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Quality Poultry Meat Production

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양질의 닭고기 생산 방안

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ABSTRACT

Concerns about meat quality, including chicken meat, for the human diet has led to many attempts to manipulate the carcass fat and increase the eating quality. For actual eating quality, the birds must be grown and finished in a manner that results in meat that are tender, succulent and of good flavor, as well as being free from any foreign taint, flavor or safety hazard. Tenderization treatment with high voltage(820V) electrical stimulation and prechill muscle tensioning would improve the tenderness of chicken meat. Proper programs for the withdrawal of feed and water require a team approach for maximizing yield of meat and minimizing carcass contamination. Also feeding of supplemental levels of -tocopherol to poultry with vegetable or fish oils increases the desirable polyunsaturated fatty acid(PUFA) content and stablizes the meat against rancidity and fish off-flavors. The nutritional effects of varying dietary ingredients on broiler carcass fat content are also important. Increasing the levels of energy in the ration increases the carcass fat content, while increasing the protein levels decreases carcass fat content. Supplementation of poultry diets with amino acids such as methionine, lysine, glycine and tryptophan as well as amino acid mixtures can reduce body fat deposition. Normal stress leads to chicken muscular damage resulting in reduced meat quality, but this can be controlled by preslaughter management practices. Feed manufacturers can utilize nutrient modulation to control pale soft exudative(PSE) syndrome.

Finally, the success in poultry meat production depends on the consistent achievement of carefully selected levels of quality. Quality assurance should be the wider function of incorporating quality into the production system and the combination of motivating quality into actions and operations.

(Key words: carcass fat, tenderness, stress, PSE, nutrient modulation)

INTRODUCTION

Worldwide consumption of poultry meat will continue to rise. Prices have not increased significantly over the past 30 years and improvements in productivity will probably ensure that prices will remain relatively low in the future. Shifts of consumption from beef and pork to poultry meat will continue, partially due to this price stability.

In the US, consumption has already reached high levels and limits are in sight according to one report(Boekhuyse, 1994). In Asian countries with high incomes and in Europe further increases in consumption are likely, but growth in Europe will probably be less than the current growth rate of 4 % per year. As a result of less rapid increases in US consumption, annual production growth will decline from 6 % to between 3 and 4 %(Broekhuyse, 1994). It has been predicted that Mexico and the leading producers in Latin America, such as Brazil and Argentina, will continue to have rapid growth. The same forecast of continued growth applies to most Asian countries, except Japan and Hong Kong. China is presently trying to increase poultry meat production to satisfy growing domestic demands(Earnst, 1993).

Individual economic and agricultural policies will be influenced by the competitive edge of exporting countries. Labor costs, the availability of low cost feed of good quality, know-how, infrastructure and environmental requirements will be important factors. Some studies have shown that the US, Brazil, Thailand, France and the Netherlands are the best placed for worldwide competition. The strong competitive position of these countries is determined by extensive availability of feed resources, their high technical know-how, and a stimulating government policy(Nahm, 1996). The high technical know-how results in low cost production and quality poultry meat.

Wherever per capita incomes have risen, demands for high quality protein have also risen. The traditional meat preference are predominate at first, but the technological miracle of poultry quickly comes to the front. People in the industrial countries are not the only ones who need to produce leaner meat, including chicken, while people in other countries will want to consume low fat, the correct types of fat, and the correct fat balance in meat in the 21st century, which is provided through quality poultry meat. In addition to these, a number of quality attributes are associated with poultry meat. Of these, the actual eating quality, the nutritional control of stress, the meat quality of free-range chickens, and quality assurance programs will continue to attract the attention of research workers as well as consumers in a number of countries, which are the aims of this paper.

THE QUALITY OF POULTRY MEAT

1. Actual eating quality

The actual eating quality of poultry meat is the combination of texture, succulence and flavor(Holroyd, 1991; Nahm and Chung, 1995).

Texture is defined as being tender or tough as the two extremes. It is the first quality characteristic to be appraised when placing any food into one's mouth. The sensation of tenderness is a complicated physical process since chewing involves cutting and grinding, as well as squeezing, shearing, and tearing.

Succulence(moisture) is the degree of dryness through the degree of wetness. Dry meat usually is unpalatable but when it is measured for a tenderness score, it is not judged to be so. Succulence is really relative to the amount of fat in the meat. The presence of fat around and particularly within the muscles increases the succulence of the meat.

