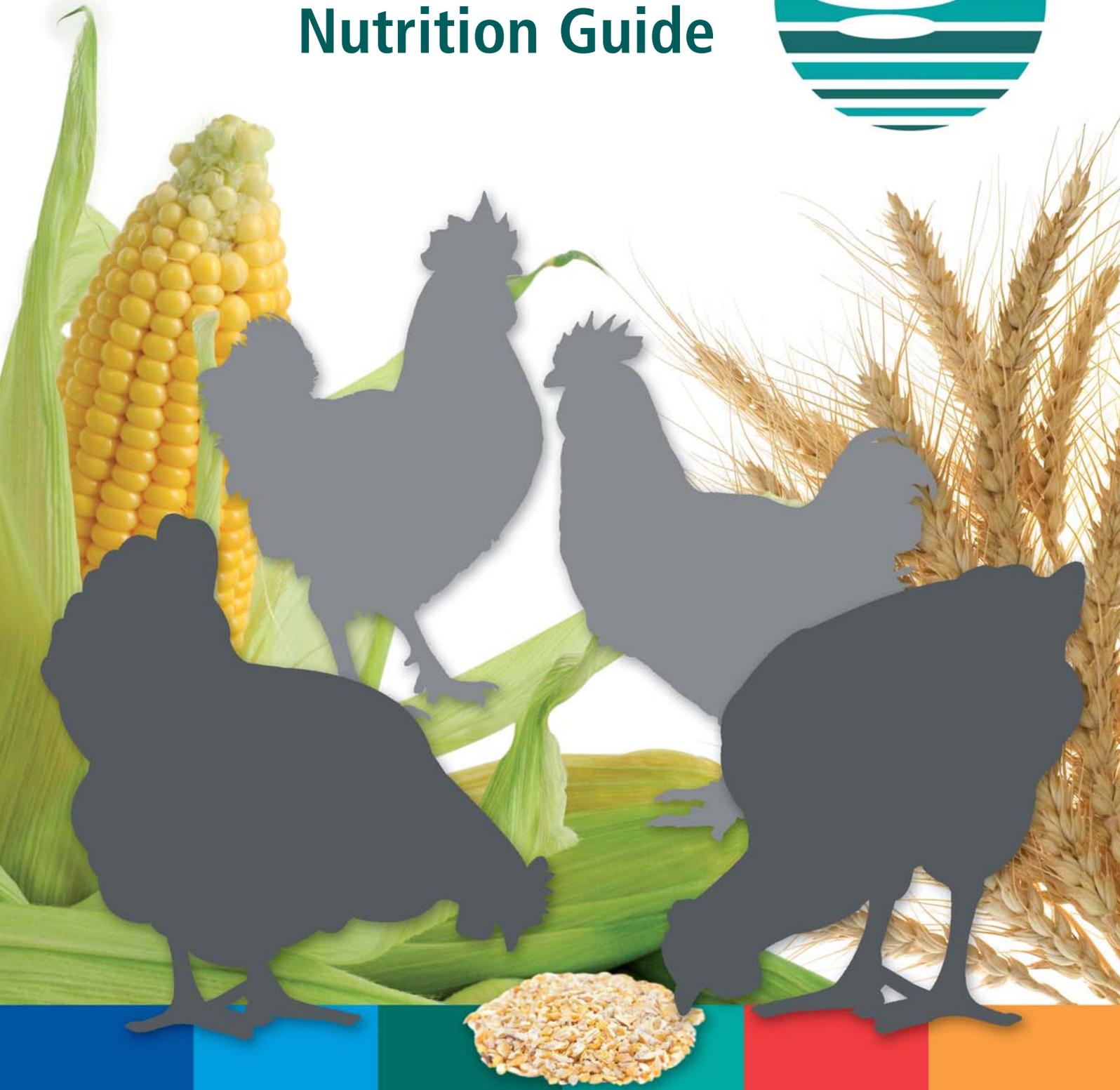


# Breeder

## Nutrition Guide



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## NOTES

**Note:** The performance data contained in this document was obtained from results and experience from our own research flocks and flocks of our customers. In no way does the data contained in this document constitute a warranty or guarantee of the same performance under different conditions of nutrition, density or physical or biological environment. In particular (but without limitation of the foregoing) we do not grant any warranties regarding the fitness for purpose, performance, use, nature or quality of the flocks. Hubbard makes no representation as to the accuracy or completeness of the information contained in this document.

# INTRODUCTION

Annual genetic progress improves broiler performance and as a consequence comes genetic changes in the breeder too. Indeed, as broiler advances are continuous, one should also expect that breeder changes will also be continuous. Understanding how these changes affect nutrient requirements of the parent stock is one of the keys to maximizing breeder performance.

New knowledge related to broiler breeder management and nutrition appears also to be driving the development of new management techniques. For example, research and field experience has shown that pullet rearing may have a dramatic effect on subsequent hen performance. Recommendations for pullet rearing programs today and in future will continue to focus not only on body weight but body composition as well. Research also shows that nutrient supply to the broiler breeder affects not only breeder performance but also influences the quality of progeny and broiler production performance. These effects place greater emphasis on cooperation between the nutritionist to provide the correct nutrient balance and correct nutrient density and the flock manager to provide the appropriate feed intake for the breeders.

Our recommendations for energy, protein, amino-acids, minerals and vitamins are provided as general indications of optimal values. The local optimal nutrient values will be affected by environmental effects including climate, disease, management and raw materials and must always be interpreted by local nutritionists.

September 2011

## ENERGY REQUIREMENTS

Energy is not a nutrient but a means to describe the metabolism of energy yielding nutrients. Energy is supplied by dietary nutrients (i.e., fats, carbohydrates, and amino acids) and is necessary for maintaining the bird's basic metabolic functions, body weight growth and egg production.

In most breeder formulations, energy appears to be the first limiting 'nutrient' and this is true under both hot and temperate environments.

Traditionally for poultry, the metabolizable energy (ME) system has been used to describe the energy content of poultry diets. ME describes the gross amount of energy of a feed consumed minus the gross amount of energy excreted in feces, urine, and gaseous products. ME is therefore used to express the available energy content of feed ingredients and complete diets.

### ❖ The accuracy of energy evaluation

As illustrated in the table 1 below, differences in the ME values assigned to feed ingredients of the same name by different nutrient databases differ substantially. Some of the geographical differences can be attributed to differences in the feed ingredients' moisture content, but even when the ME value is expressed on a dry matter basis, the assigned ME values differ significantly.

Table 1: Value of corn, wheat and soya bean meal showing difference in ME values (as fed values).

Region – Table	Corn (maize)		Wheat		Soya bean meal, 48%	
	Kcal/kg	MJ/Kg	Kcal/kg	MJ/Kg	Kcal/kg	MJ/Kg
Brazil – Rostagno (1)	3 381	14.15	3 046	12.74	2 302	9.63
Europe – Janssen (2)	3 289	13.79	3 036	12.69	2 323	9.72
France – INRA (3)	3 203	13.40	2 988	12.50	2 366	9.90
Netherland – CVB (4)	3 415	14.29	3 258	13.63	2 309	9.66
USA – Feedstuffs (5)	3 390	14.18	3 210	13.43	2 458	10.28

(1) Rostagno, H.S. (ed). 2005. Brazilian tables for poultry and swine. Composition of feedstuffs and nutritional requirements. 2<sup>nd</sup> ed. Departamento de Zootecnia, Universidade Federal de Vicosa, Brazil.

(2) Janssen, W.M.M.A. (ed). 1989. European table of energy values for poultry feedstuffs. 3<sup>rd</sup> ed. Spederholt Center for Poultry Research and Information Services, Beekbergen, The Netherlands.

(3) Sauvant, D., J-M Perez, and G. Tran (eds). 2004. Tables of composition and nutritional value of feed materials. 2<sup>nd</sup> rev. ed. INRA-AFZ, France.

(4) Centraal Veevoederbureau (CVB). 2008. CVB Table booklet feeding of poultry. CVB-series no.45.

(5) Feedstuffs 2008 Reference issue and buyers guide. Feedstuffs, September 10, 2008. Minnetonka, Minnesota, USA.

The main differences are related to:

- ➊ Method of measurement.
- ➋ Animal used as model (adult poultry versus young broilers)
- ➌ Apparent ME and True (taking into account Endogenous Energy) ME.
- ➍ Feed intake during trial.
- ➎ Correction for Nitrogen balance

As a result, the calculated ME content of a given diet may vary substantially depending on which assigned ME values were used for the individual feed ingredients.

In theory, TME is more reliable. But practical estimation of Endogenous Energy is difficult (function of Feed Intake and type of feed, etc ...). Practically, AME is the more commonly used system.

The Nitrogen retention introduces a deviation of the ME value, as it is very dependant of the physiological status (growing, production or maintenance), the nature of the feed or the feeding level. As the target is to formulate balanced feed, and for all physiologic status, a nitrogen correction has been used in most research works.

In the recent past, most feed companies conducted cockerel digestibility studies on raw materials and corrected for nitrogen and intake. Using these well known Apparent Metabolizable Energy system (AMEn) and results, prediction equations were developed.

The recommended ME content of the Hubbard breeder diets (see supplements) are all based on the assigned ME contents of feed ingredients commonly used worldwide using these AMEn system.

The difference between the values of high energy (fat) and low energy (fibre) diets can only be truly assessed in practice by measuring the bodyweight and production of the breeders and relating these to the breed standard. Furthermore, energy intake may also be greatly affected by feed presentation.

## ❖ Energy requirements

The accurate prediction of energy intake is important to formulate diets for breeders and to estimate feed allocation under a controlled feeding program.

Conventional fast growing broiler breeder lines with access to *ad libitum* feeding may consume energy up to 30 to 50 % in excess of the actual requirement for maintenance and optimum egg production (Lopez and Leeson, 1994). Excess feeding and energy intake of breeders negatively affected egg production, shell quality, fertility and hatchability (McDaniel et al., 1981). Therefore, feed restriction during both the rearing and laying periods is effective in considerably reducing erratic oviposition and improving the number of settable eggs, even during later stages of production (Yu et al., 1992). Furthermore, feed restriction improved the duration of fertility compared to full feeding (Goerzen et al., 1996).

In contrast, regardless of which energy system or dietary energy content used, there must always be sufficient energy in the diet to meet the birds' need for maintenance, growth, and egg production.

Generally, broiler breeder hens are fed according to their productive stage reducing feed allowance shortly after peak production or egg mass output peak is reached. Nevertheless, other factors such as environmental temperature, current body weight and desired weight gain must be taken into consideration.

The major environmental factor that influences energy requirement of the bird is temperature. As the ambient temperature varies, energy intakes may be adjusted as follows:

- Increased by 25 kcal (Dwarf breeders) to 30 kcal (Conventional)/day if temperature is decreased from 20 to 15°C (68 to 59°F).
- Reduced by 20 kcal (Dwarf) to 25 kcal (Conventional)/day if temperature is increased from 20 to 25°C (68 to 77°F).
- The influence of hot conditions on energy requirements is not clear. At temperatures above 27°C (81°F), birds require energy to dissipate heat. However, these additional energy demands are not the same for all birds because bodyweight, feed intake, feathering and activity can affect the response to temperature changes. Feed composition, feed amount and environmental management (ventilation) should be controlled to reduce heat stress.

Birds in cages have lower levels of activity and heat production. Feed intake and ME intake is significantly lower for breeders housed in cages ranging from 5 to 8 % less than ME intakes of similar breeders kept on the floor (see product supplements guideline). However, it is not easy to predict energy requirements in cage as other effects such as ventilation, cage size and feathering effects are important.

## ❖ Energy level and the advantages of high fibre breeder diets.

Broiler breeders can tolerate a wide range of ME concentrations (2400 – 3000 kcal/kg).

Field experiments suggest that when low ME diets were fed in the rearing period, these may help to promote flock uniformity, delay reproductive tract development and increase early egg size. Other studies

with low density broiler breeder diets during lay showed an increase in egg and day old chick weight, an improvement in offspring growth rate and a reduction in progeny mortality (Enting et al. 2007).

Feed restriction of broiler breeders and possible hunger implications may lead to excessive water intake, stereotypic pecking directed towards objects in the environment, a general increase in activity (Savory and Kostal, 2006; Hocking et al., 1996; Zuidhof et al., 1995) and increases in corticosterone level in the blood (Mench, 1991; Hocking et al., 2001). Attempts to feed broiler breeders with diluted and high fibre diets (2400 – 2700 Kcal) in order to increase satiety is receiving more attention today on the basis of observed improvements in bird welfare. When birds become more voracious, low density diets are preferred to maximise feed volume, increase feeding time and gut fill.

