RESEARCH TOPIC REVIEW: Organic Poultry Nutrition and Rations

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1. Scope and Objectives of the Research Topic Review:

The scope of the review is to consider recent sources of information relating to the feeding of organic laying hens, broilers and turkeys. In particular it reviews all the research commissioned by Defra together with other UK and European work and collates the results of that work in the light of commercial experience, providing advisers with a summary of the key recommendations. The study will in particular focus on determining the suitability and availability of organic ingredients and the ways in which farmers can make the best use of these.

Best practice i.e. the use of 100% organic ingredients should be at the forefront of all feed formulation. The main problem faced by producers is the sourcing of organic ingredients that provide adequate levels of essential amino acids (AA) such as methionine and lysine without introducing higher levels of anti-nutritional factors (ANF) into the diet. For these reasons many diets are formulated using the non-organic allowance i.e. 15% annual dry mater intake can be approved non-organic ingredients, permitted until 31st December 2007. After that date the level falls to 10% then 5% two years later and finally 100% organic from 1st January 2012.

Genotype, the birds' ability to utilise naturally occurring ingredients and factors governing the use of range will be reviewed.

The review will indicate the ways in which farmers can optimise performance taking into account the types of bird available, the feed that can be provided on the farm and the management of the range. There will be some consideration of the cost of feed and the ways in which this may change.

2. Summary of Research Projects and the Results

For poultry's performance to be optimised it is first necessary to define nutrition and the components of the feed that are required. The definition of nutrition (Kuhl 2006) is the sum of the processes in which an organism takes in food and utilises it for growth, tissue repair and replacement or elaboration of products. Related problems fall into four categories; undernutrition, overnutrition, deficiency and secondary malnutrition from illness, genetic disorder or the effect of the environment. The classes of nutrients found in feed are carbohydrates, proteins, lipids, vitamins, minerals and water. An essential nutrient is one that must be obtained in the diet and a non-essential is one that the body can make sufficient quantities of, if it is lacking in the diet. There are ten essential AA, three conditionally essential and ten non-essential. When considering the diets of chickens (Gordon 2005) the overriding factor is their inability to synthesise these ten essential AA that therefore have to be supplied by the diet. These essential AA (Labier and Leclercq, 1994) can be divided into three categories: 1) those which cannot be synthesised at all (e.g. lysine and threonine); 2) those which can be synthesised from precursors but at an insufficient rate (e.g. leucine, valine and isoleucine), and; 3) those that may be synthesised within general metabolic processes but at an insufficient rate to meet needs (e.g. arginine and histidine). Methionine can be synthesised in the body but is dependent upon the availability of other AA, choline, betaine, folic acid and vitamin B_{12} and is generally inadequate to enable optimum growth. Of the essential AA methionine and cystine are regarded as having the most limiting factors (Schutte et al., 1994; Bertram et al., 1995; Jeroch and Dänicke, 2002).

Non-organic rations differ from organic rations in the use of synthetic AA, an ingredient prohibited under organic regulations. When comparing organic and non-organic rations AA contents are significantly lower in organic rations (Velik, 2004). Not only does this have an effect on performance it can also increase feather pecking (Zollitsch et al., 2004).

Organic cereals, or more specifically organic wheat, are the main components of poultry feed (personal communication Hi-Peak feeds) and are generally low in methionine, lysine and threonine (Labier and Leclercq 1994) with the lack of methionine having the greatest impact on the overall level of methionine in the diet. This lack has to be balanced by the inclusion of AA rich ingredients such as soya and other pulses. Greater use could be made of alternative cereals such as naked oats, which have been demonstrated to be nutritionally and economically viable as a wheat alternative within poultry rations (Maunsell et al. 2004), having higher levels of AA than wheat, and triticale that has better protein and lysine levels, 2.8% and 0.9% respectively, than wheat (Benbelkacem 2002). However in both cases the uncertainty of supply makes the feed companies reluctant to commit to greater use of these crops.