Flavor is a mixed sensation of aroma and taste by which identification of foods occurs.

This information about how the quality of meat is determined can be used to establish target standards for all involved with the production and processing of chicken. This means that the birds must be grown and finished in a manner that produces meat which is:

- well fleshed and wholesome
- tender, succulent and of good flavor
- blemish free
- free from any foreign taint, flavor or safety hazard.

2. Factors which influence product eating quality

The production and processing of chicken meat involves many factors which influence the eating quality of the end product. We also must realize that we do not fully understand all the factors that can be of significance for influencing quality. Meat quality has been summarized as "the totality of all properties and characteristics of meat that are important to its nutrient value, acceptability, human health and processing"(Jones, 1991).

Reckless disregard of live birds during catching, transport and unloading may cause significant stress, which then results in the birds being presented to the stunner in an unrelaxed state. The end effect of this bird after processing, cooking and being presented on the dinner table is tough meat. (Read the section on effect of stress on meat quality). Equally, fresh birds that are chilled too rapidly can result in toughness of the meat. Raw feed materials that are highly tainted are known to cause foreign flavors in the meat. The wrong litter material can cause a musty taint in chicken, especially when combined with inadequate ventilation and overstocking(Guer, 1991; Coelho, 1994).

The farm covers live production to the point of on-farm catching. The processing plant covers from the in-house catching to the final products. Quality production involves careful planning and using materials and components at every stage in the production and processing that are well documented and proven to improve upon the final eating quality of poultry products(Maurer, 1988).

3. Tenderizing by electrical stimulation

Broiler carcasses must be aged for a minimum of 4 hours to avoid the toughening that accompanies prerigor harvesting of broiler breast meat(Lyon et al., 1992). Because holding carcasses for the aging period is expensive, postmortem electrical stimulation(ES) has been examined as a means to eliminate the toughness associated with early harvesting(1 hour postmortem) of broiler breast fillets(Sams et al., 1989).

While this technique was effective with low voltages(40 to 59V), potentials in the range of 100 to 3000V were said to ensure a more positive effect(Holroyd, 1991). Research indicated that tendon treatment of high voltage(820V) ES and prechill muscle tensioning(MT) would improve the tenderness of early-harvested broiler breast fillets(Birkhold et al., 1992). The increased tenderness was believed to arise from physical disruption of the muscle structure itself. It has also been shown that voltages as low as 100 volts may damage muscle fibers.

While the tenderness of cooked turkey breast has been shown to increase with high or low voltage stimulation, there is little proof that voltage will significantly reduce variations between birds. Although the Danish work(Sosnicki and Wilson, 1992) mentioned that electrical stimulation at various voltages has also little or no effect on the toughness of broiler meat, subsequent work in England showed that the application of low voltage stimulation could actually increase the toughness of chicken breast meat and that the tenderness was not completely resolved by extended "aging". The cause of the problem was probably rigor- or hot-toughening, a phenomenon known for a number of years and which occurs when rapid glycolysis results in rigor taking place while the muscle temperature is above 25 degrees C. The problem may be exacerbated by the fact that stimulation accelerates glycolysis(Honikel et al., 1981).

Much of the research on stimulation has been directed towards determining at which time after slaughter carcasses may be deboned. When chickens are stimulated at low voltage for up to 18 seconds, the tenderness of breast muscles harvested immediately after plucking is increased(Nahm and Chung, 1995). The studies by U. S. workers indicated that in order to be fully effective, low voltage stimulation should be applied within 9 minutes of the birds' slaughter. European studies employing low voltage have confirmed the toughness of stimulated chicken breast meat deboned soon(within 15 minutes) after slaughter, but showed that if a delay was introduced before deboning, the stimulated meat was more tender than that of unstimulated controls. At twenty minutes post mortem, the pH of stimulated muscle is generally 0.3 to 0.4 units lower than controls, but there is no evidence that the ultimate pH values differ. ES(440 V, 2 seconds on and 1 second off for 15 seconds) also reduced muscle pH values (Birkhold and Sam, 1993). This decline in pH is a result of numerous biochemical changes that are caused by the conversion of muscle into meat. One result may be that the storage carbohydrate, glycogen, is degraded as the tissues attempt to maintain the muscle cell's energy supply of adenosine triphosphate(ATP). Under the anaerobic conditions in the meat, the final product of glycolysis is lactic acid, which is responsible for the low pH value of the meat. A rapid fall in muscle pH results in a pale meat which readily loses water. Dry meat is often unpalatable(Xiong et al., 1993).