Fiber is a nutritionally, chemically and physically heterogeneous material. This heterogeneous mix can be categorized into two major subclasses i.e., soluble, viscous and fermentable fiber and insoluble, no viscous and no fermentable fiber. Differentiation of water-soluble and insoluble fiber components has helped elucidate the physiological effects of fiber (Newman *et al.*, 1992) as the two subclasses have different roles in the digestive/absorptive processes within the gastrointestinal tract (table 2).

Table 2: Soluble versus insoluble fibre.

Soluble fibre	Insoluble fibre
<ul style="list-style-type: none"> <li>• Lowering intestinal passage rate</li> <li>• Reduces digestion of fat, protein and starch.</li> <li>• Energy source for monogastric animals</li> <li>• Affects viscosity of the digesta</li> <li>• Mainly fermentable parts</li> <li>• Reduces dry matter of faeces</li> <li>• Binds nutrients (pectin)</li> </ul>	<ul style="list-style-type: none"> <li>• Structuring fibre</li> <li>• Accumulate in the gizzard. Regulate digest passage</li> <li>• Improves starch digestibility</li> <li>• Increased intestinal passage rate.</li> <li>• Poorly fermentable</li> <li>• Stimulation of intestinal villi</li> <li>• No energy source for young monogastrics</li> <li>• Increases dry matter content of faeces</li> </ul>

The insoluble fraction used to be considered as performing an exclusively dilutionary role. However, in addition to their effect on energy consumption and consumption time, it was shown by Hetland et al (2003) that the insoluble fibre increased retention times in the gizzard and improved the digestibility of the starch by increasing the gastro-intestinal reflux of bile salts. It is also apparent that an increased content of insoluble fibre may reduce stereotypic behaviors such as tail pecking.

For all high fibre diets it is essential that growth of the broiler breeders remains in the range recommended for the given breed and with low ME diets, the birds should eat quantitatively more feed than observed normally with higher ME diets. It is also important that water availability is sufficient to allow swelling of the food to aid the feeling of satiety from gut fill.

The trend to lower density diets especially in the growing stage will also be affected by the availability and cost of raw materials and their quality. For some high fibre ingredients, the ME content for poultry may not be well defined while some ingredients may increase the risk of contamination such as mycotoxins concentrated in fibrous seed coatings.

## ❖ Benefit of fat

The evidence for the benefits of fat levels and fat sources on breeder performance is conflicting but there is no question that this is an important consideration in practical breeder nutrition.

Fat has several characteristics that make it especially useful in broiler breeder feed formulations including:

- Fat is a concentrated source of energy. Fats have about 2.25 times more energy per unit of weight than carbohydrates.
- Energy from fat is generally more efficiently utilized by the bird than the energy from protein or carbohydrates especially when depositing body fat. Under hot conditions, fat is helpful as a source

of readily available energy to help with the increased energy demands for an increased rate of respiration (panting).

- Fat has a relatively low heat increment, meaning less body heat is produced from digesting and metabolizing a calorie from fat than a calorie from protein or carbohydrate. This is especially beneficial when the bird is heat-stressed.
- Fat blends containing vegetable oil are a good source of linoleic acid (LA) and other essential fatty acids. LA may be at marginal levels in some grain-based diets which may risk egg size being smaller than normal.
- Added fats and oils bind dust and increase the palatability of mash feed

Polyunsaturated fatty acid (PUFA) especially n-3 PUFA is receiving more attention in relation to its beneficial effects on immunity and inflammatory diseases but also cell membrane integrity, immune competence, fertility and embryonic development.

The fatty acid composition of the maternal diet has been shown to affect the fatty acid composition of the yolk, which in turn can affect hatchability and progeny quality (Vilchez *et al.*, 1990).

Male dietary supplementation with oil will also result in a partial remodelling of the phospholipid fatty acid profile of the spermatozoa. Fertilizing ability of chicken semen is improved by dietary supplementation with long-chain PUFA of n-3 series (Blesbois *et al.*, 1997).

However, PUFA are highly susceptible to peroxidation (Oarada *et al.*; 2008) and maternal supplementation with added antioxidants (see antioxidant effects in egg yolks, spermatozoa and embryo hereafter) has a beneficial effect on antioxidant protection of the sperm, yolk and neonatal chick.

## PROTEIN AND AMINO ACID REQUIREMENTS

Proteins are found as structural components in tissues ranging from feathers to muscle. Birds do not require protein but rather the amino acids which are the building blocks of protein. Crude protein provides little information about the amino acid composition and/or availability.

### ❖ Minimum crude protein levels

In some cases, commercial feeds are still formulated to minimum crude protein (CP) levels. This often results in feeds that with the exception of methionine and cystine (TSAA) have amino acid levels significantly higher than required. For example, when formulating to minimum crude protein levels, a corn/soy diet may have excess lysine (up to 30 % above requirement) and isoleucine which in turn can drive muscle deposition and lower fertility (Coon et al, 2006).

Although minimum recommendations for dietary crude protein contents are shown in the Hubbard breeder feed tables, it is strongly recommended that diets are formulated on an amino acid basis. However, when no minimum crude protein content is specified during formulation, it is important to consider the content of *all essential* amino acids to avoid deficiencies. With the use of the major synthetic (crystalline) amino acids, lysine, methionine (plus cystine) and threonine, the limiting amino acids in most diets may be tryptophan, arginine, valine, or isoleucine. Therefore, if the dietary contents of only methionine (plus cystine) lysine and threonine are considered, a crude protein minimum should be specified to avoid deficiencies of other amino acids.

Crude protein level can also be used as a means to analyze mixed feeds and ensure correct blending of ingredients.

### ❖ Digestible amino acids

The total amino acid requirement of an individual breeder hen includes three components: a requirement for maintenance, a requirement for tissue protein accretion and a requirement for egg production.

A portion (typically 10–15%) of the dietary amino acid ingested is not digested. These are excreted which elevates the nitrogen in the faeces. High nitrogen in the litter results in foot pad lesions and excess ammonia, which can irritate eyes and the respiratory tract.

Because the indigestible portion varies considerably among feed ingredients, it is highly recommended that diets are formulated on a digestible amino acid basis. For instance, soybean meal, meat and cottonseed meal contain about the same amounts of total methionine but their methionine digestibilities vary widely.

Diets formulated on a total amino acid basis must contain large safety margins to account for the differences in digestible amino acid content of different feed ingredients. By formulating diets on a digestible amino acid basis, safety margins can be reduced and feed ingredients can be more accurately valued based on their content of bioavailable amino acids. Modern diets should only be formulated on a digestible amino acid basis. This process is more accurate, results in more economic diets and can reduce the impact on the environment compared to formulation on total amino acid basis or on a crude protein basis.

The progress made in raw material analyses and digestible amino acid evaluation should avoid unnecessary protein excess which risks to hatchability and litter quality.

## ❖ **Balance of protein and amino-acids to energy.**

The protein and amino acid contents in the diet and their ratio to energy content are important not only for parent performance and hatchability but also for chick quality.

Modern breeds are more responsive to dietary amino acid density and have the potential to deposit a lot more breast muscle and less fat. While broilers are fed to optimize growth and meat yield, the propensity for rapid growth and development of a large breast must be controlled in parent stock.

Feeding unnecessarily high levels of amino acids to high yielding broiler breeder strains will lead to over-fleshing. This extra muscle demands increased energy for maintenance. This in turn places a further demand on the energy requirements of a bird that is already less inclined to accumulate fat.

Protein and amino acid inclusion levels of the pullet starter, developer, prebreeder and breeder feeds have been investigated in a number of laboratories. The effects of absolute levels of protein or amino acids on performance are confounded by differences in feed intake between studies. Attempts to determine and model the relationship between amino acid intake and egg production have been made for example by Fisher (1998) and Fisher and Gous (2008).

However, many studies emphasize the effects of both excess and inadequate protein intakes. Whitehead et al. (1985) demonstrated that a high protein to energy ratio depresses reproductive performance and chick quality. Lopez and Leeson (1995) clearly illustrated the negative effect of excess crude protein on fertility.

The balance of amino-acids to energy in the modern broiler breeder diet is very important and has become a focus of many breeder farms and broiler breeder feed suppliers. The diet must allow a producer to feed sufficient volume of feed to meet the energy intake requirement of the bird without an excessive amino-acid intake. Most trials and field results indicate that the optimum level is quite steeply defined with 54 to 56 g protein per 1000 kcal for conventional females and 59 to 62 g protein per 1000 kcal for dwarf breeder females. For a diet containing 2750 Kcal, it converts to an optimum of about 15.00 % CP for conventional females and to about 16.00 % CP for dwarf females.

## MINERAL AND VITAMIN NUTRITION

Vitamin and trace mineral nutrition is important not only for breeder performance but also for the performance of the progeny.

In contrast to the energy and protein composition of the egg, the vitamin and mineral content is dependent on the maternal diet and deficiencies, excesses and imbalances may affect hatchability, chick viability and broiler growth (Whitehead et al., 1985).

The mineral and vitamin content of the egg may vary over a fairly wide range suggesting that requirements of the parents for their maintenance and productivity may not match those of the embryo. There is increasing evidence of the beneficial role and higher levels of maternal vitamin and mineral nutrition on components of the immune system in broilers (Robel et al. 2004).

The responses of breeder productivity and progeny performance to vitamin and mineral nutrition may be small with negligible differences observed under trial or ideal conditions. However, under stress such as disease, differences in responses to vitamins and minerals may be more apparent.

Adequate vitamin and trace mineral supplementation with quality vitamins and available minerals is an inexpensive way to ensure that the young chick is prepared for optimal skeletal growth and has a healthy immune system to help cope with challenges during brooding.

It is important that trace elements and vitamins should be correctly mixed before being added to the raw materials. It is suggested that mineral and vitamin premixes are mixed at a minimum level of 3 kg per ton to ensure proper mixing. For micro ingredients to be added at less than 3 Kg/T, mix them in a smaller mixer to get more bulk before adding to the main mixer.

Improper mixing or handling can be checked by dosing Manganese as a tracer marker.

### ❖ Minerals

Major minerals (Calcium, phosphorus, sodium, potassium, magnesium and chloride) are involved in shell formation hence general improvements in shell quality lead to better egg and chick quality.

There is also very good evidence that maternal levels of trace minerals especially zinc manganese, copper and selenium impact levels in the egg. The shell must be sufficiently strong to afford physical protection to the growing embryo and it must be constructed in such a way as to provide an efficient conduit for gaseous exchange and inhibit bacterial ingress.

#### ➤ Calcium and phosphorus metabolism

Because low calcium levels increase phosphorus excretion and low phosphorus levels increase calcium excretion, a proper ratio of calcium and phosphorus must always be maintained in order to satisfy the hens' requirement of either nutrient. If hens become deficient in calcium or phosphorus, the excretion of the other nutrient is increased at the expense of the skeletal system.

Calcium and phosphorus requirements are critical from pre-lay to post-peak due to the high calcium demand and consequent phosphorus demand and after 40 weeks production due to skeletal calcium depletion and poor calcium absorption.

Under normal conditions, Hubbard breeders are not sensitive to sudden mortality at the onset of production. They show a fair tolerance to variations in the Ca/av.P ratio, which should be kept within the range of:  $7 \leq \text{Ca/av.P} \leq 8.5$  for breeder I and  $8 \leq \text{Ca/av.P} \leq 10$  for breeder II after 40 weeks of age.

The maximum daily calcium intake should be between 4,8 to 5,2 g for conventional breeders and 4,5 to 5,0 g for dwarf breeders while 65 - 70% of this Calcium should come from coarse limestone particles of 3-4 mm diameter. It is important when using low energy diets to take this coarse particle constraint into consideration during formulation.

Research on maternal phosphorus supply has not provided clear picture of optimal phosphorus nutrition. Practical experience suggests the use of relatively low phosphorus levels in breeder diets, while benefiting egg shell quality, may not optimize bone integrity in the early stages of chick growth.

Heat treatment of feed or over reliance on low quality mineral phosphate sources may lead to a reduction in the availability of dietary phosphorus. This may result in pecking problems, especially if water intake is severely restricted. It is therefore important to control the quality of mineral phosphorus which in most cases supplies most of the available phosphorus.