Soya is an important protein source, containing, as it does, a high proportion of easily digestible essential AA in a favourable pattern. Soya has to be toasted to reduce the high ANF content and the soya full bean has a very high fat content, which limits its possible use. Maize gluten complements soya bean meal in that it has a higher proportion of sulphur containing AA than soya bean meal but less lysine (Labier and Leclercq 1994). Adequate supplies of organic soya are available from the continent but organic maize supplies are more variable (personal communication Hi-Peak feeds).

The home-grown organic protein sources that can be used to replace soya all have drawbacks so a combination of ingredients are needed. The grain legumes have varying levels of digestibility between and within species (Jeroch et al., 1993), the crude protein digestibility being between 74-88% with peas having the highest energy content (12.1 MJ/kg DM), a level that is in-line with the energy value of poultry feeds. However the use of legume proteins is limited by the ANF, such as tannins, lectins, protease inhibitors and pyrimids-glycosids, that are present in all of them to varying levels but most markedly in beans. Modern varieties have been bred with lower ANF but these are still high enough to limit their use. Over use of these proteins can lead to refusal of the feed (Holle et al., 2006). Some can be removed by treatments after harvest, such as peeling, autoclaving, expanding, extruding, toasting (Abel, 1996) or steam-pelleting (Vogt et al, 1979). Lupins have similar crude protein contents to soya but lower energy, lysine, methionine and cystine contents. As well as the low levels of essential AA that limit their use they are further restricted by the various ANF.

Other organic protein sources (Sundrum et al., 2005) include physically expelled oilseed cakes such as sunflower cake, rich in sulphur-containing AA, deficient in lysine but with moderate metabolisable energy, while rape cake has a high crude protein content with lysine and methionine comparable to soya but low metabolisable energy and a high concentration of ANF. Linseed meal has a moderate crude protein content, a low level of methionine and lysine. The ANF in both linseed and rapeseed can impart fishy taint and rancidity to meat and the rapeseed can produce the same effect in eggs. The high linolenic acid content of linseed can enhance the tissue and egg concentrations of linolenic acid.

Fishmeal and fish oil either as a by-product of fish for human consumption or from sustainable fisheries can be used. It is an excellent source of protein and supplies high levels of lysine and methionine and contains useful minerals such as calcium and phosphorous. It’s preferred use is in starter rations at a rate of around 2.5% where it helps to balance the AA requirements (Hancock et al 2004).

Potato protein, brewers yeast, tomato residues and whey powder are all high value protein by-products of the food industry that are used in non-organic feeds, which may become available as organic ingredients in the future.

Laying hens

Non-organic laying hen hybrids (Lohmann, 2004) can produce 300 eggs with a weight range of 61.5 to 64.5 g per year. To maintain this production the rations should contain 163 g/kg crude protein, 3.6 g/kg methionine and 7.3 g/kg lysine from week 29 onwards, given a daily feed intake of 120 g. An organic hen is generally expected to be less productive, producing on average 280 eggs per year. The diet should provide the essential AA level to meet the birds' need for health and performance, defined as a level that is financially and biologically sustainable (Gordon 2003).

An important contribution to the nutrition of laying hens is that provided by the range. If conditions are right considerable amounts of herbage can be consumed (Horsted et al. 2006). When ordinary clover/grass leys are used between 10-30g/hen/day is possible where there is no restriction to supplementary feeding and this can rise to 20-40g/hen/day where supplementary feeding is restricted. Where additional forage crops such as chicory are grown the intake can be doubled. It was calculated that the forage can contribute up to 70% of their requirements for lysine and methionine and 25% of their requirements for calcium. For these requirements to be met the quality of forage needs to be maintained. Gordon (2003) also concluded that ryegrass swards are not well utilised by birds and nutrient rich swards species are preferred while greater use is made of the range when a tree canopy is present (Gordon 2003). In a further experiment conducted in Denmark (Horsted et al., 2005) a greater consumption of forage is found when wheat on its own is fed as supplementary feed as opposed to a concentrate mix. The type of forage, either a mix of clover/grass and various herbs or clover/grass plus chicory, had no effect on egg production whereas wheat fed with forage produced lower egg weights than concentrate fed with forage.
Roth (2003) found that a combined feed regime of wheat and supplementary feeding gave improved egg production with a small decrease in feed intake when grass was included in the diet. Folsch et al., (2004) contrasted two 100% organic diets with an 85% diet and found that all three gave satisfactory production results and excellent health and plumage condition but the results did indicate that the nutrient requirements of the birds on the 100% diet may have been met to a lesser degree. They also consumed and wasted more.