4. Color problems and their elimination in poultry meat

The presence of raw-like, color defects in fully cooked poultry meat have been well documented(Trout, 1989). Such defects have important economic implications because consumers believe that this meat is undercooked and, therefore, unsafe. Although many factors have been reported to be associated with color defects in poultry, no cause-and-effect relationships have been conclusively shown.

The poultry personnel needs to control a number of variables to be free from color defects in chicken meat.

a. Blood vessels can rupture resulting in bruises if there is improper grasping of shanks, excessive wing flapping, and incorrect stunning prior to slaughter(Gurer, 1991).
b. Aflatoxins in the feed may cause capillaries to become fragile and result in pinpoint (petechial) hemorrhages in the breast and large muscle hemorrhages at slaughter

(Jones, 1991).

c. Adenoviruses may cause hemorrhagic enteritis(Holroyd, 1991).

d. Very warm or fluctuating temperatures cause birds to bruise easily. When nights are cold and days are warm, there is an increase in bloody thigh and wing joints (Kranen et al., 1996).

e. Proper stunning immobilizes the bird and stimulates the heart beat to help bleed-out.

Overstunning results in engorged blood vessels that the picker will burst, resulting in a red bruise-like appearance(Kirton et al., 1981).

f. Pinkish red carcasses may result from incomplete or improper bleeding during processing (Coelho, 1994).

g. Nitrates and nitrites in chicken feed increase the redness of cooked chicken meat. Chicken meat may also absorb enough nitrate or nitrite from the chill water or ice to produce pink flesh. Spices and vegetable ingredients used in processed products are also sources of nitrates(Holroyd, 1991).

h. Pinkness of the meat may also be caused by ammonia leakage from refrigeration or nitric oxide contamination of the gases used for freezing(Cornforth et al., 1991).

i. Irradiation can cause a red color in irradiated meat that is stored at elevated temperatures in the absence of oxygen (Scheele, 1992).

j. A pinkish color may also result from the improper cooking of chicken meat. This is more prevalent in thin-skinned birds. One possible reason for pink discoloration in cooked turkey meat is reduced sensitivity of myoglobin to heat denaturation due to further processing before completion of the rigor process(Young et al., 1996)

k. Salt and seasonings added to a tumbling solution may increase the pink color. Sodium chloride increases the heat stability of cytochrome c, which is one of the pigments responsible for unwanted pinkness(Kijowski and Niewiarowicz, 1978a; Acton et al., 1983).

Poultry producers must follow good management practices such as feeding quality feed and water. They need to be careful when catching, crating, handling, hanging and processing birds, and the use of proper techniques for stunning, scalding and picking is important at the processing plant. The water used in the plant must be free of metals and nitrates. Chicken products must be formulated with high quality ingredients, followed with appropriate manufacturing processes aiming for mildly oxidizing conditions in some products during processing. People in the poultry industry must make sure that all equipment is clean and functioning properly, and then products are cooked to doneness.

5. Effect of feed and water withdrawal on meat quality

Withdrawal of feed and water prior to slaughter is important for maximizing yield, minimizing carcass contamination and improving line speeds, grower payments and product shelf-life. Proper programs for the withdrawal of feed and water require a team approach and good communication between live production and processing.

6. Carcass yield

For maximum yield, broilers should be processed within four hours of feed and water withdrawal(FWW)(Denton, 1985). This report suggested that the birds must be delivered plantside and processed as soon as possible after implementation of FWW. The time of FWW includes the time birds are off feed and water in the broiler house, during transportation to the plant and while in the plant's holding area before slaughter.

Live shrinkage of the birds increases with time and was significantly increased with each increase interval in hot and thermo-neutral weather. Intervals studied were withdrawal time, hauling and simultaneous withdrawal of both feed and water or feed only with an additional two hours of water. Hauling of the birds caused greater live shrinkage, as did simultaneous withdrawal of feed and water. Carcass yield has a negative correlation with live shrinkage. Greater shrink levels are reported in males and greater yield losses occur in old birds (Denton, 1985).

7. Contamination

The percent of fecal contamination of the meat declines after 6 hours through 8, 10 and 12 hours, and increases until the highest levels are obtained at 24 hours after FWW. If the physical condition of the fecal material is moist initially, it becomes firm between 8 and 10 hours following feed withdrawal, and then becomes loose and watery with withdrawal periods exceeding 12 hours(Farr, 1989).