The use of phytase and the choice of the source of mineral phosphate both require careful judgement so as not to over estimate the true phosphorus availability (see chapter on exogenous enzymes)

### ➤ Chlorine, sodium, potassium

Sodium, Potassium and Chloride are needed for general metabolic functions and are required for optimum egg production.

Increased sodium, potassium and magnesium levels result in increased water intake and excreta moisture which in cold or temperate climates, can rapidly lead to bad litter conditions. The effect of these cations on water intake and excreta moisture increases with age and is dependent on the anion source.

With chloride, effects on excreta moisture are less pronounced but an excess of chloride leads to changes in eggshell quality especially when water supplied to the birds has high chloride content.

The Cl/Na ratio should remain within the following limits:  $1.1 \leq \text{Cl/Na} \leq 1.3$ .

In hot weather, it is good practice to provide part of the sodium in the form of sodium bicarbonate which helps to maintain the acid/base balance.

Under certain formulation conditions (limited soya availability), the potassium level may be too low to have the correct ionic balance in the range of:

$$180 < (\text{Na} + \text{K} - \text{Cl}) < 220 \text{ (m.Eq/kg)}$$

Corrections may be made by supplying mineral potassium (potassium carbonate).

Note: There is a need to be cautious when formulating diets with very low sodium content and assuming phytase enzyme is contributing sodium to the total dietary available sodium content. When dietary sodium is less than 0,14 %, this approach may risk actual sodium supply being less than assumed.

### ➤ Trace minerals

The determination of trace mineral requirements has been a secondary concern in poultry nutrition and has suffered from a lack of recent research into the fundamental aspects of nutrient availability and animal requirements in comparison to other nutrients. If we examine the existing data, it is evident that broilers are much better represented in the literature, whereas minor avian species, including layers and breeders often rely on extrapolation from broiler data to ascertain their mineral needs, as specific data does not exist. In view of the key role that many trace minerals have in the development of essential tissues and maintenance of animal health, this deficit may lead to production and welfare problems.

However, research has generally indicated that mineral fortification of parent diets may result in improved reproductive performance and influence mineral levels in the egg and so influence progeny performance (Table 3).

As an example, deficiencies of the trace minerals Se, Zn, and Mn have been linked to impaired reproductive performance in male and female farm animals (Smith and Akinbamijo, 2000). Research has also shown that inorganic and/or organic Zn increase levels of Zn in the bone and increase bone weight (Kidd et al., 1992). In general, almost all minerals play a role in ensuring optimum immunity. In general terms, minerals act as cofactors of different enzyme systems or as component of hormonal systems responsible for maintaining the integrity of the cellular and humoral defence mechanisms.

Table 3: Summary of effects of inorganic and/or organic minerals fed in breeder diet on reproductive and progeny performances.

	Reproductive performances	Offspring early growth	Early progeny liveability	Immune function	Skeletal development
Selenium	X	X	X	X	
Manganese	X				X
Copper	X				
Zinc	X	X	X	X	X

Over the last 40 years, trace element nutrition research has led to the development of more bio-available organic minerals, several of which have been approved for use in poultry. These include trace metals derived from chelates (Cu, Fe, Mn and Zn) and organic Se from strain-specific yeasts.

Although those minerals bound to organic compounds have been available to the industry for some years, their adoption in commercial practice has been slow. In part this was due to the difficulty in discriminating between different claims made by manufacturers but also there has been a lack of understanding of the role the product can play in commercial poultry production including poultry breeding.

Most recent research on chelated minerals and seleno-methionine complexes has shown an increased mineral deposition in the egg and improved mineral transfer to the tissues of the hen and the embryo. Hatchability improvements are often reported in most case but few of these trials involve a proper assessment of subsequent broiler performance although practical comments about chick quality are generally positive. Supplemental zinc methionine and manganese amino acid complexes have shown improvements in chick immunity and liveability.

Although further work is required for the full elucidation of the new optimum mineral intakes based on organic minerals, there is now evidence to show that these sources of trace minerals with better stability within the digestive tract and improved absorption characteristics provide an opportunity to develop new trace mineral nutritional strategies and reduce trace mineral build up in the environment.

Conventional levels of mineral supplementation are recommended below (Table 4).

Table 4: Added trace mineral recommendation per kg.

Manganese	ppm	100
Zinc	ppm	100
Iron	ppm	50
Copper	ppm	10
Selenium	ppm	0.30 – 0.40
Iodine	ppm	2

Notes:

- ① These recommendations could be used from day old to the end of the laying period. Or, the mineral premix level can be reduced by 20 % in the growing stage.
- ② Assumes inorganic and organic mineral sources.
- ③ Check local regulations for the maximum permitted amount of selenium.

## ❖ Added vitamins

Vitamins are essential micro-nutriments, occupying a central role in most metabolic processes. They are required for optimum health and normal physiological functions such as growth, development, maintenance, reproduction. They are also an integral part of foetal development and diets for adult breeder hens probably contain the highest level of supplemental vitamins of any feed manufactured at a commercial feed mill.

Grossly underfeeding vitamins is not commonly seen in commercial practice. It is more likely to encounter marginal deficiencies caused either by low supplementation, sources of questionable quality and availability and less dominant breeders consuming less than the average calculated feed intake.

A marked deficiency of any one vitamin is known to result in negative responses in parent egg production, fertility, hatchability and offspring performance as there is increased evidence for important vitamin carry over effects to chicks. With a marginal vitamin supply, the progeny will not exhibit classical deficiency syndromes but they will not necessarily perform to their potential.

Unfortunately, what we consider to be optimum vitamin needs of the breeder are often questioned as being too high and too expensive in terms of cost per kg of feed. In reality however, it is low vitamin inclusion levels in the feed that are ultimately the most-expensive scenario for the bottom-line of the breeder or integrated broiler operation. Vitamins account for about 4 % of the cost of a breeder diet, so economizing on vitamin inclusion rates is rarely a cost effective option.

### ➤ Vitamin requirements

Breeder requirements for vitamins are usually met by adding all vitamins as synthetic sources. Regular feed ingredients such as corn, wheat and soybean meal, all contain natural sources of vitamins and in some situations could theoretically contain enough to meet the breeders' needs. However the concentration of vitamins will vary in feed ingredients because of crop location, fertilizer usage, plant genetics, plant disease and weather. Harvesting conditions often play a major role in the vitamin content of many feedstuffs. Vitamin content of corn is drastically reduced when harvest months are not conducive to full ripening. In addition to this inherent variability is the effect that factors such as natural plant toxins and mycotoxins can have on vitamin availability.

Given these constraints, it is perhaps not too surprising that regular feed ingredients are not relied on to supply vitamins and consequently, our vitamin premix recommendations are designed to supply all the vitamins the breeder requires.

It is quite difficult to determine the vitamin needs of breeders. Breeder hen research takes a long time to complete and is expensive. The most recent official public vitamin requirements are from the US NRC (1994). These may be viewed as absolute requirements to prevent clinical deficiencies. In practical nutrition of breeders, the objective is not only to prevent signs of vitamin deficiency but also to support optimum health and ensure good egg production, hatchability and early chick vitality.

Genetics and management of breeders have also considerably changed in recent years while there has been a relative recent shortage of information focused on the application of vitamins in optimizing hatchability and post hatch livability of chicks during the first week of life. As a result, there is an extensive variation in vitamin supplementation around the world.

There is also extensive variation in vitamin recommendations according to environment effects (Ward, 1993) such as growing conditions and management, disease, diet considerations and strain. Higher levels can be recommended when the flock conditions are challenging such as high stocking density and severe internal and external microbial challenges.

Our recommendations (table 5) ensure the optimum delivery of vitamin to the breeder and the developing embryo. With these extra levels of vitamins in the feed, there should be no need to use supplemental vitamins in the water except in situations of environmental or disease stress when feed intake is not optimal or there is evidence of enteritis.

Table 5: Added vitamins recommendation per kg

		Standard feed		Heat treated	
		Wheat based	Maize based	Wheat based	Maize based
Vitamin A	IU	13 000	12 000	14 000	13 000
Vitamin D3	IU	3 000	3 000	3 200	3 200
Vitamin E	IU	40 - 100	40 - 100	60 - 100	50 - 100
Vitamin K (menadione)	mg	3.0	3.0	5.0	5.0
Thiamin B1	mg	3.0	3.0	3.5	3.5
Riboflavin B2	mg	12	12	12	12
Pantothenic acid	mg	12	14	14	16
Nicotinic acid	mg	55	55	60	60
Pyridoxine B6	mg	5.5	4.5	6.0	5.0
Folic acid B10	mg	2.0	2.0	2.5	2.5
Cyanocobalamin B12	mg	0.030	0.030	0.035	0.035
Biotine Vit. H	mg	0.30	0.25	0.30	0.25
Choline	mg	500	750	500	750

Notes:

- ⚙️ These recommendations could be used from day old to the end of the laying period. Or, the vitamin premix level can be reduced by 20 % in the growing stage.
- ⚙️ Inclusion level should be increased by say 10% if feed intake is observed or expected to be below 135g/day (Dwarf breeders)

### ➤ Vitamins and progeny responses

The influence of increased vitamin levels fed to parent stock on progeny performance is an area which has received significant recent commercial interest. Increasing dietary vitamin levels above those considered adequate will increase vitamin contents in the egg (Naber, 1993; Mattila et al. ,2004). However, this does not automatically lead to higher progeny concentrations and a positive impact on chick growth and livability (Table 6).

The beginning of the production period is critical for fertility and chick quality and nutrients are not efficiently transferred to the egg at this stage. In commercial conditions, the progeny from young parent stock fed elevated levels of vitamins have shown improved early growth and reduced mortality.

Broilers derived from breeders fed elevated vitamins and mineral levels had increased numbers of leukocytes at day old (Rebel et al 2004) which indicated stimulation of the immune system. Findings such as these support the need for further work exploring the vitamin requirements of the breeder especially in the early production period and to ensure adequate vitamin levels in the Breeder N° 1 feed.

Table 6: Vitamins and progeny responses

A	High vitamin A in hens has been shown to decrease dl-alpha-tocopheryl acetate in egg yolks (Grobas et al., 2002) . Increased liver vitamin A in embryonic and chick liver but decrease vitamin E, carotenoids and ascorbic acid (Surai et al 1998). Antagonism with vitamin E under practical levels needs more research. It is possible that high vitamin A can affect vitamin D3 utilization when D3 is marginal
Carotenoids	High maternal supplements resulted in high progeny concentrations to 7 days (Karadas et al., 2005). Transferred from the hen to the yolk but not absorbed well by the embryo and chick ( Haq and Bailey – 1996). No positive impact on chick growth, organ development or humoral immunity in chicks five weeks post hatching (Haq et al. (1995).
D3	Recent research (Kidd, 2003) suggests that nutritional concentrations for vitamin D are higher for optimum performance than for egg production. Progeny weight gain is greatest when broiler breeders are fed the highest maternal dietary concentrations and the incidence of Ca rickets and tibial dyschondroplasia in progeny is significantly reduced in the offspring especially from young broiler breeders (Atencio et al., 2005; Driver et al.,2006).
E	Vitamin E plays various roles including stimulation of the immune system and fat antioxidant. Hossain et al (1998) obtain the best hatchability at 50mg/kg at 52 weeks but in studies offspring immune response continued to increase up to 100mg/kg. In other studies the combination of selenium and vitamin E to broiler breeders has been shown to decreased lipid peroxidation of all progeny tissues (Surai et al., 1999).
K3	Vitamin K3 has been shown to improve bone quality of progeny by increasing tibia glutamic acid levels (Lavelle et al.,1994).
B1	Hen dietary thiamine addition increased progeny blood thiamine levels and heart function and broiler thiamine supplementation was independent from hen effects (Olkowski & Classen, 1999).
B2	Riboflavin is critical for embryo development, but interestingly is also need to establish liver and yolk sac reserves for chick viability post hatch (Squires and Naber (1993)
B6	The pyridoxine need of the hen for reproduction and hatchability was much less than that needed to optimize progeny tissue levels and performance, but feeding chick diets adequate in pyridoxine overcame maternal deficiencies (Abend et al., 1977).
B12	Studies have shown omission of cobalamin from the premix will cause long term effects on egg production (over 4 wk) effects still observed once vitamin B12 is added back to the premix (Leeson et al., 1979).
Niacin	Deficiencies (Leeson et al., 1979) and excesses (Romanoff and Romanoff, 1972) of nicotinamide impair hatchability and embryos.
Pantothenic	Improved livability of progeny (Utno and Klieste, 1971)
Biotin	Increased yolk and chick plasma biotin content (Whitehead,1984)
C	75 mg ascorbic acid/kg diet showed no effect on egg production, eggshell porosity, fertility, hatchability, or plasma ascorbic (Creel et al., 2001). 3 mg, but not 12 mg, improved hatchability and chick weight from in ovo injections at days 11 and 15, but not 19 (Zakaria and al-Anezi, 1996).
Choline	Feeding layers 440 mg/kg choline improved egg production when diets were marginally deficient in Methionine (Harms et al., 1990). Feeding broiler breeders 760 mg/kg choline decreased hen liver fat (Rama Rao et al.,2001)

### ➤ Loss in potency of vitamins

Another reason for higher vitamin fortifications relative to published NRC requirements is the loss in potency of vitamins that occur between feed manufacture and consumption by the bird. Different vitamins are susceptible to various stresses to varying degrees (table 7) but as a generalization it can be stated that the major causes of loss of vitamin potency are storage time, storage temperature, and storage humidity of the premix before mixing and of the feed after mixing.