Where energy concentrations are very low, 9.6 MJ ME as opposed to 11.8 MJ ME as found in a nutritionally complete diet (Rose et al 2004), hens will compensate by increasing feed consumption (Andersson et al 2005). Laying performance in the first 14 weeks was comparable with the performance of the control group fed with a "standard" ration, but decreased later although remaining at an acceptable level. It was felt that the increased feed intake would allow lower concentrations of AA to be used. However increased feed consumption has implications for the amount of nitrogen secreted by the birds. This is also noted in Rose et al (2004) where the increase in crude protein levels in an effort to increase the level of AA in the diet can result in manures with higher levels of nitrogen. Gordon (2005) concluded that feeding the excess crude protein needed to balance the lysine and methionine requirements will result in greater excretion of nitrogen in the manure with an increased risk of nitrogen pollution.

Rose et al. (2004) used an 80% organic feed plus synthetic AA as a control against three experimental diets. These were an 80% organic without synthetic AA, and two different 100% organic feeds, one high protein/low energy with the same methionine and cystine as the control feed and the other had the same balance as the control diet but less methionine and cystine. All the experimental diets had a 17% higher feed intake than the control diet, the high protein/low energy had a higher egg weight but no differences in egg numbers, the 100% organic low methionine diet had lower egg weight than the control diet and the 80% diet without synthetic AA has birds with less feather cover and the birds were more aggressive. The content of insoluble fibre in the diet may influence feather-pecking behaviour, and oats have been shown to decrease the risk whereas wheat had the opposite effect (Elwinger 2005).

Future sources of novel organic proteins have been considered (Gordon 2006), ranging from animal sources through herbs to microalgae, all of which require further investigation and resources despite some promising properties. The animal sources were all similar to components of the diet of feral chickens, namely earthworms and insects in various stages of development while the plants were purslane, algae and aquatic plants. Some could be grown on individual farms but the processing required may be expensive in terms of labour and power.

The modern laying hen comes from the hybridisation of the White Leghorn and the Rhode Island Red with inputs from the New Hampshire, Plymouth Rock and Sussex. Pingel & Jeroch (1995) found that pure leghorns produce 220 to 240 eggs per year while the leghorn crosses produce about 300. Different genotypes were found to behave significantly differently to variations in the diet's methionine content (Elwinger 2005).

Broilers

Modern broiler strains have all been bred with a high protein accretion capacity thus needing a high level of essential AA, usually supplied by including synthetic methionine in the diet (Sundrum et al., 2005). The genotypes used in organic farming have a growth pattern that is significantly different from that of conventional broilers so their AA requirements will be covered by dietary protein contents that are lower (Peter et al., 1997a). A crude protein content of 200g/kg (4.3g/kg Methionine) and an ME of 10.9MJ/kg are sufficient to provide maximum growth rates without affecting carcass traits (Peter et al., 1997b). Suitable slow growing strains have been developed in France, notably the 'Label Rouge' (LR) birds that achieve a 12-week weight below 2kg (Wicke et al., 2000). These typically have less meat on the frame, larger drumsticks, more meat on the wings and better survival rates (Lewis et al., 1997) when compared to Ross birds. Culioli et al. (1990) carried out sensory tests that indicate that the flesh from LR was preferred being firmer and having stronger flavour and odour.
Serry (1990) found that different end goals needed different nutrient supplies in that slow growing birds producing good carcass quality with reduced depot fat formation and a high health status required a lower feed intensity of 18% crude protein at 11 MJ ME/kg DM as opposed to 23% crude protein and 13.5 MJ ME/kg DM for intensively reared birds.
Gordon (2003) concludes that slower growing breeds will have lower potential breast meat yields than broiler hybrids so that lysine and methionine contents in feed will have less of an impact.

