals. The most common source of oil or fat for poultry rations currently is vegetable oil such as soyabean. Although an excellent source of energy, there are limits to the quantity of oil that can be added to feeds, because of the risks of rancidity and the likelihood that feed will not flow easily out of hoppers or bins on the farm if it is too oily. The cereal and oil content of commercial poultry feeds is largely responsible for their ability to provide as much as 12000 kJ metabolisable energy/kg.

Before the bovine spongiform encephalopathy crisis the use of meat-and-bone meal, of bovine origin or otherwise, was common in poultry feeds as an excellent source of protein. Its use was discontinued in the UK several years ago, and the primary protein source for chickens is now soyabean meal, either in its entirety or in a higher-protein de-hulled form. Fishmeal is still used where poultry producers' contracts with their suppliers do not prohibit it. A crude protein (N × 6·25) content of about 200 g/kg for broiler meat chickens and 160 g/kg for laying hens is typical for a commercial feed.

Minerals and vitamins are provided as supplements in most commercial feeds for poultry. These supplements ensure that the birds receive the correct amount of trace elements in their diet, the compound form of which may be deficient in some minerals and vitamins. The more common elements such as Na may be provided through the addition of NaCl or $NaHCO_3$ as separate items. Ca is vital to poultry for skeletal growth, and for eggshell formation in the case of laying hens, and is often added at the feed mill in the form of dicalcium carbonate.

Table 1 gives a feed formulation for free-range table chickens (this example is for an organic flock). Note that the cereal content increases, and the soyabean content decreases, in the grower and finisher phases compared with the starter phase.

Table 2 shows an analysis of the feeds shown earlier. Note that the protein content of the feed declines as the birds progress from their 'starter' ration in early life to their 'finisher' ration as they reach slaughter weight, and their growth rate declines. This decline reflects the reduction in soyabean content described earlier, and illustrates the concept of matching the nutrient supply in the feed with the requirement of the bird as it ages. Although not shown in Table 2, the energy value of the feed would increase as the protein content decreases. This increase reflects the increase in the birds' energy requirement for maintenance even though its requirement for growth is declining.

Table 1. Feed formulation for organic table chickens

	Quantity (kg/t)		
Ingredient	Starter (0–10 d of age)	Grower (11–28 d of age)	Finisher (29–81 d of age)
Wheat	550	700	710
Wheatfeed	105	50	50
Full-fat soyabean	260	198	192
Peas (*Pisum sativum*)	50	20	17
Starter supplement	35	–	–
Grower supplement*	–	32	–
Finisher supplement	–	–	30

*A supplementary mineral and vitamin premix.

Table 2. Calculated analysis of feed for organic table chickens

Content (g/kg)	Starter	Grower	Finisher
DM	873	871	870
Crude protein (N × 6·25; DM basis)	182	161	159
N	29·1	25·8	25·4
Total P	7·3	6·5	6·5
K	8·0	6·7	6·6

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The contribution of grazing to the diet

In recent years the contribution of grazing to the nutrition of the birds has generally been considered negligible. Thus, commercial pasture management has often consisted of little more than keeping the grass tidy. Sward composition, using mixtures dominated by perennial ryegrass (*Lolium perenne*), has been aimed at the provision of durability and ease of management rather than at nutritional potential. However, birds on range appear to ingest a little grass, and therefore the quality of the pasture may affect their performance. The plant species sown and the age and maturity of the herbage affect the botanical and chemical composition of the pasture. We also know that the nutrient value of grass changes according to the time of year and growth stage. In spring grass has high sugar and protein contents and a relatively low fibre content. In summer the sugar and protein contents fall before a resurgence in early autumn. In addition, the botanical composition of permanent grassland and older sown pastures has been described by Brockman (1995) as dependent on factors within the farmer's control, such as drainage, compaction, acidity, fertility, weed population, stocking rate and grazing control, as well as factors out of the farmer's control such as altitude, aspect, soil type, geology and climate. The technology of these factors for ruminant pastures is well documented, but not for poultry pastures.

Authors of the pre-industrial era of poultry production were convinced that pasture grass had feeding value. Thompson (1952) considered that properly-managed short good-quality pasture could be so beneficial in spring and early summer as to reduce the consumption of purchased feed by 5%. Robinson (1948) also recommended keeping the grass short, and quoted estimates of ≥10% feed savings from the grazing of high-quality young fresh grass, while commenting that the contribution was the subject of debate. It was also considered that grass contributed to the achievement of an acceptable yolk colour. The source of the information is not clear on the issue of whether the feed savings were made at the expense of egg output. Of course, the chicken genotypes of 1948 were less prolific than those of today, and it could be argued that the poultry feeds of that time were closer in nutritional value to the pasture on which the chickens ranged.

In a handbook of guidelines Poultry World (1959) mentioned that many different seed mixtures had been tried for poultry pasture, but gave an example sward composition (Table 3). The sward was dominated by perennial ryegrass.