Table 7: Sensitivity of vitamins to environmental conditions

	Temperature	Oxygen	Humidity	Light	pH 5 - 5	pH 6 – 7,5
A	XX	XX	X	X	X	O
D3	X	XX	X	X	X	O
E	O	X	O	O	X	XX
K3	XXX	X	XX	XX	XX	O
B1	X	X	X	O	O	XX
B2	O	O	X	X	O	O
B6	XX	O	X	X	X	O
B12	XX	X	X	X	O	O
Pantothenic	X	O	X	O	O	O
Beta-carot.	XX	XX	X	XX	X	O
Niacin	O	O	O	O	O	O
Biotin	X	O	O	O	O	O
Folic acid	XX	O	X	XX	XX	O
Choline	XX	XX	XX	X	X	X

O Stable                      X Sensitive                      XX Highly sensitive

Another major loss of vitamins occurs if they are premixed with minerals and Choline Chloride and stored for any length of time prior to incorporation in feed (table 8). Also conditions within the premix and feed can cause loss of potency. For example, some vitamins are acidic whereas others deteriorate under acidic conditions.

Table 8: Monthly percent loss of vitamin (0,5 % premix including Choline)

	Chumachenko 1978	Boha 1983	Jaskiewicz 1998	F.Stuffs Oct 1996	F.Stuffs Oct 1996	RPNA 1	RPNA 2	Average
A	9.0	5.0	6.0	9	3.0	6.6	6.6	6.5
D3				4.5	3.4	6.0	5.0	4.7
E		5.0	2.0	1.1	2.4	6.6		3.4
K3 MPB				10.1	13.0	7.0	20.0	12.5
B1				7.9	6.0	5.0	8.3	6.8
B2		2.0		2.7	3.8	1.7		2.6
B6				8.6	4.5	10.0		7.7
B12	4			5.4	2.0	11.0		3.2
Ca Pantoth				0.0	5.5	3.3		2.9
Niacin				3.2	4.0	1.7		3.0
Biotin				2.9	4.5	6.6		4.7
Folic acid				5.6	8.5	13.0		9.0
Choline				4.9				4.9

Manufactures of vitamins can provide information about factors that affect the potency of their vitamin products. With this knowledge coupled with the anticipated field conditions, it is possible to predict the necessary safety factors required to ensure optimum breeder performance.

It is important not to forget another vital factor affecting vitamin stability. In many cases breeder feed is now heat treated (heat treatment of mash feed and/or pelleting) and here the temperature, pressure and humidity combination can cause vitamin breakdown. Recommendations for both non heat treated and heat treated feed are provided (see table 5).

## ❖ Antioxidant effects in egg yolks, spermatozoa and embryo.

The chemical composition of eggs is approximately 11% lipids, located primarily in the yolk (33%). The lipids present in the yolk play an important role in the development of the embryo, serving as a source of energy, fatty acids and lipid-soluble vitamins. These lipids undergo further metabolism in the liver of the embryo to form long-chain polyunsaturated fatty acids (PUFA's).

Chicken spermatozoa are unique in their structure and chemical composition. The most important feature of lipid composition of the avian semen is the extremely high proportions of long-chain PUFA's in the phospholipid fraction of spermatozoa. The high proportion of PUFA's is necessary to maintain specific membrane properties (fluidity, flexibility, etc).

The reaction of free radicals with PUFA's initiates a chain-reaction process known as lipid peroxidation in living systems resulting in the formation of toxic products. High concentrations of PUFA's in any cellular membranes such as those of spermatozoa or embryo increase their susceptibility to peroxidation (Surai, 1999). The potential harm by free radicals ultimately depends on the level of their production and efficiency of the natural antioxidant defence system. The integrated antioxidant system in tissues is considered to be a key element in maintaining semen and embryo quality. It has been suggested that the antioxidant system is based on interactions of various antioxidants.

The use of antioxidants in broiler breeder diets improves chick oxidative status with vitamin E having probably the largest impact on sperm motility and progeny (table 6). Vitamin E was discovered as a "vitamin of reproduction" in 1922. Many studies show that vitamin E has antioxidant activity in the egg yolk, protecting embryonic tissues efficiently during incubation and in the first days of a chick's life. This is even more important in older breeders as natural antioxidant protection decreases with age. In general it seems to be justified to supplement practical breeder feeds with 100 mg/kg vitamin especially when breeder diets have added unsaturated oil added as an ingredient.

Other possible health promoting and natural antioxidants which act in synergy with vitamin E are:

- Natural fat-soluble antioxidants such as carotenoids.
- Water-soluble antioxidants such as ascorbic acid.
- Se supplementation is known to affect the antioxidant defences (Surai et al., 1998).
- Zinc, Copper, Iron and manganese participate in antioxidant defence

For instance, a supplementation with seleno-methionine has been shown to improve the anti-oxidative status of eggs, embryos and chicks up to 10 days of age.

## RAW MATERIAL AND QUALITY CONTROL

Many feed ingredients are suitable for feeding to poultry parent stock. Supply, price and quality will usually determine the choice. Most countries are limited in the choice of basic ingredients, few have a wide choice.

Raw materials should be of good quality with predictable and uniform nutritional value across all consignments. The quality of a feed material is determined by the nutrient composition of the material and how efficiently they can be digested and released for absorption and utilization in the bird.

Nutritionists continuously make choices over the margin of safety as they construct the feed formula especially for poultry breeders of high value. This margin of safety can be increased or decreased according to several factors. The quality-assurance scheme for assessing nutrient content and the resulting uniformity of nutritional values across batches of all raw materials must be taken into consideration when building a margin of safety into a feed formula.

Ingredients must also be free of contamination by chemical residues, microbial toxins and pathogens. They should be as fresh as possible within practical limitations and should be stored under good conditions. Storage facilities must be protected from contamination by insects, rodents and in particular, wild birds; all of which are potential vectors of disease. It is common in many countries for these aspects of the production process to be monitored and managed within a scheme such as HACCP.

### ❖ Cereals and Cereals by-products

Corn (Maize) is a raw material favored by most poultry nutritionists and poultry producers. However, corn prices in the market have increased dramatically in recent years due to high demand worldwide and the increasing use of corn for production of bio-energy in some countries. In many countries other grains like wheat, barley, oats, sorghum and broken rice are used successfully. Additionally grain by-products such as wheat or rice bran are important and valuable feed ingredients in most part of the world. However, their efficient use in monogastric diets is often impaired by the presence of elevated contents of non starch polysaccharides (NSPs) and phytate.

#### ➤ Corn

The expected differences in corn composition due to growing conditions, corn variety and processing appear small (protein +/- 2,0 %, oil +/- 0,8 %, starch +/- 2,0 %). Nevertheless, corn is usually the largest component of breeder rations so small variations in corn quality have the biggest impact on finished feed nutrient variability. Proximate analysis can determine chemical composition and expected nutrient values but proximate analysis alone can neither determine the quality of starch nor protein. Recent work indicates that protein digestibility and starch quality (amount of amylase and amylopectin) are variable between batches of corn and have inconsistent effects on nutritive value and animal performance.

Corns harvested during the wet season or wet conditions have increased risks of higher levels of mycotoxin contamination than corn harvested in the dry conditions. Prolonged storage of corn with high moisture content prior to drying also increases the risk of fungal infestation resulting in increased mycotoxin production.

#### ➤ Wheat

In many countries all year or at specific times of the year in others, wheat is the more cost effective primary cereal in place of corn and wheat based broiler breeder diets have given good field results.

However a number of factors need to be considered when using wheat:

- All major wheat-producing countries report variability in ME content. The main reason is the content of non-starch polysaccharides (NSP's) which are poorly digested by poultry and interfere with the digestibility of other feed components. The NSP content in wheat may range from 1-10 % or more and is negatively correlated with the ME content – the higher the NSP content, the lower the ME content. Unfortunately there is currently no rapid easy test available to the feed manufacturer to measure the NSP content of wheat. Feed companies can use an enzyme mixture (xylanase, beta-glucanase and pectinase) that will break down the complex polysaccharides in the gut of the chicken resulting in improved energy utilization and a higher ME content in the wheat (see exogenous enzymes section)
- One of the benefits of wheat is that it contains between 10 – 13 % crude protein, compared with 7,5 – 9,0 % crude protein in corn. As a result, the reliance placed on expensive protein sources is lower in wheat-based diets to achieve the desired amino acid levels in finish feed.
- When using pellets or crumbles, diets containing at least 10% wheat bind better during feed manufacture resulting in improved pellet quality and durability.
- The availability of vitamins such as biotin is lower in wheat based diets (see Table 5).

### ➤ **Wheat milling by-products**

The composition of wheat milling by-products varies markedly both within and between different geographic regions and among suppliers. While the protein content in samples of wheat by-product can be readily determined, ME values are more difficult to obtain. When components of proximate composition are used as predictors of ME, crude fibre (CF) or neutral detergent fibre (NDF) appear to be significantly correlated with ME content.

### ➤ **Rice by-products**

Several rice by-products are commonly used as a major ingredient in poultry feed in rice producing countries. After being dried, the hull from the paddy (or "rough") rice is removed in the first stage of milling yielding brown rice. In the second stage of milling, the outer brown layer is removed to produce white rice and rice bran. White rice is usually further processed or polished and the residue is termed rice polishings.

In most cases, rice bran and rice polishings are the two rice by-products used for feeding poultry. They are good sources of protein, energy, vitamins and minerals (Saunders, 1990). They also contain a better balance of amino acids, particularly lysine and methionine, compared to other cereal grains.

Rice bran is recognized as being highly variable in its composition with respect to oil and crude fibre contents depending upon the severity with which the rice is threshed, the extent to which the oil is extracted (Daghir, 1995) and the amount of ground husk mixed in the batch (Ichhponani et al 1980) as indicated by presence of sand/silica in the samples. Full fat rice bran contains 15 to 23% oil depending on the processing technique and contains significant amounts of the essential fatty acid linolenic acid.

The feeding value of rice polishings depends upon the degree of polishing to which the grain has been subjected. Typical values range 11 – 13 % for crude protein and 12 -15 % for oil

Besides the variation in chemical composition, problems such as a high moisture content, mould growth and rancidity are often associated with the keeping quality of rice by-products. Rice bran becomes rancid rapidly due to the breakdown of the lipid fraction that occurs during storage. The length and conditions (temperature and humidity) of storage are important in determining the rate of hydrolysis of the oil (Farrell, 1994).

Both rice bran and rice polishing can be used in breeder rations at fairly high levels providing the proximate analysis of the source or batch is well defined and their oil component can be stabilized by an antioxidant to prevent their ME value being lost through oxidative degradation.

## ➤ DDGS

Corn Dried Distillers Grains with Solubles (DDGS) is a corn co-product obtained in the dry-milling process of corn to produce ethanol after the fermentation of corn starch by selected yeasts and enzymes. It has been recognized that DDGS is a valuable source of energy, protein, water soluble vitamins, and minerals for poultry (Jensen, 1978, 1981; Wang et al., 2007).

However, use of DDGS in poultry breeder diets has historically been low due to limitations such as the supply and pricing of the product (Waldroup et al., 1981), a wide variability in nutrient content and digestibility (Noll et al., 2001) and handling problems during storage and transport.

Concerns have also been expressed regarding the levels of the mycotoxins Fumonisin, Aflatoxin and DON in DDGS. The residue from ethanol production concentrates seed coatings in products such as DDGS and the seed coating is where much of the mycotoxin content of the whole grain is located. Therefore, DDGS represents a concentrated source of any original contamination by mycotoxins in the whole grain

## ❖ Plant protein sources

There are other raw materials high in protein content in addition to soybeans. Examples are rapeseed or sunflower meal.