An experiment conducted by Hall & Dänicke (2003) using Hubbard ISA 257, a slow growing strain, found that the target weight could be met with a two- or three-phase feeding period with an adaptation of protein concentration and an ME of 12MJ/kg. This has also been demonstrated by Peter et al (1997a,b) who showed that the protein content could be lower; 20% in the first fattening phase then falling to 17.5% after the 6^{th} week. Similarly Bellof et al., (2005) found that rations with different levels of energy and essential AA were compensated for by differing levels of intake but still allowed 100% organic rations to provide an acceptable performance. O'Brien et al, (2005) have shown that a 100% organic diet fed to two strains of bird produces results comparable to an 80% organic diet without any negative implications for health, growth, behaviour or welfare.

Turkeys

The production of turkeys for the organic market can be divided into two streams – those using white broad-breasted hybrids that are given lower levels of feed than they would receive as non-organic birds and those using slower growing more traditional birds. Birds can be divided into lightweight, medium and heavyweight with a marked difference between male and female hybrids. Wegner (1987) notes a range of weights between 6 and 25 kg for males and 4 to 12 kg for females. Light birds will reach slaughter age at 12 weeks as opposed to 20 weeks for the top end of heavy birds. This range of growth and final finishing weights has given rise to differing AA requirements. Jeroch et al., (2002)

recommend a crude protein percentage that drops from 28% in week 1 to 15% in week 20 and beyond. Using modern hybrids it is difficult to balance the demand for essential AA without supplementing the diet with synthetic methionine (Richter, 1996). Richter et al., (2001) found that it is possible to replace extracted soybean meal with faba beans until the 17th week of fattening. Bellof (2002) concluded that the essential AA requirements could be met by high protein feedstuffs such as casein or milk powder. If AA is restricted during starter and grower periods there is a negative effect on both body weight and breast meat yields and no discernible compensatory gains after restrictions were lifted (Waldroup et al., 1993)
Damme (1998) found that bronze broad breasted turkeys from the Kelly company were better suited to organic conditions than Big 6 hybrids. Reinforcing this Wicke et al. (2000) recommended bronze and black turkeys for organic production as being more suited to the less intensive management and also offering a clear definable demarcation.

3. Analysis and Conclusions

- The requirements of poultry for proteins, amino acids and energy are well researched and understood. Organic poultry need the same constituents but the balance need not be the same while the means of supplying them are more limited. No synthetic amino acids are allowed, the range of organic proteins is limited and the protein energy balance can be harder to achieve.

- Poultry breeding, production of feed on the farm, sourcing high quality feeds, the development and implementation of innovative feeding strategies and consideration of effects on animal health and welfare, animal performance and product quality and the effect on the environment have to be linked together.

- In the first instance any organic diet needs to provide performance, maintain health and provide ingredients that are acceptable to the birds. It may be necessary to consider the publics' reaction to some proposed novel feed ingredients e.g. fly pupae.

- Currently a shortfall in organic arable crops is resulting in large increases in the price of organic cereals and pulses with corresponding rises in the cost of animal feed. There is little hope that the rate of arable conversion is going to change with many non-organic farmers persuaded that the rush for renewable energy will push up the price of crops. Therefore there is great pressure to maximise nutrient utilisation through output, which can be in contrast to organic farming, which does not demand maximal livestock performance. The shortage of organic ingredients will almost inevitably result in greater use being made of the permitted non-organic allowance until 1st January 2012 when the derogation ceases.

- Due to the processing required to make many protein sources acceptable to the birds it may not be possible to provide these sources on the farm. Where possible producers should grow the cereal portion of the diet on the farm and then mix in any bought-in processed protein such as soya bean meal or maize gluten.

