International Journal of Science, Environment and Technology, Vol. 6, No 6, 2017, 3338 – 3345

ISSN 2278-3687 (O)
2277-663X (P)

Review Article

NUTRITIONAL INFLUENCE ON QUALITY OF EGG AND MEAT IN POULTRY – A REVIEW

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Abstract: Consumers are more and more interested in the health aspects of their food. Therefore, it is essential for egg and meat production to be aware of factors affecting egg and meat quality in poultry. Furthermore, changes in consumption features and the increasing interest of consumers in value for money products have to be considered. Several nutrients have an effect on egg quality and have to be considered to adjust egg quality. Calcium levels, calcium particle size, calcium source, solubility, phosphorus and vitamin D have a direct effect on eggshell quality. Total fat, feed fatty acid profile, choline, folic acid and vitamin B_{12} are also indirectly affecting eggshell quality. Feed distribution management have a strong effect on eggshell quality. Dirty eggs are linked to water consumption, manure structure and water holding capacity. Electrolytes like sodium, potassium, chlorine and the electrolyte balance affect water consumption. Soluble fibre increase water consumption but appropriate enzyme use can decrease this negative effect. Raw material fibres have different water holding capacity and affect proportion of dirty eggs. Egg white composition is linked to water soluble vitamins and some trace elements concentration in feed. Blood spots are linked to vitamin A, vitamin K, ochratoxin and choline concentration. Egg yolk fatty acid composition is strongly influence by feed fatty acid profile. Egg yolk vitamins, trace elements and carotenoids concentration could be adjusted according to the feed concentration. Vitelline membrane fatty acid profile is linked to feed fatty acid profile. Vitelline membrane strength is related to vitamin E concentration mainly in hot weather condition. Nutrients in poultry meat may be divided into classes with positive (improved nutritional value) and negative (probable or real impairment of human health) effects. Examples for nutrients with positive effects are omega-3 fatty acids, conjugated linoleic acid and antioxidants (vitamin E, Se), whereas oxidation products, cholesterol and xenobiotics (e.g. allergenic proteins) are examples for negative ones. Feeding of birds may considerably influence the presence of the mentioned components in tissue. But, we should never forget that optimised management (husbandry conditions, feeding management, catching, transport, unloading, stunning, processing) might be the key to favourable consumption quality.

Introduction

Important components of egg quality are egg shell quality (strength and cleanness), nutritional egg composition, egg size, vitelline membrane strength, etc. Egg quality is not only the feed composition but the way birds are feed. Feeding and management of meat-type

*Received Oct 16, 2017 * Published Dec 2, 2017 * www.ijset.net*

poultry have a great impact on poultry meat quality, both in terms of the nutritional value and potential risks to human health. The greatest risk comes from microbial contamination. Nutrient composition was originally the deciding factor for consumers when choosing poultry meat due to its favourable content of protein, profile of amino acids and fatty acids, low fat content and the scarcity of undesirable components such as purines and cholesterol. Meanwhile, poultry meat has been discovered as an interesting basis for functional foods. Enrichment with favourable nutrients such as long-chain polyunsaturated fatty acids (LC-PUFA) may be easily achieved, although negative effects on the oxidative stability of products have to be expected. Preventing lipid oxidation in the meat has become a great challenge due to minimizing sensory deteriorations and probable harmful effects on human health. In general, undesired substances such as residues, contaminants and xenobiotics are also of major concern in human nutrition. Tenderness of poultry meat is one of the most important sensory features. It is well known that besides genetics management has the greatest influence on tenderness. Primarily, handling of birds in the house, during transport and prior to slaughtering is known to contribute to this abnormality. Also, slaughter technology (stunning, temperature scalding and electro stimulation) may affect consumption characteristics of meat.

Egg Shell Quality

Many nutritional factors have been reported to have a direct and indirect effect on egg shell quality. Direct factors which have a strong effect on egg shell quality and indirect factors which have an effect on egg size and indirectly on egg shell quality.