### ➤ Soya bean meal

Soya bean meal (SBM) is a well-established and relatively inexpensive protein source for poultry diets including breeder diets. However, reports on the use of SBM in poultry diet are not always consistent. Harvest, transportation to either storage or to processing should have an effect on the nutritional value of SBM especially amino acid digestibility. Processing conditions of soybeans to generate oil and meal is perhaps the best understood factor about SBM quality.

Insufficient toasting means that SBM contains excessive levels of trypsin inhibitors and depending on the degree of under-toasting, it may also contain excessive levels of lectins.

The targets of SBM processing should be:

- Trypsin inhibitor values of 1.8-2 mg/g of SBM (max. 3.5)
- or expressed as urease activity, 0.00 to less than 0.10 pH units.

Excessive toasting results in protein quality deterioration. There are at least two laboratory methods available to determine the over processing of SBM:

- Solubility in 0.2% KOH (KOHPS) with a KOH protein solubility target of 80- 85%.
- The application of NIRS that allows calibration of the NIR spectra of specific SBM samples with their content of digestible amino acids. This allows a real time correction of the amino acids that have been affected by over toasting.

### ➤ Sunflower meal

Sunflower meal (SFM) is a good vegetable source of protein with amino-acid digestibilities similar to those of SBM and much higher values than those in cottonseed or rapeseed meals. Its lysine content is relatively low but the methionine content makes it suitable for breeder diets in addition to SBM.

The fibre content of sunflower meal is usually high and variable depending on the dehulling process of the sunflower seed for oil extraction. This often makes sunflower meal a promising feed ingredient in low energy diluted diets due to the high content of insoluble fibre inextracted sunflower meal (see Energy level and the advantages of high fibre breeder diets chapter above).

Another characteristic of SFM is that it does not usually have anti-nutritional factors such as those found in soybean, cottonseed and rapeseed meals. Sunflower can be successfully being included in broiler breeder diets to replace 50 – 100 % of SBM especially in grower and male diets.

### ➤ Rapeseed meal

Extracted rapeseed or canola meal is economically favoured in low energy feeds such as breeder feed due to its relatively low ME value for poultry. Also, some producers have limited their use of rapeseed meal (RSM) due concerns about the risk to health and performance problems based on problems they have experienced including for example, hemorrhagic liver and small egg size. All of these problems can be managed effectively once a few key points about amino acid digestibility, glucosinolate content and dietary mineral balance are understood.

Based on appropriate supply (low glucosinolate RSM) and feed formulation techniques (amino acid digestibility and cation-anion balance) RSM inclusion levels in breeder diets can reach 5 % in the grower breeder diet and 3 % in the breeder diet in lay.

### ❖ Added oil

The inclusion of raw materials (grains and by-products) that have low ME contents produces a demand for oil in breeder diets.

Fat is not only an important raw material but crude fat is also a very important nutrient (see benefit of oil page 6). It is important to know the fatty acid profile (especially linoleic acid content) when using fat and oil as raw materials for breeder diets (Table 9). Increasing or decreasing the linoleic acid content of the diet is a well-known method of adjusting egg weight especially at the onset of lay.

Table 9: Fatty acid profile (%) of several vegetable oils.

Oil	Myristic acid C14:0	Palmitic acid C16:0	Stearic acid C18:0	Oleic acid C18:1	Linoleic acid C18:2	Alpha linoleic acid C18:3	Unsat. /Sat.
Canola oil	-	4	2	62	22	10	15.7
Cocunut oil	18	9	3	6	2	-	0.1
Cotton seed oil	1	22	3	19	54	1	2.8
Palm oil	1	45	4	40	10	-	1
Rapeseed oil	-	4	2	62	22	10	15.7
Sesame oil	-	9	4	41	45	-	6.6
Soybean oil	-	11	4	24	54	7	5.7
Sunflower oil	-	7	5	19	68	1	7.3

Added fat inclusion levels should be kept between 1 to 3 % in breeder feed and preference given to unsaturated vegetable oils as various work comparing unsaturated vegetable oil and poultry fat generally supports the use of more unsaturated fat.

Products of fat oxidation and trans-fatty acids in vegetable oils are all undesirable in the nutrition of parent stock.

Table 10: Broiler breeder major ingredient constraints (%)

	Pre-starter & starter		Grower and male		Pre-lay and breeder	
	Min.	Max	Min.	max	Min.	Max
Corn	0	70	0	70	0	70
Sorghum	0	5	0	20	0	15
Wheat	0	50	0	50	0	50
Barley	0	5	0	10	0	8
Oats	0	4	0	6	0	4
Wheat by-products	0	10	0	15	0	10
Broken rice	0	15	0	15	0	15
Rice by-products	0	10	0	15	0	10
Soya bean meal	10	30	0	25	10	30
Full fat soya	0	10	0	10	0	10
Sunflower meal	0	8	0	15	0	10
Cotton meal	0	3	0	4	0	3
Peanut meal	0	2	0	2	0	2
DDGS	0	3	0	5	0	3
Rapeseed meal 00	0	2	0	3	0	3
Fishmeal	0	4	0	3	0	4
Veg. oil (Saturated)	0	0.5	0	0.5	0	0.5
Veg. oil (Insaturated)	0.5	2	0.5	2	0.5	2
Palm kernel cake	0	0	0	2	0	0
Oat hulls	0	0	0	3	0	2
Sugar beat pulp	0	0	0	3	0	2
Molasse	0	1	0	2	0	1
Ca Carbonate (granular)	0	0	0	1	4	6
Ca Carbonate (powder)	0	2	0	2	2	4

## ❖ Use of exogenous enzymes

Enzymes produced endogenously by poultry are able to digest only 5 to 20 % of the NSP (non starch polysaccharides) present in the feed.

Numerous studies over the past twenty years have demonstrated improvements in feed utilization with exogenous enzyme supplementation. With improvements in the technology of production of certain enzymes they became less expensive and are now being routinely used in poultry and poultry breeder feeds to improve digestibility of feed ingredients.

For instance, phytase can be used effectively to increase the digestible phosphorus concentration of monogastric rations, whereas carbohydrases, such as xylanase and beta-glucanase, can effectively increase the diet's energy digestibility of feed ingredients high in NSP (wheat, barley, etc).

In order to obtain maximal benefits from the inclusion of enzymes in animal feeds, it is necessary to ensure that the enzymes are chosen on the basis of the feed composition. In simple terms, the enzyme must be matched to the substrate. Failure to consider the phytate content of the complete diet when assigning an available-phosphorus credit to the phytase product may lead to phosphorus deficiencies, resulting in poor egg production, osteomalacia, and gout. Similarly, failure to consider the xylan or beta-glucan content of the complete diet when assigning energy credits to a carbohydrase product may lead to wrong energy assumptions, resulting in incorrect feed allocation with reduced growth, egg weight, and egg production.

Since enzymes are proteins, the structure of the enzyme is critical to its activity. The pH, heat or certain organic solvents can alter enzyme structure. Changes in the structure of the protein can decrease or negate enzyme activity. The temperatures to which feeds are exposed during the pelleting or heat

treatment process can range from 60 to 90°C under normal conditions. Recent studies reveal that temperatures over 80°C and pressures can lead to loss of feed-borne and added enzyme activity.

The supplier of the enzyme or your nutritionist should be consulted to ensure the raw material matrix and feed specification values for energy and amino-acids are correctly adjusted for the enzyme being used and for the conditions where the enzyme is used. Consideration must be given to phosphorus, calcium, sodium and other minerals ensuring correct values have been ascribed to the product.

Future developments in enzyme technology will likely focus on more thermo-tolerant enzyme preparations, greater enzyme activity and enzymes which function optimally at low gastric pH values. Additionally, as more is known of the chemical nature of our feed ingredients, better methods of degrading these compounds may be found.

### ➤ **Phytase and phytate**

Phytases have been used in the feed industry for close to 20 years. Over that period the number of products has increased and the recommendations on how to use these products have changed. However, despite several thousand scientific papers and a rapidly growing market, the use of phytase and the importance of phytate in practical poultry nutrition remains an area of some confusion. Initially phytases were offered as a means to improve the phosphorus bioavailability from phytate-containing ingredients. However, it was gradually understood that the digestibility of other minerals (notably calcium but also sodium), carbohydrates and amino-acids were also variably influenced by the ingestion of phytase. The mechanisms at work are not entirely clear but recent evidence suggests that phytate is an anti-nutrient, beyond its effect on digestible phosphorus and influences secretory and absorptive processes in the gut.

Most commercially used phytases are not intrinsically thermostable enough to survive the harsh conditions encountered when feed is steam conditioned and / or pelleted. Two approaches have been employed in order to circumvent this problem: Genetic modification or coating the enzyme to produce a more thermotolerant enzyme and spraying the phytase onto the feed after the heat treatment and/or pelleting process. To date, all of these solutions have limitations: genetically modified product are stable enough for most but not all steam temperature, coated product may delay the release of phytase and the accuracy of post heat treatment application is difficult to ensure on a consistent basis.

The commercial usage of phytase is based on the assignment of a nutrient matrix to a given dose of the enzyme. However, differences between the various commercial phytases in respect of nutrient release, degradation and correct mixing or application method are factors which influence the scale and consistency of the phytase and these should be carefully considered in diet formulation especially for breeder rations. For this reason, a programme of frequent enzyme recovery measurements after feed processing is needed.

### ➤ **Enzyme cocktails**

It is now well known that NSP can exert anti-nutritive activity in monogastric animals. The NSP of barley, wheat and rye (Beta glucan, arabinoxylans or pentosans) are those most intensively investigated. Ingestion of NSP by monogastrics results in increased viscosity of the digesta (Burnett, 1966; Antoniou and Marquardt, 1983). This increased viscosity reduces the passage rate of the feed leading to overall reductions in performance, sticky droppings and dirty eggs. The addition of enzymes to the diet to address NSP viscosity can improve feed efficiency, improve manure quality and increase the use of lower cost feed ingredients.

Enzyme cocktails containing more than one enzyme will often improve the response compared to pure, single enzymes, assuming that cost considerations are not ignored. This is due to the fact that feedstuffs are complex compounds containing protein, fat, fiber and other complex carbohydrates. Merely targeting a specific substrate such as Beta glucan may not provide maximal benefits since layers of other substrates may inherently protect some of the Beta glucan. For example, Beta glucans and arabinoxylans may be

bound to peptide or protein in the cell wall of the feedstuff. Therefore, enzymes capable of hydrolyzing protein may enhance the activity of pentosanases and beta glucanases.

As a consequence of the mode of action of the NSP-hydrolysing enzymes, an increased utilization of dietary energy may well be expected. In fact, increases in ME values of either whole diets or specific raw materials due to enzyme supplementation have been repeatedly described in the literature. Because of improvements observed in protein digestibility it is tempting for the nutritionist to lower the overall target protein and amino-acids levels of the diet. However, because of the variation in individual amino acid digestibility, caution is advised in doing this in order to ensure adequate levels of limiting amino acids are provided.

Enzymes therefore allow diets to be reformulated to reduce cost and maintain performance or be added as an extra component to reduce the variability in raw material digestibility and increase performance.

## ❖ Quality control programs

Feed quality-control programs are targeted to deliver feeds that consistently contain the formulated nutrients in an available form and contain minimal levels of toxic substances.

### ➤ Raw material quality control

Not only does it make good economic sense to pay attention to ingredient quality but it follows that a large proportion of the variation in the nutrient content of finished feeds can be traced to variability in the ingredients assuming effective mixing of ingredients during manufacture

Ingredients must be described in terms of analytical values and physical and/or sensory characteristics. Ingredient assessment that only considers colour (heat damage), odour, contaminant and texture generally will fail to identify much of the variation in ingredient quality. Every quality control program should include a combination of rapid appropriate tests at the feed mill (e.g. moisture, test weights, rancidity, etc) combined with periodic chemical analysis of ingredient samples at a reliable laboratory. The frequency of these analyses is often linked to the variability of particular ingredients.

On site rapid analysis may lead to the rejection of deficient loads. This discipline in the analysis and record keeping represents a clear indication to the ingredient supplier of the feedmills commitment to quality.