- Partnerships with neighbouring organic arable farmers are to be recommended. Benefits accrue on both sides – for the poultry producer a guaranteed source of feed with lower transport costs and for the arable producer a source of quality manure and a local market for the crops without any marketing costs.

- Improvement of range management should be the first step to improving feed utilisation. At present standards only require birds to have access to the range. Birds that make greater use of the range consume less feed while maintaining production so producers should be encouraged to make the range more attractive. It should be enhanced by maintaining it in good condition, improving the biodiversity of the sward, planting specific crops that have feed value for the birds, specifically high protein forage crops, and providing shelter to engender a sense of safety to encourage birds to make better use of the range. If birds do not make good use of the range forage intake will be low. Incorporation of trees into the range as at ORC Elm Farm/Sheepdrove Organic Farm has been shown to improve range utilisation. Introducing these factors onto units where the stocking is at the maximum allowed under organic regulations may be challenging but should be encouraged.

- When chicks can observe the outside world through windows or have direct, sheltered access then the older birds will make more use of the range than birds that are not habituated until later in life. Where possible birds should be bought from hatcheries that have encouraged early access to the range. Preferred sources should be organic hatcheries.

- Laying hens with high genetic performance capacity are more severely affected by an inadequate supply of AA. Hens are able to compensate partially for suboptimal supply of AA by increased feed intake but high energy feed limits intake. More work is needed to develop strains of birds that are better adapted to a restricted availability of limiting AA and further research is needed to optimise the production of eggs under organic framework conditions.

- Unlike laying hens there are strains of broilers that are suited to organic production, which allows the protein content of feed to be lower. Where the faster growing breeds are used there are still health problems caused by rapid growth under organic conditions.

- Animals under natural conditions can adapt to huge variations in feed supply and this ability still exists in domestic animals. However young stock are more sensitive to an unbalanced nutrient supply. This is especially true in turkeys where the potential accretion rate of protein is high relative to the live weight and a low feed intake potential. For turkeys as for laying hens more research is needed into genotypes and their response to lower quality feeds.

- For both turkeys and broilers, depending upon the type chosen, health problems caused by rapid growth still exist in organic birds, but to a lesser extent.

- The effects of lower methionine on feather pecking can be reduced by better management of the birds so that they are encouraged to make more use of the range and provision of the feed in a form that requires more time to be spent feeding, both practices that allows the birds to fulfil their pecking instincts. Pelleted feed is consumed much more rapidly than mash, hence it does not satisfy the birds pecking instinct and can result in feather pecking, but the heat treatments used in pelleting do have the advantage of reducing the ANF of many pulses.

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Annex 1

Some published suggested maximum inclusion rates of various vegetable protein sources (g/kg) (GORDON, 1999)

	Broiler feeds	**Layers feeds**	**References**
Peas	250-300	150-200, 300 for better egg taste	UNIP-ITCF (1995)
	Starter 50, finisher 100	100	LEESON & SUMMERS (1997)
		100	LARBIER & LECLERCQ (1994)
		300	CASTANON & PEREZ-LANZAC (1990)
		200	IGBASAN & GUENTER (1997B)
Lupins	50	100	McDONALD et al., (1995)
	Started 80, finisher 100	150	LEESON & SUMMERS (1997)
		200	CASTANON & PEREZ-LANZAC (1990)
Beans		100	LARBIER&LECLERCQ (1992)
	300		JANSMAN et al., (1993)
Sunflower	Starter 80, finisher 100	100	McDONALD et al., (1995)
		150	LEESON & SUMMERS (1997)
Rapeseed	50		McDONALD et al., (1995)
	100 (double 00 varieties)	100 (double 00 varieties, white layers only)	van KEMPEN & JANSMAN (1994)
	Starter 50, finisher 80		LEESON & SUMMERS (1997)

Annex 2

Examples of 100% organic feed ration for broiler (starter period) (1 - 4. week)