Table 3. A typical traditional seed mixture for poultry pasture

Species	Quantity lb	Quantity kg
Perennial ryegrass (*Lolium perenne* var. Aberystwyth 23)	20	9·07
Creeping red fescue (*Festuca rubra*)	3	1·36
Wild white clover (*Trifolium repens*; English certified)	1	0·45
White clover (var. Aberystwyth 100)	1	0·45
Total	25 lb/acre	28·1 kg/ha

Table 4. Seed mixture used in Department for Environment, Food and Rural Affairs-funded project* at ADAS Gleadthorpe

Species	Quantity (kg)
Amenity perennial ryegrass (*Lolium perenne*)	31·50
Smooth-stalked meadow grass (*Poa annua*)	4·50
Brown top bent (*Agrostis capillaris*)	2·25
Timothy (*Phleum pratense*)	2·25
White clover (*Trifolium repens*)	4·50
Total	45 kg/ha

*Project OF0153.

The seed mixture used in a recent Department for Environment, Food and Rural Affairs-funded project at ADAS Gleadthorpe is typical and is given in Table 4. The mixture was chosen to be representative of a robust pasture for poultry and is similar to those specified in the literature. It proved to be hard wearing for meat birds during a wet summer, and the birds were observed to eat it.

Some herbs (rosemary (*Rosmarinus officinalis*), sage (*Salvia officinalis*), oregano (*Origanum vulgare*) and thyme (*Thymus vulgaris*)) have powerful antioxidant capabilities and moderate antimicrobial activities (Adams, 1999). It may be desirable, therefore, to include herbs in the sward if such a practice permitted a reduced reliance on the feeding of synthetic antioxidants, and if immune responses were to be enhanced.

It is possible that grazing stock may benefit from antimicrobial effects of nitrates in the foliage of forages that are converted to nitrite in the gastrointestinal tract. McDonald *et al.* (1995) mentioned that herbage contains non-protein-N and Coultate (1996) ascribed antimicrobial properties to nitrite used in curing meat.

If poultry were simply to consume pasture largely in the form of grass, then the nutritional value they would derive from it would be relatively poor in comparison with that of their compound feed. The grass would constitute a source of energy and fibre, but would make little contribution in terms of protein. According to McDonald *et al.* (1995) young grass has a DM content of 200 g/kg and a crude protein content of 31·2 g/kg on a fresh-weight basis, whereas mature grass has a DM content of 282 g/kg and a crude protein content of 28·2 g/kg. These values can be compared with those shown in Table 2. If, however, birds additionally consumed invertebrates in the pasture, their supplementary intake of protein could be high.

Chickens have been reported to feed on a wide range of macroinvertebrates living in the surface soil, including ground beetles (*Carabidae*), rove beetles (*Staphlinidae*), spiders (*Araneae*) and earthworms (*Lumbricidae*; Clark & Gage, 1996).

In a review of management of laying hens in mobile houses Bassler *et al.* (1999) cited work reporting the nutrient value of earthworms, grasshoppers (*Orthoptera*) and housefly (*Musca domestica*) pupae. The metabolisable energy values of these organisms were potentially useful, at between 12 400 and 12 800 kJ/kg DM, and the crude protein and lysine contents were very high. For example, in earthworms the values were 610 g crude protein/kg DM and 42 g lysine/kg

DM. Earthworms were lower in crude protein content than grasshoppers or housefly pupae, but earthworms were richest in lysine, the first limiting amino acid for poultry.

In comparison, current ADAS (unpublished results) recommendations for the crude protein and energy content of free-range laying hen rations are approximately 170 g/kg and 11 700 kJ/kg respectively. Laying hens in a free-range system might be expected to consume about 130 g feed/d in average weather conditions (an ambient temperature of about 16°) and their crude protein intake would therefore be about 22 g in the course of 1 d. The equivalent of this intake would be provided by the consumption of 36 g earthworm (DM basis). The authors are not aware of any recent work in which measurements have been made, and so it is difficult to say whether the productivity of present-day free-range poultry flocks is being affected positively or otherwise, by their consumption of pasture. Furthermore, the extent to which the quality of the end product (whether eggs or meat) is being affected is not known.

In the absence of published recent research using modern chicken genotypes, the likely approach that poultry nutritionists would take is a precautionary one. They would need to know the answers to some key questions, such as the full nutritive value of the pasture and the likely quantitative intake by the birds. They would then make adjustments to feed formulations at what they considered to be a 'safe' level, so that the risks of impairing performance are minimised. It is our view that a small (0–5) percentage contribution is the most that could be achieved, but given that feed accounts for about 70% of the variable costs of poultry production, such a contribution is economically important. There are other major gaps in our knowledge to which research should be addressed. Although it is known that birds will consume pasture, it is not know how selective they are in terms of their preferences for components of the pasture. Valuable information could be obtained on this subject by studying the grazing habits of outdoor poultry.

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