If the rapid inspection of important ingredients at the feed mill suggests a risk of poor quality, then use a safety margin for Energy (ME), Protein etc in case of poor digestion as follows:

- 🕒 e.g. corn normal ME 3360 –poor use 3200 kcal/kg
- 🕒 e.g. soya normal crude protein 47%, use 45% (or lower)
- 🕒 e.g. soya normal crude protein 43%, use 42%

Basic nutrients which should be analysed regularly are crude protein, starch, crude fiber, crude fat and the main minerals calcium, phosphorus, sodium and chloride. However analysis of amino acid contents especially lysine, methionine and threonine are beneficial where possible. These represent the nutrients that must be listed for every raw material in order to build a raw material matrix. This matrix needs to be adjusted on a regular basis based on local ingredient information. It is absolutely impossible to build a locally accurate matrix based only on published tables from reference sources or the internet. While this simple fact seems to be obvious, it is very often forgotten in practice.

Sampling is a critical part of any quality-assurance program. Steps involved with collecting a representative sample include following a sampling scheme; collecting numerous samples to ensure it is representative; using the correct sampling equipment and procedure; inspecting the sample for its sensory characteristics and finally mixing the samples and subsample for lab analysis. Always retain a portion of the subsample for possible later analysis.

Each new batch of grain or grain by-products should be sampled because grains tend to be unpredictable in nutrient content according to their source. When processors are bound by local law to meet guaranteed analysis (feed tags), raw materials such as soybean meal may not have to be sampled quite so often.

If premixes are purchased from a reputable company, it is not necessary to routinely send samples for expensive laboratory analysis. Nonetheless, it is a good idea to sample each shipment of premixes and keep samples stored in freezer. This sample permits further analysis if problems with premixes are suspected.

### ➤ **Process control**

The process by which high-quality ingredients are made into high-quality feeds involves three components within the feed mill: personnel, machinery and procedures.

The company commitment to quality must be supported by everyone from top management down to all feed mill employees. Any employee who discovers a problem with a batch of an ingredient should be recognized for their commitment.

Equipment selection, operation, repair and troubleshooting can become a very complicated process which can not be covered in this guide. However, considering the special characteristics of breeder feed, it is important to emphasize:

- ④ Verification of the cleanliness of equipment (see chapter on feed contaminants and feed hygiene) including the delivery truck.
- ④ Meters and scales. Batch scales should be inspected at least once each month, while micro-ingredient procedures and scales should be checked weekly.
- ④ Grinding (see chapter on feed presentation)
- ④ Mixing efficiency (minor ingredients and main raw materials) related to risks of insufficient mix time (to be checked at least twice a year). Risks include mixers used beyond their designed capacity and worn, altered or broken equipment.  
Attention must be given to accuracy of inclusion of premix and feed additive such as phytase into feed and there must be assurance that the minerals, vitamins and all feed additives are blended into the feed in a homogenous manner.

### ➤ **Finished feed quality**

A programme of monitoring the quality of finished feed should be agreed between the supplier and the feed buyer. This will minimize disputes and claims based on an analysis of the feed that is not representative of the actual diet supplied. This agreement should include sampling method, sampling frequency, and procedure for comparing the actual diet analysis with the diet specification, tests for contamination and microbiological status and the storage of samples. Routine laboratory analysis of finished feed should be conducted every two months at the minimum.

It is recommended to keep samples of all delivered feed on farm for at least 3 months or preferably the lifetime of each flock to assist the diagnosis of any future performance problems while not forgetting these samples may play an important role in understanding microbiological problems such as salmonella contamination.

The practical difficulties in achieving the exact control of feed composition emphasize the importance of continuous monitoring of stock performance as described throughout Hubbard breeder management manuals.

Note: The time taken for feed to reach the birds after manufacture should be as short as possible. This is especially important under conditions of high temperature and humidity, which will accelerate vitamin loss and other changes.

## FEED CONTAMINANTS AND FEED HYGIENE

All feed must be considered a potential source of bacterial infection for parent stock, particularly Coliforms and Salmonellae, and should be decontaminated if microbial pathogen control is required.

The growth of moulds on feedstuffs (grains, finished feeds) and the elaboration of toxins by these moulds (i.e. mycotoxin) are a prevalent problem due to their detrimental effect on animal performance and reproduction. By some estimates, mycotoxins affect as much as 25 to 40 % of the world's food crops each year.

### ❖ Moulds and mycotoxins

There is a huge interest in these naturally occurring chemical compounds due to their adverse effects, their wide variety of clinical signs and their more or less severe economic losses.

Identification of mycotoxin contamination is made difficult because the symptoms are often vague and can be associated with other diseases. Some of the problems associated with mycotoxicosis in poultry breeders are as follows:

- Reduced weight gain and decrease of uniformity in rearing. Increase feed clean up time.
- Decrease serum proteins. Increased liver and kidney weights. Liver and kidney lesions.
- Induced immunosuppression
- Altered feathering
- Reduced egg production, fertility and hatchability. Smaller day old chicks.

#### ➤ Mould growth

Fungal contamination of grain and poultry feed is versatile and pervasive. Mould spores are commonly found in the soil on decaying plant debris and are transported to the plants by air currents, water movement and insects. It can start in the field, or on the crop itself, or during post-harvest transport and storage. Environmental factors such as moisture content (> 14%), optimum temperature and insects are the main factor in the activity of moulds

Whether they are field or storage fungi, these micro-organisms require nutrients for growth. Therefore, the presence of mould in grain and feed will reduce the available nutrient content. Nutritional deficiencies associated with mould growth in grains and feeds include decrease in dietary energy values (Bartov et al, 1982), altered amino-acid profile and reduced vitamin levels. This lead to a negative impact on animal performance together with feed refusal (smell and taste are modified) and more or less specific pathology (enteritis).

#### ➤ Mycotoxin contamination

Among thousands (USDA, 1999), well over 300 mycotoxins are currently identified but the important mycotoxins studied are aflatoxins, ochratoxins, trichothecenes, fumonisins and zearalenones. These toxin agents are ubiquitous in distribution and have been isolated from a wide variety of grain, oilseed and mixed feeds.

The response of a poultry breeder receiving a dietary mycotoxin will depend upon numerous factors. These factors include weight, age, physiological and health status of bird, combined effects between several mycotoxins (synergistic effect) and most importantly, the dose coupled with the duration of feeding that dose (= amount consumed).

It should also be kept in mind that a threshold dose must be reached (table 11) before a response to the dietary mycotoxin will be noted.

Table 11: Estimated minimum level of main mycotoxins to affect breeder performances

Toxin (ppb)	Breeder pullets	Breeders in lay
Aflatoxin (B1)	50	20
Fumonisin (B1+B2)	1 000	750
Ochratoxin	20	10
T2 toxin	200	50
Vomintoxin (DON)	800	400
Zearalenone	100	80

Source: bibliography.

In contrast, if the level of contamination is high, the response may occur rapidly and with a high degree of severity. Acute mycotoxicosis outbreaks are however rare events in modern commercial poultry production. More commonly, low mycotoxin doses that may go undetected are responsible for sub-chronic, non-specific effects that result in reduced efficiency of production and greater susceptibility to other infectious diseases especially with long production cycle such as those of poultry breeders.

### ➤ Moulds and mycotoxins control

The most cost effective prophylactic measure to protect investments in grain, feed and animal performance is a comprehensive risk management program that starts with appropriate drying of cereals and corn following harvest. Prevention of condensed water on the silos walls and elimination of pests and mites are also important together with humidity control from a representative sample.

The “risky” grain can be blended with clean grain and/or given to species of animal less sensitive to the mycotoxins like broiler of more than 20 days of age rather than high value breeders.

The completed breeder feed should be treated with a mold inhibitor. Several commercial products are available and are generally mixtures of organic acids (i.e. acetic acid, sorbic acid and propionic acid) which, in combination, prevent the growth of a wide variety of molds. If the incoming feed ingredients are thought to be of poor quality (i.e. if the corn contains many cracked and moldy kernels, or has a moldy odor), it should be treated with a mold inhibitor. This will prevent further mold growth but will not negate the nutrient destruction that has already taken place as a result of earlier mold growth. It will not eliminate mycotoxins that have already been produced.

The detection of mycotoxins, though, is difficult and sampling methods do not provide consistency in their results, as specialized laboratory equipment supported by qualified technicians is needed.

Speciality feed additives, known as mycotoxin organic adsorbents or inorganic binding agents are the most common approach to prevent mycotoxicosis in animals. It is believed that the agents bind to the mycotoxin preventing them from being absorbed. The mycotoxins and the binding agent are excreted in the manure. Be aware that not all binders are equally effective. Many may impair nutrient utilization and are mainly marketed based on in-vitro data only.

In addition to using toxin adsorbents/binders in feed, an additional solution especially when facing tricothecenes (T-2, DON) toxins, is to provide early protection for the liver (hepato modulator), the main organ that supports detoxification of toxins and metabolites.

### ❖ Feed-born microbial contamination: salmonella.

It is estimated that about 15% of the *Salmonella* contaminations in poultry products are caused by feed. One of the major challenges for feeding breeders includes the use of Salmonella-free feed. This is a standing request of many breeding companies because consumers demand and expect Salmonella-free food products.

Zoonoses have only become a focus of attention in recent years. Salmonellosis is generally accepted to be one of the most important zoonoses transmitted by meat and eggs. Salmonella cannot be entirely eradicated, but it can be controlled. Breeding flocks free of salmonella have been considered as a fundamental pre-requisite for a better control of Salmonella at broiler level.

A broad range of Salmonella can be isolated from poultry; however, the most relevant to the poultry industry are broad host range serovars Enteritidis (SE) and Typhimurium (ST) and host specific serovars Pullorum and Gallinarum. Other serotypes in the top 10 of causes of human salmonellosis cases included Infantis, Hadar and Virchow which are typically associated with broiler meat.

Many strategies such as in feed antibiotics or vaccines have been tried and tested to control Salmonella in the poultry industry but none of these Salmonella control strategies have been successful on their own. Therefore, the control of Salmonella must be considered in terms of an integrated approach combining improved hygiene, biosecurity and management practices including specific nutritional technology.

Feed has traditionally not been considered a major source of SE for breeder flocks when it does not contain animal protein ingredients. However, some by-product used in breeder feed may contain various type of salmonella. Monitoring has shown that vegetable raw materials may have similar levels of Salmonella contamination to animal sources. The most common vegetable raw material found to be contaminated is oil seed protein such as sunflower, rape, palm kernel and soya.

Salmonella bacteria are moderately resistant to the environment and are inactivated by most disinfectants, formaldehyde gas, heat and extremes in pH.

#### ➤ **Enterobacteriaceae level as indicator of salmonella contamination.**

Enterobacteriaceae are a group of gram-negative, non-spore forming bacteria that includes *Salmonella*, *Escherichia coli*, and other enteric bacteria. The level of enterobacteriaceae in feed is a strong indicator of the feeds microbial quality and therefore level of enterobacteriaceae in feed is considered a reliable indicator of raw material and feed quality.

When enterobacteriaceae levels are high, the probability of Salmonella contamination is also high and concomitantly, when enterobacteriaceae levels are low the probability of Salmonella contamination is low. The “acceptable” maximum levels of enterobacteriaceae, where action needs to be taken, have not been determined for all feeds or feed ingredients. In Europe, a maximum limits for enterobacteriaceae has been established. In breeder feed, the maximum acceptable level of enterobacteriaceae is 100 cfu/g with a target level of 0 cfu/g.

To achieve this, a very strict feed control program is recommended building on heat treatment of the compound feed, use of feed additives and regular checks at defined critical control points (CCP) in feed mills.

#### ➤ **Critical control points**

The following CCPs have been identified and indicate where process-monitoring samples should be taken in feed mills in order to effectively identify frequent contamination problems with ingredients or post-processing contamination:

- ④ Dust taken from ingredient auger system below or behind the intake pits.
- ④ Dust from ledges inside tops of raw materials silo's and bins, or dust from ingredient sieves or spillage from ingredient bin augers if bins are inaccessible or do not accumulate dust.
- ④ Swabs from coolers – taken below coolers or on associated framework, at the pellet shakers or for meal ration lines take dust from finished product bins or augers.
- ④ Dust from ledges near to feed discharge points.

The processing equipment in the feed mill must be designed to allow easy and effective cleaning. Special attention should be focused on mill hygiene during the shut down periods.

For a feed production of more than 10 000 MT per year, a monthly sampling at each CCP listed above is the minimum required. In the case of feeding grand-parent stock, the sampling frequency at each CCP can reach 1 per 150 MT produced.