Direct effect

Calcium deficiency will lead to weaker eggshell with a decrease of eggshell weight and eggshell strength (Bar *et al*., 2002). Calcium particle size is probably the most important parameter which affects eggshell quality. Most of calcium particle below than 2mm are found in the manure, unlike particle above 2mm which are retained in the gizzard (Rao and Rolland, 1989). Calcium particle store in the gizzard will slowly solubilise, delaying the calcium assimilation. Eggshell formation takes 12 to 14 hours and occurs mainly during the night period. Most of the calcium required for eggshell formation is during the night. Bones are the calcium storage organs and more precisely medullary bone. According to the limestone source, solubility may be different. Calcium with a high solubility will be not store for a long time in the gizzard, cancelling the particle size effect (Zhang and Coon, 1997). Phosphorus is an important nutrient for eggshell quality. Phosphorus has a strong

effect on bone strength. Calcium and phosphorus are combined in the hydroxyapatite crystal, storage form of calcium and phosphorus in the bones. If calcium provide from the feed is not enough to support the calcium requirement for the eggshell formation, calcium is mobilize from the bone. But this calcium mobilisation is link with a phosphorus release in the blood. A high phosphorus level in the blood inhibits the calcium mobilisation from the bones.

Vitamin D is necessary for calcium metabolism. Vitamin D deficiency leads to poor eggshell quality, mainly due to a decrease of the eggshell weight. Trace elements like zinc, copper and manganese have shown to have an effect on eggshell quality. They are influencing calcite crystal growth during the eggshell formation and influencing mechanical propriety of eggshell (Mabe *et al.,* 2003).

Indirect effect

Indirect effects could be through egg size management or liver protection effect. Smaller eggs have a better eggshell strength. Diets rich in fat (Antar, 2004), in unsaturated fatty acid like linoleic acid (Grosbas *et al*., 1999), with high levels of protein and amino acids, push up the egg size. Liver is the key organ for egg production. Egg yolk is synthesised in the liver and after transported to the follicles. But liver is also the place where the first vitamin D hydroxylation occurred. Vitamin D needs two hydroxylation before being efficient for calcium transportation. Laying hens suffering of fatty liver produced less eggs and eggs with a bad eggshell quality. All the nutritional factors which help to protect the liver, like choline, folic acid and vitamin B_{12} have also an indirect effect on eggshell quality by preventing the liver ability to convert vitamin D.

Cleanness of egg shell

Eggshell cleanness depends on water consumption, manure structure, manure water holding capacity and interaction between each other. Most of these parameters are linked with nutrients. Water consumption is influenced by electrolytes levels in the diet, mostly sodium, potassium and chlorine, and the balance between all of them. Soluble fibres, like xylan, β-glucan and pectic substances, increase water consumption. These elements increase gut viscosity (Choct, 1997). For fighting against this effect, birds increase water consumption. Use of enzymes (xylanase / βglucanase) has been shown to decrease negative effect of soluble fibre by decreasing water consumption (Engberg, 2004). Fibres, soluble and insoluble, give physical proprieties to excreta by influencing their water holding capacity. Water holding capacity and sticky proprieties of manure is linked and has an impact on dirty eggs. Clays have a high water

holding capacity. According to the type of clay (bentonite / sepiolite /etc.), water holding capacity differs. Clay addition to layer diet decreases dirty eggs percentage (Ouhida, 2000).

Egg White Quality

Egg white composition is strongly linked to the diets used. Feed vitamins concentration, and mainly water soluble vitamins, has been shown to affect vitamin egg white concentration. Riboflavin, folic acid, niacin, thiamine, pyridoxine, panthotenic acid, biotin and vitamin B_{12} are well transferred into the egg white and their concentrations depend on feed concentration (Leeson and Caston , 2003).Trace elements are also well transferred into the egg white. Egg white concentration of iodine (Yalcin, 2001), selenium (Surai and Dvorska, 2001) and copper (Idowu, 2006) are linked to the levels used into the feed. Blood spots found into the egg weight could have some nutritional links. Blood spots are affected by mycotoxins contamination like ochratoxin (Shirley and Tohala, 1983), strong choline deficiency, vitamin A (Bearse *et al.,* 1960) and vitamin K (Berruti and Didrick, 1961).

Egg Yolk Quality

Egg yolk composition strongly reflects feed composition. Egg yolk fatty acid profile is directly linked to the fatty acid profile of diets. Diets rich in omega-3 lead to egg yolk rich in omega-3 and omega-6 fatty acids. Fatty acids found in the egg yolk are linked to the feed fatty acid profile (Leeson *et al.* and Calson, 1990). Feed vitamins concentration affect also egg yolk vitamin composition. Compare to the egg white, where water soluble vitamins are well transferred, for egg yolk due to its composition, it is mainly fat soluble vitamins which are transferred like vitamin A, vitamin E and vitamin D (Leeson and Caston, 2003). The proportion of water soluble vitamins transferred in the egg yolk is higher. Feed trace elements concentration affects directly the egg yolk composition. Good transfer rates have been shown for iodine, copper and selenium. Some differences have been observed according to the trace element source; organic forms have a better transfer than inorganic forms (Surai and Dvorska, 2001, Idowu, 2006). Egg yolk concentration is directly linked with feed concentration. Transfer efficiency is not the same according to carotenoids. Carotenoids bring colour to the egg yolk which is important for consumers, but modulate the anti-oxidant potential of the eggs too.