Ingredients	I 1	II 1	III 2	IV 2	V 3	VI 3	Average
Wheat	18	14	40	40.5	13	25	
Wheat bran						2.5	
Barley	10	14					
Oat		7.5					
Maize	21	18	18	18	15	15	
Cereals Portion in the diet	**49**	**53.5**	**58**	**58.5**	**28**	**42.5**	**48**
Peas	10	12	8.5	14		12.6	
Pulses Portion in the diet	**10**	**12**	**8.5**	**14 0**		**12.6**	**10**
Soya bean	10				35	35	
Soya cake	13	15			26.5		
Maize gluten	2		7				
Linseed cake	5	7					
Sunflower cake	6	9	9	11	5	5	
Fish powder				10			
High protein feeds Portion in the diet	**36**	**31**	**27**	**21**	**66.5**	**40**	**37**
Minerals	3.7	3.5	3.5	3.5	3.5	3.9	
Oil	1		3	3	2	1	
Additives Portion in the diet	**4.7**	**3.5**	**6.5**	**6.5**	**5.5**	**4.9**	**5**
Energy MJME	12	11	12.5	12.5	12.1	12.2	
Crude protein			21.3	17.5	27.2	21.9	
Lysine g	10.2	9.4	9.9	9.2	14.3	11.5	
Methionine g	3.7	3.4	4.4	3.8	4	4.1	

1 BELLOF & SCHMIDT, 2005 2 DAMME, 2001 3 DAMME, 2005

Annex 3

Examples of 100% organic feed ration for broiler (fattening period)

Ingredients		I 1	II 1	III 1	IV 1	V 2	VI 2	VII 3	VIII 3		Average
Wheat	21	23	21	20	20	30	18.5	32.7			
Wheat bran									3		
Barley	11.2	15.2	14	20							
Oat				9.3	10.3						
Maize		19	21	19	18	33.5	40	10	10		
Cereal Portion in the diet		**51.2**	**59.2**	**63.3**	**68.3**	**53.5**	**70**	**28.5**	**45.7**		**55**
Faba beans											
Peas		14	14	12	12	17	10		15		
Lupins											
Pulses Portion in the diet		**14**	**14**	**12**	**12**	**17**	**10**	**0**	**15**		**12**
Soya bean		15	12					35	28.5		
Soya cake				12	10			25.3			
Potato protein					6	6					
Maize gluten		2				8					
Linseed cake		5	4	4	3						
Sunflower cake		7	5	5	3	10	8.5	5	5		
High protein feed Portion in the diet	**29**	**21**	**21**	**16**	**24**	**14.5**	**65.3**	**33.5**		**28**	
Minerals		3.8	3.8	3.7	3.7	2.5	2.5	3.5	3.85		
Oil		2	2			3	3	2.75	2		
Additives Portion in the diet	**5.8**	**5.8**	**3.7**	**3.7**	**5.5**	**5.5**	**6.3**	**5.85**		**5**	
Energy MJME		12.4	12.4	11.2	11.2	12.8	12.8	12.3	12.3		
Crude protein					20.5	15.6	27.8	21			
Lysine		7.2	6.5	7.2	6.5	9.3	7.8	14.5	10.5		
Methionine		2.7	2.4	2.7	2.4	4.2	4.2	3.9	3.9		

1 BELLOF & SCHMIDT, 2005; 2 DAMME, 2001; 3 DAMME, 2005

Annex 4

Examples of 100% organic feed ration for turkey

Ingredients	I 0-51	II 6-9 1	III 10-131	IV 14-171	Average
Wheat	30	35	46.5	53	
Cereal Portion in the diet	**30**	**35**	**46.5**	**53**	**41**
Faba beans	10	10	5	5	
Peas	37.6	32.8	27.8	22.9	
Pulses Portion in the diet	**47.6**	**42.8**	**32.8**	**27.9**	**38**
Potato protein	13.5	12.5	11	9	
Maize gluten	3	3	3	3	
Brewer's yeast	2	2	2	2	
High protein feeds Portion in the diet	**18.5**	**17.5**	**16**	**14**	**16**
Minerals	3.4	3.2	3.2	2.6	
Oil	0.5	1.5	1.5	2.5	
Additives Portion in the diet	**3.9**	**4.7**	**4.7**	**5.1**	**5**
Energy MJME	11.8	12.1	12.3	12.6	
Crude protein	27.4	26.1	24	22	
Lysine	17.3	16	13.9	12.2	
Methionine	4.5	4.3	4.1	3.7	
Methionine + cystine	9	8.7	8.2	7.6	