Where a result is obtained with more than 1000 enterobacteriaceae cfu/g, the following should be taken:

- ④ Re-sampling at the CCPs and analysis.
- ④ Serotype any positive samples
- ④ Implement the necessary cleaning and disinfection programme.
- ④ Additional investigation including evaluation of raw materials.
- ④ Inform the raw material supplier of the results if a specific ingredient is the reason of the contamination.

➤ **Dedicated heat treatment line.**

Traditionally, Salmonella control in finished feeds, such as poultry breeder feed, has been attained by heating the feed through a manufacturing process such as pelleting. However, at standard pelleting temperatures (65-70°C) total de-contamination is highly unlikely and furthermore, subsequent multiplication of any residual Salmonella and re-contamination, especially through the cooling system, may occur.

For effective de-contamination, the best system consists of a dedicated heat treatment line for poultry mash feed or both pellet and mash diets. Dedication starts prior to heat treatment and includes all routing through the heat treatment process to dedicated bulk outloading bins and from there to the bulk delivery vehicles.

Regarding heat treatment itself, a defined combination of a set temperature for a set period of time, at a set relative humidity must be consistently applied to the finished feed. The system requires a cooler to return temperature and moisture to the pre treatment levels. All plant at the heat treatment and cooling stage must be kept clean and sterile through a controlled access of both personnel and equipment. All the air supply to the biosecure milling facility should be filtered through a comprehensive specific air circulation system especially after the de-contamination process

One of the advantages of the concept is to enable breeders to continue mash feeding which increases the time it takes the birds to consume their daily allowance (see chapter on feed presentation).

➤ **Feed additive for salmonella control**

Some feed additive products are sold for salmonella control in the feed. To date a number of products have gained commercial acceptance, including short chain fatty acids (formic, acetic, propionic and butyric acids) and formaldehyde. They all demonstrate anti-Salmonella properties.

Medium chain fatty acids (C6 to C12; caproic, caprylic, capric and lauric acid), essential oils, probiotics, prebiotics and glycans have also been listed. However these products will limit colonization of the gut by Salmonella but may not have sufficient bactericidal properties.

The development of such feed additives for the control of Salmonella has been somewhat empirical and often the concentrations used in commercial operations is determined by cost of addition rather than scientifically determined minimum inhibitory concentration as determined by the supplier.

The antibacterial activities of organic acids are also dependent of the temperature, moisture, dose of acids and time between addition of acids and feed consumption by the birds. The actions of acids are relatively slow and 48 h exposure appears to be a minimum for best efficiency.

Note that some of the commercial acids products can be corrosive to the mill equipment.

These organic acid and formaldehyde products may also help in preventing re-contamination during the handling, storage and transportation phases.

### ➤ Risk of recontamination

One of the biggest challenges in producing salmonella-free feed is to avoid any kind of recontamination during cooling, delivery and storage of the feed. Recontamination occurs when dust and residues in the cooler or feed transport system (inside the mill, in feed trucks, and in the farm feed system) become incorporated into the breeder feed. Dust and feed residues contain high levels of mould and bacteria which result in an increased incidence and increased level of bacteria /mould in the feed consumed by the animal.

Feed generally becomes recontaminated during transport by passing through contaminated feed-handling equipment, such as augers, elevators, drag lines, bagging equipment and trucks. For instance, any introduction of Salmonella into coolers with a high humidity may support the survival and spread of Salmonella.

All vehicles used to transport of breeder feed should be subjected to a risk based cleaning and sanitizing programme to ensure they are maintained in a clean state with no build up of waste material. Ideally, separate vehicles should be designated specifically for breeder feed but it is recognised that resources may not allow this. Therefore, if vehicles are used for the carriage of other materials, they must be appropriately cleaned of organic matter, sanitised using approved disinfectant and procedures and dried before being used to transport breeder feed. Organic matter reduces the effectiveness of disinfectants so scratching if needed and removal of dust inside each truck's compartments is essential. Schedule of feed deliveries should give priority to the farms with the highest health rating to be the first in a sequence of visits by the same truck.

Although some special supplements like organic acids are very useful to keep the feed salmonella-free until it is consumed by the birds, the major problem is often the storage and handling of the feed at the farms.

### ❖ Cross-Contamination

Feed ingredients and premixes should meet acceptable and if applicable, statutory standards for levels of pesticides and undesirable substances. Excessive dosages, inappropriate use of feed additives and cross-contamination of feed can pose a serious risk to breeder flocks.

It is generally acknowledged that under practical conditions during the production of mixed feeds, a certain percentage of a feed batch remains in the production circuit and these residual amounts can contaminate subsequent feed batches including breeder diets.

Manufacturing procedures should be used to avoid such cross-contamination (for example flushing, sequencing and physical clean-out) between batches of feed and feed ingredients containing restricted or otherwise potentially harmful materials such as certain animal by-product meals and veterinary drugs. These procedures should also be used to minimize cross-contamination between medicated and non-medicated feed and other incompatible feed. In cases where the safety risk associated with cross-contamination is high and the use of proper flushing and cleaning methods is deemed insufficient, consideration should be given to the use of completely separate production lines, transfer, storage and delivery equipment for breeder feed.

Note:

- 🔊 It is not recommended to use Lasalocid (Avatec) for dwarf breeders.

## FEED PRESENTATION

Nutrient recommendations are published and adapted to various breeds and their genetic evolution. However, the physical aspects of the feed (particle size, uniformity and hardness) are seldom defined as precisely.

Feed mills have improved technology in grinding, sifting and it is now possible to achieve a precise range of particle sizes according to the age of the flock. However, this is not an easy task.

The form of feed used is dependent on the feed ingredients available and the feed compounding facilities. For instance, the oil, protein, starch, and fiber content of cereals and cereals by-product will affect not only the nutritional value, but also the feed milling characteristics.

### ❖ Pelleted or crumbled diets

In theory, presenting a diet in crumb or pellet form may contribute to better bacteriological quality and will lead to shorter clean up time with a lower chance of diet segregation compared to mash.

However, this assumes:

- ④ The systems before and after the pelleting process are clean and maintained (see chapter on feed hygiene).
- ④ The feeding systems in operation and the raw materials used are providing the birds with a good quality pellet or crumb at the feeder levels.

Very often, the difficulties in obtaining a good quality pellet and crumb are responsible for technical problems because of:

- ④ The break down of the crumb/pellet in the feed distribution system and the build up of fine feed particles in the feeders.
- ④ Shell quality problems related to the difficulties using granular limestone
- ④ More feather pecking because of a short feeding time.
- ④ The increased cost of manufacture.

The two main physical quality of pellet are:

- ④ Hardness – measured by pellet resistance to breaking when submitted to external pressure
- ④ Durability – measured by the level of “fines” produced during transportation from the feed factory to the farm, and distribution in the feeding at farm.

### ❖ Mash diets of good texture

#### ➤ Advantage of mash diets

In the rearing stage, with the exception of the first 3 or 5 weeks when the diet should be provided as crumbs, the use of mash feed is preferred. The degree of feed restriction is often increased and it is better to extend the eating time to promote good body weight uniformity. To achieve this target, the feed is best presented in the form of a regular and uniform mash with low levels of small and large particles (Table 12)

During the laying period, a good textured mash diet will allow the birds to increase their feed clean up time. However, it is better if feed is consumed quickly (3-4 hours) to help the hens to organize their eating, laying and mating activities throughout the day. It is undesirable if eating time is too long (eggs laid on the floor, risk of having males eating with the females and less mating activity in the afternoon). In this case, it is important to feed a palatable mash made of coarse particles. The mineral and vitamin part may be presented as a crumble instead of the usual fine powder to help reduce the amount of fine particles and the risk of separation.

Table 12: Distribution of particle size (percentage using standard sieves)

Standard sieve (mm)	>3.15		3.15–2.0		2.0 -1.6		1.6-1.0		1.0-0.5		< 0.5	
	%	% cum	%	% cum	%	% cum	%	% cum	%	% cum	%	% cum
Starter - crumbs	2	2	20	22	18	40	45	85	13	98	2	100
Starter - Mash	5	5	20	25	15	40	25	65	20	85	15	100
Grower - Mash	5	5	20	25	15	40	25	65	20	85	15	100
Breeder - Mash	10	10	20	30	15	45	25	70	20	90	10	100

For the males, limiting the eating time is achieved to a greater extent by improving the feed distribution system than by feed presentation itself.

Mash quality is assessed by the size and uniformity of its particles. Good uniformity of particle size is essential because birds prefer bigger particles. Thus the dominant birds will quickly eat those bigger cereal particles, while the rest of the birds will eat the finer particles.

Being grain eaters, birds have a digestive tract designed to quickly ingest amounts of feed, that are stored in the crop to be “hydrated” and “acidified” by lactic acid secretion before going through the proventriculus. In the proventriculus, hydrochloric acid and pepsin and mucus secretions are increased when feed particle size is large. The gizzard carries out feed grinding, feed impregnation and pre-digestion of the feed by the secretions from the proventriculus, as well as the regulation of the feed in-flow and out-flow to the lower digestive tract. The intestinal peristaltic motility slows down the feed flow, allows better absorption of the nutrients by the intestinal villi and helps to stabilize the intestinal flora. Too fine feed particles will not allow the above natural process as small particles will not remain sufficiently in the crop and will not favor correct grinding and pre-digestion in the gizzard.

However, mash feed can be problematic due to inconsistent supply of nutrients caused by segregation of light from heavy feed ingredient particle. Therefore it is important to provide consistent and uniform mash feed to breeders.

### ➤ Feed grinding technology

As shown above, a coarse and uniform mash feed is an optimal for breeder production. Coarse mash that may even be used to produce a pellet is an important factor to regulate feed digestion. Feed particle size depends mainly upon grinding. Two types of grinder are available:

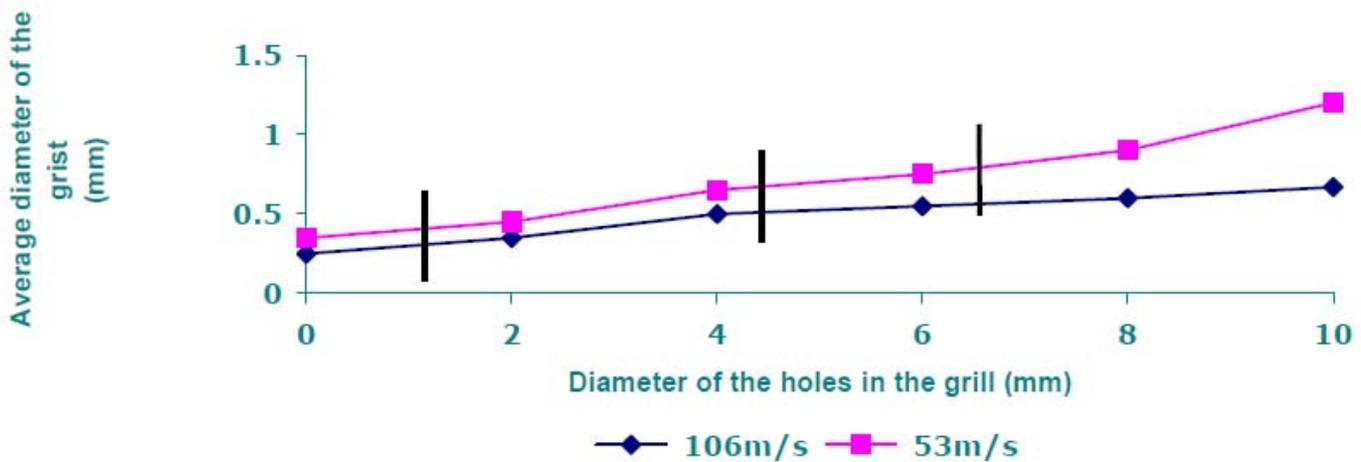
- Grinders with fluted cylinders are not designed for heavy volume production. They are more sensitive to deterioration by foreign bodies, but they consume less power and the feed produced has a more uniform particle size.
- Grinders with hammers are more commonly used. Grinding is achieved both by contact between feed particles and the hammers and the abrasive effect of the grills. Thus grinding control depends upon two main factors: hammer peripheral speed, and grill mesh size (Figure 1 and Table 13) and the percentage of holes. Hammer peripheral speed is a combination of grinder diameter and rotation speed. For one given raw material, the higher the hammer speed, the wider is the distribution range of the feed particles.