Vitelline membrane

A strong membrane is useful to separate easily white and yolk. Weak membrane leads to important economical loses because once the membrane is broken, egg yolk is polluting the egg white. Like the egg yolk, vitelline membrane fatty acid profile depends on feed fatty acid profile. Type of fat in the feed used affects fatty acids incorporated in the vitelline membrane (Watkins,

2003). Elasticity and permeability of the membrane are then affected. Saturated fatty acid increases vitelline membrane permeability (Aydin, 2001). Vitamin E has been shown to increase vitelline membrane strength.

POULTRY MEAT QUALITY

Nutrition of birds has a significant impact on poultry meat quality and safety. The dietary energy supply of birds via carbohydrates or fat directly affects fatness of carcasses. Low-fat, carbohydrate-rich diets do not influence sensory characteristics (Moran, 2001), but decrease carcass fat, carcass yield and breast meat yield (Smith *et al*., 2002). Hess (2004) reported that feeding diets with a high nutritive density (high energy, high protein) resulted in an improved carcass yield and decreased fatness, with more distinct responses in males. Reducing dietary fat and increasing crude protein or single amino acids increased the contents of protein and amino acids in carcasses (Waldroup *et al*., 2001). Additional supplementation of Lysine improved feed conversion, carcass yield and breast meat yield, but effects were small and only visible until 42nd day of fattening. It is well known that dietary fatty acid profiles are reflected in tissue fatty acid profiles. Also fatty acid for incorporation in muscle tissues is conjugated linoleic acid (CLA). In humans, CLA acts anticarcinogenic, prohibits atherosclerosis, improves immune function, reduces body fat and improves meat yield (Sirri *et al*., 2003). The observed decrease in mono unsaturated fatty acids (MUFA) contents and increase in saturated fatty acids (SAT) contents was explained by the inhibition of Δ9-desaturase by CLA. Du and Ahn (2002) observed an increase in protein content and a decrease in the fat content of tissue by increasing CLA supplements in diets to 3 per cent. The higher texture values were caused by the significant increase of SATs and of protein in the meat.

As oxidation of long chain poly unsaturated fatty acid (LC-PUFA) is a general problem in enriching poultry meat with n-3 fatty acids, the level of antioxidants (mainly α-tocopherol) has to be increased as well. Cortinas *et al*. (2001) showed that enriching tissue with n-3 LC-PUFA resulted in lower contents of α-tocopherol in tissues, due to the use of vitamin E for prohibiting oxidation. Dietary supplementation of α-tocopherol significantly reduces thiobarbituric reactive substances (TABRS) in tissues (Guo *et al*., 2003) and significantly improves meat functional properties under heat stress. Selenium is an important trace element and acts as a key component of functional Se-proteins as prerequisite of normal health. Selenium can easily be enriched in tissue (3 to 4 times the normal content) and effectively reduces TBARS both in breast and thigh meat.

Different undesirable components are residues (drugs, pesticides, antibiotics, etc.), contaminants (Poly Chlorinated biphenyls (PCB), polybrominated diphenyl ethers (PBDE), mycotoxins etc), xenobiotics (antigens and toxins) with and without proven effects on human health (Yaroshenko *et al*., 2003). Also xenobiotics have gained more interest as allergies have become a severe disease in today's affluent society. But, in contrary to the egg little is known about the allergic potential of meat proteins.

Conclusion

Consumer awareness on heath aspect of their food is increasing day by day. Therefore, poultry producers should aware of the factors affecting both egg and meat quality of the birds. Changes in consumption pattern and increased interest of the consumer in value added animal products needs to be addressed. Egg white composition is linked to water soluble vitamins and some trace elements concentration in feed. Egg yolk fatty acid composition is strongly influence by feed fatty acid profile. Egg yolk vitamins, trace elements and carotenoids concentration could be adjusted according to the feed concentration. Vitelline membrane strength is related to vitamin E concentration mainly in hot weather condition. Optimised management of the birds (husbandry conditions, feeding management, catching, transport, unloading, stunning, processing) might be the key to favourable consumption quality of meat and eggs.

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