1 RICHTER, 1996

Annex 5

Examples of 100% organic feed ration for laying hens

Ingredients		**I 1**	**II 2**	**III 2**	**IV 3**	**V 3**	**VI 4**	**Average**
Wheat	35	49	47.7	29.3	28.3	39.4		
Triticale							16	
Barley	5			7.5	7.5			
Oat		10			5	5		
Cereals Portion in the diet		**50**	**49**	**47.7**	**41.8**	**40.8**	**55.4**	**48**
Faba beans		6		10				
Peas		15	23	15	44	43	12.5	
Pulses Portion in the diet		**21**	**23**	**25**	**44**	**43**	**12.5**	**28**
Potato protein						4.5		
Maize gluten		12	10.6	9.9			9.8	
Dried grass meal		3	5	5	2	4	5	
Linseed cake							1	
Whey powder	2							
High protein feed Portion in the diet	**17**	**15.6**	**14.9**	**2**	**4**	**20.3**		**12**
Minerals		10	10.4	10.4	10.2	10.2	10.2	
Oil		2	2	2	2	2	1.6	
Additives Portion in the diet	**12**	**12.4**	**12.4**	**12.2**	**12.2**	**11.8**		**12**
Energy MJME		11	11.3	11.2			11.2	
Crude protein	18	18.6	18.8	15	15.4	19.6		
Lysine g		7.5	7	7	8.1	8.1	7.9	
Methionine g		2.8					3.5	
Methionine + Cystine g			6.5	6.4	4.2	8.2	6.8	

1 DEERBERG, 2004 2 ZOLLITSCH & BAUMUNG, 2004 3 KJAER&SØRENSEN, 2002 4 STROEBEL et al., 2002

Annex 6

Demand of nutrient supply in broiler production.
Percentages are taken from tables A-2 and A-3. Data of feed intake (Kamphues et al., 1999).

Broiler	Starting (28 days)		Fattening period (53 days)		Demand per broiler	
	%	kg	%	kg	kg	%
Total	**100**	**1.0**	**100**	**4.8**	**5.8**	**100**
Cereals	48	0.48	55	2.64	**3.1**	**53.8**
Pulses	10	0.10	12	0.58	**0.7**	**11.7**
High protein feed	37	0.37	28	1.34	**1.7**	**29.5**
Additives	5	0.05	5	0.24	**0.3**	**5**

Annex 7

Demand of nutrient supply in turkey production
Percentages are taken from table A-4. Data of feed intake (Kamphues et al., 1999).

	Age in weeks									
	0-5		6-9		10-13		14-17		Total Turkey	
	%	kg	%	kg	%	kg	%	kg	kg	%
Total	**100**	**1**	**100**	**4**	**100**	**18**	**100**	**30**	**55**	**100**
Cereals	30	0.30	35	1.4	46.5	8.4	53	15.9	**27**	**49**
Pulses	47.6	0.48	42.8	1.71	32.8	5.9	27.9	8.37	**17**	**30**
High protein feed	18.5	0.18	17.5	0.7	16	2.88	14	4.2	**8**	**15**
Additives	3.9	0.04	4.7	0.19	4.7	0.9	5.1	1.53	**3**	**6**

Annex 8

Demand of nutrient supply in laying hens
Percentages are taken from table A-6. Data of feed intake (Kamphues et al., 1999).

	Laying hens	
	%	kg
Total	100	6.4
Cereals	48	3.0
Grain legumes	28	1.8
High Protein feed	12	0.8
Additives	12	0.8