Example of calculation:

- Rotation speed = 1,500 RPM (Rotations Per Minute)
- Grinder diameter = 0.7 m
- Peripheral hammer speed =  $0.7 \times 3.14 \times (1,500/60) = 55\text{m/s}$

If the grinder runs at 3,000 RPM, the peripheral speed is 110 m/s. For poultry breeder feed, 55 m/s is the most frequently used speed. Grinders with variable speed allow adapting speed to the raw materials and to the targets for feed particle size.

Figure 1: Hammer speed influence on the grist size of maize.



For grinder grills, the two important criteria are mesh diameter (from 2 to 10 mm), and the percentage of holes in the grill (from 27 to 52 %). The higher these two values are, then the higher the average feed particle size and the feed particle size distribution range will be.

Note that grill with mesh screens have a higher proportion of holes and allow higher throughputs.

Table 13: Average grist size of maize (cumulative %) using standard grills.

GRILL	"GRILL" 6mm		"GRILL" 10mm	
	SPEED OF HAMMER		SPEED OF HAMMER	
GRINDER	1,500 RPM	3,000 RPM	1,500 RPM	3,000 RPM
Diameter of sieve	Cumulative %	Cumulative %	Cumulative %	Cumulative %
3.15 mm	5.05%	8.25%	13.53%	15.61%
2.00 mm	48.1%	45.22%	46.59%	42.66%
1.00 mm	75.83%	70.42%	76.14%	67.38%
0.5 mm	88.91%	85.32%	90.81%	82.12%
Fine < 0.5 mm	11.09%	14.68%	9.19%	17.88%
3.15mm < Standard >0.5mm	83.86%	77.07%	77.28%	66.51%
Large > 3.15 mm	5.05%	8.25%	13.43%	15.61%

The feed particle size and the average distribution range of the feed particle size must be regularly monitored. Excessive variation is a sign of hammer or grill wear.

When blades are worn, the distance between the blade and grill (normally 8mm) is increased. The peripheral feed particle layer therefore becomes thicker and particle ejection is slowed down. The abrasive effect at grill level is increased. Grinder yield diminishes and more fine particles are produced.

In the same manner, worn grills will tend to reject particles back to the grinder instead of letting them out.

For most poultry species, the relevant range for feed particle size is -0.5 to 2 mm. Under 0.5mm, particles are less readily ingested, but this size is essentially composed of vitamins and minerals. Above 2 mm, comprises mostly of the cereals, which may give rise to feed particle selection by the birds.

Grinders with variable speed improve the uniformity of particle size and diminish the amount of particles outside the desired range. Grinders with 55 m/s speed, together with post-grinding sifting to exclude those particles above 3 mm, give good results when working with larger diameter mesh grills to reduce the production of fine particles.

Starter, Grower, Pre-lay and Breeder feeds, when they are crumbled or pelleted, should be made from a mash particle size equal to that described in table 12.

In hot climates, a very coarse mash is better than a pellet both for price and palatability and it allows for the addition of supplemental fat if necessary.

## FEEDING PROGRAMME / FORMULATION

Parent Stock birds require a series of balanced diets which promote growth and development during rearing and support egg production in the reproductive period to ensure that maximum performance is achieved (see also supplements specific to each Hubbard broiler breeder products)

Feed for breeders must be consistent –physically and chemically -otherwise the manager will provide birds with changing levels of nutrients and cannot optimise or ‘fine tune’. Do not keep changing breeder formulas too often.

### ❖ Pre-starter and/ or Starter feed

Promoting optimal growth during the first few weeks of chick’s life appears to positively hen laying performance. This may relate to the concept of nutritional programming discussed by a number of groups (Knight and Dibner, 1998, Giesen, 1998).

Higher early crude protein intake increases lean tissue accretion, skeletal mass and flock uniformity. A relatively small increase in total protein intake appears to positively influence egg production through peak and beyond.

When it may be difficult to achieve a minimum intake of 160g of crude protein to four weeks of age for all birds (chicks from young breeders, long chicks transportation,...etc), it is advisable to use a high crude protein & amino-acids pre-starter for the first 10 days of age before moving to the more conventional starter diet (see supplement at end of this guide)

Care should be taken to avoid presenting large particle sized grain to chicks. Individual chicks will select these large pieces to the exclusion of the crumbles and consequently develop nutrient deficiencies (e.g. rickets). Pre-starter and/or Starter feed should be best provided as a sieved crumble.

### ❖ Grower feed

This is the phase when the degree of feed restriction is highest. However, parent stock must not be deprived of sufficient nutrition during rearing if reproduction is to be optimal (Lilburn et al., 1992). It has become increasingly apparent that cumulative nutrition and the feeding program during rearing and early lay can affect modern broiler breeder development and carcass conformation in such manner as to affect egg weight, livability and fertility, as well as performance of the broiler progeny.

The minimum cumulative intake of ME and crude protein (CP) at photo-stimulation (147 or 154 days of age) are as follows (see also product guidelines):

- Conventional females: 24 000 Kcal ME and ~ 1 300 g CP
- Standard dwarf females : 22 000 Kcal ME and ~ 1 200 g CP
- Colored dwarf females : 20 500 Kcal ME and ~ 1 125 g CP

These minima require that total lysine, on a good quality grower feed, be 4,9 - 5,0 % of CP and methionine + cystine be 83 % of lysine.

Where possible, a low energy grower feed ( $\leq$  2650 Kcal) as a uniform mash form is the best compromise. This will give longer feeding times and a better opportunity for all individuals to feed. An acceptable eating time of 40-60 minutes is achievable using a ‘4 or 5 feed days in 7 days’ feeding program, providing this is permitted by local regulations.

In some management systems, such as floor feeding (spin feeding), a high quality durable grower pellet is essential.

### ❖ **Transition to breeder diet**

The traditional view (e.g. Brake 1985) was that hens needed a minimum lean tissue mass to start lay. Therefore, increased protein intake was needed to stimulate lean tissue growth before egg production commences. For hens that are heavier than the breed target or with increased feed intake, increasing protein and amino acids before egg production may increase the risk of over fleshing in modern and heavy breeds.

The use of a pre-lay feed is now optional and in temperate climates with well presented feed made from good quality ingredients then it may be possible to continue use of the Grower diet until the start of lay. However, increased protein and amino acids may be justified in this period for flocks less than 90% of the target body weight at 19 weeks or if fleshing is very poor. In hot climates or where feed ingredient quality is marginal, it may be also advisable to use a pre lay diet.

A smooth transition between grower and breeder diets should be considered during feed formulation. Sudden changes in feed ingredients and feed texture that may reduce feed intake, even transiently, should be avoided. When the difference between grower and breeder ME level is more than 100 Kcal/kg, it may be interesting to consider a "transition" or "pre-lay" diet with a ME level 50 to 100 Kcal higher than in the grower ration (more oil when possible).

The calcium level (1.25-1.40%) is slightly higher compared to the grower feed, to obtain a better mineral balance that helps to avoid kidney damage and litter deterioration.

For the males, in order to prevent excessive weekly weight gains, grower feed may be continued until mixing with the females, or even longer.

Provision of extra vitamins (similar level as in the laying phase) will increase levels in the body before egg production commences and may provide a benefit in early hatchability. The breeder diet must be in use when egg production commences ensuring that the diet is not just in the feed bin but being presented to the birds by at the very latest 5% daily egg production.

### ❖ **Breeder diets**

A feeding program that uses only 1 feed during the entire laying period will be simple and easy to manage. The slightly reduced daily requirements for amino acids are normally compensated by the withdrawal of feed after peak production and therefore the level of amino acids in the feed can be maintained.

Calcium requirements will increase in older birds but this can be satisfied by using additional calcium grit at the breeder farm level.

However, such a single diet has to be designed to meet the peak nutritional requirements of the hens at all times under all conditions (level of production, season, etc). The feed has a high nutrient density to meet the maximum energy and amino-acids requirements needed at peak of lay. This may result in an over-fortified and overpriced feed during the remaining period of the laying cycle.

A two phase feeding program is used by most companies. Typically, the levels of other nutrients, along with protein and amino acids, are lowered as the hen ages or when egg production in the flock declines to a certain percentage. Calcium percentage is increased due to skeletal calcium depletion and poor calcium absorption especially after 50 weeks of age.

In hot conditions or when flocks start early in lay (which proper management should strive to prevent), a specific diet for the onset of lay period may be recommended. In such specific onset of lay diet, increasing

vitamin and mineral premix by 10%, increasing synthetic amino-acids and linoleic acid are additional precautions (see supplements).

### ❖ **Male feed**

The use of specific male rations in the laying period has been shown to be beneficial to the maintenance of male physiological condition and to male fertility. However, the widespread practice of giving males the same feed as females indicates that using a single feed for both sexes is not necessarily harmful to male performance. This practice avoids the extra cost and inconvenience of the separate manufacture, quality control and storage of two feeds. Although we propose an optional male feed in the production period, the essential target can be reached by restricting the feed amount and by following strictly the male bodyweight standard.

Excessive intakes of protein and calcium by males are of greatest concern. A separate male diet with lower nutrient density may be beneficial in situations where males tend to develop excessive breast muscle or where the control of uniformity is problematic.

This specific male diluted feed with a high level of insoluble fiber, lower protein and calcium content will help male behavior towards females, favours uniformity, male health and activity.

Poly-unsaturated oil and anti-oxydant such as vitamin E and selenium are expensive. However, as PUFA and anti-oxydant has several biological functions impacting the reproductive systems and sperm quality (see Antioxidant effects in egg yolks, spermatozoa and embryo), supplementary levels are beneficial and not too expensive when used in male feed only.

## FREQUENTLY ASKED QUESTIONS

### ❖ “Hot climate” specific feeding?

- 1. Ensure coarse & homogenous feed structure with coarse mash or perhaps provide feed as crumbles or pellet, which is more attractive. Birds don't like powdery and dusty feed especially in hot conditions.
- 2. When energy and feed intake decreases, it is important to increase the nutrient density of feed especially amino acids levels such as lysine and methionine. This is to maintain daily nutrient intake. However do not automatically increase crude protein but prefer higher inclusion of synthetic amino acids (see optional onset of lay feed in Hubbard broiler breeder supplements).
- 3. Decrease starch content and increase crude fat content to decrease metabolic heat production.
- 4. Add sodium bicarbonate.
- 5. Vitamin C (ascorbic acid) which plays an important part in skeleton formation and in fighting heat stress may not be synthesised in sufficient quantities by the birds. This vitamin is not considered as essential but in circumstances, like stress or in hot climate, it can be interesting to add it (150 to 300g/tonne). Vitamin C is unstable at high temperatures and must be protected if feed is pelleted or heat-treated.

### ❖ How to prevent and treat fatty liver syndrome in broiler breeders?

Fatty liver syndrome is a metabolic condition characterized by the accumulation of excess fat in the liver and liver hemorrhage. The syndrome is associated with heavy pullets at photo-stimulation and / or excess feed before eggs. The lesions are excess fleshing, large fat pad and a fatty liver and heart.

#### Prevention:

- 1. Evaluate pullet feed distribution and improve pullet uniformity.
- 2. Evaluate hen “feed for production” program at onset of lay by not allowing an excessive positive energy balance in lay (Bodyweight monitoring according to breed target)
- 3. Diet modification: Substituting carbohydrate with supplemental fat, while not increasing the energy content of the dietary. Presumably such modification means that the liver needs to synthesize less fat for yolk.
- 4. Include sodium bicarbonate in the feed

#### Treatment:

- 1. Lower energy diets and/or change in feed allocation management.
- 2. Use of lipotropic agents such as vitamin E, Vitamin B12 and methyl donors (Choline Chloride, Betaine and methionine).
- 3. Use potassium sulfate or carnitine in water.

### ❖ Nutritional factors affecting shell quality?

There are several nutritional factors that impact on eggshell quality. Although calcium and phosphorus are the major factors, several other factors such as vitamin D3 level in feed, vitamin D3 absorption, chloride, electrolyte balance also impact on eggshell quality.

Large particle calcium is retained in the upper digestive tract and dissolves slowly providing a more uniform and sustained release of calcium (Leeson and Summers). Large particle size calcium increases calcium retained and medullary bone (Rao and Roland, 1990).

Calcium metabolism can be affected by the dietary availability of other nutrients such as vitamin D3 and phosphorus.

Phosphorus is not directly required for egg shell formation but it is essential for the replenishment of calcium in the medullary bone. Factors such as dietary phytate phosphorus level or kidney function impairment due to viral complications that decrease phosphorus retention can impact bone and eggshell status.

## NOTES



# Hubbard

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