8. Microbial quality

Salmonella is the major problem for microbial contamination, and the ceca is the primary site of the organism. Catching and cooping the birds results in stress which stops immediately the absorption of the remaining intestinal contents for several hours. The remaining intestinal contents are lost through defecation, dehydration then begins, and moisture is then reabsorbed from the body tissue into the large intestine. This process occurs generally 8 to 10 hours after withdrawal. As the withdrawal time increases, the large intestine becomes extended and the contents of the cecal pouches can be seen in the large intestine. This cecal material is higher in microbial counts, and has greater potential to contain pathogens. The gizzard also becomes more difficult to peel and the gall sack enlarges and increases the likelihood to rupture. These points are all negative for carcass yield and microbial quality(Nulder, 1993).

There are the two major sources which are the bacterial present in the gastrointestinal tract (internal) and those on feathers and skin (external). For instance, at the time of processing, salmonella spp. occur mostly externally and campylobacter spp. occur internally (Bailey and Cox, 1991). Recently Musaroue et al.(1997) reported that cecal levels of Gram-negative enterics were significantly higher for plugged birds, but there was not a significant differences between levels of cecal campylobacter spp. between treatment groups. They concluded that intestinal carriage of both campylobacters and Gram-negative enteric bacteria appears to influence the microbial quality of the carcass during processing.

9. Feed withdrawal programs(FWP)

It is essential to adhere to the feed withdrawal program. Insure that feed withdrawal procedures are being carried out as planned by establishing a strong communication network among the processing plant, the live-haul, and the grow-out personnel. Also record and analyze the actual feed withdrawal time, arrival time of the catching crew, total live-haul and yard-time and actual plant containment-reprocessing to develop the FWW program appropriate for that operation(Denton, 1985; Bilgili, 1995).

10. The utilization of antioxidants for quality poultry meats

The British Nutrition Foundation(1992) has suggested that an increased and balanced intake of omega-6 and omega-3 polyunsaturated fatty acids(PUFA) may reduce blood triglycerides, reduce hypertension, coronary heart disease and cancer, and ameliorate inflammatory diseases such as psoriasis and rheumatoid arthritis. Increasing intakes of such PUFAs as linolenic acid(18:3 omega-3), eicosapentaenoic(20:5 omega-3, EPA), docosahexaenoic acid(22:6 omega-3, DHA) and docosapentaenoic acid(22:5 omega-3) involves increased intake of vegetables and fish oils (equivalent to 2 to 3 portions of salmon a week or three portions of cod a day). Intake of these fatty acids through other sources of foodstuffs such as poultry would be more desirable.

Increasing the PUFA content of meat makes it more susceptible to oxidation. Uncontrolled lipid peroxidation causes inflammation and oxidative damage, leading to free radical formation in tissues is thought to contribute to life-threatening diseases in humans. Cardiovascular disease, stroke and certain types of cancers are considered to involve free radicals in their development(Ames, 1983, 1989). Free radicals attack DNA, proteins and PUFA found in the cell membrance. Attacks on the DNA are thought to result in mutagenesis and carcinogenesis. Although the body maintains enzyme systems and levels of natural antioxidants to terminate free radical formation, components of these enzymes and the antioxidants must be supplied from the diet. Feeding of supplemental levels of -tocopherol to poultry with vegetable or fish oils increases the desirable PUFA content and stabilizes the meat against rancidity and fishy off-flavors.

Post mortem lipid oxidation(rancidity)is one of the causes of deterioration of the meat product quality, affecting the flavor, color, nutritive value and safety. Rancidity occurs mainly in the highly unsaturated, cell membrance phospholipids as an autocatalytic free-radical-mediated process. While it is recommended that more mono- and PUFA be consumed, these are more susceptible to oxidation than unsaturated fat (Dawson et al., 1987; Birkhold and Sams, 1993).

Poultry meat contains more PUFA than red meat and is hence more susceptible to oxidation(Richardson, 1994). Vitamin E present in animal tissues in the form of -tocopherol is associated with the membranes and can terminate peroxidation chain reactions by mopping-up free radicals. Use of vitamin E as a natural antioxidant administered through the feed has received considerable research interest.

Cooking and adding salt can serve as a prooxidant. Addition of synthetic antioxidants can reduce oxidation, but it is more difficult to get them to the specific sites of oxidation and they are less acceptable to the consumer than addition of the natural antioxidants such as -tocopherol to the diet. -Tocopherol cannot fully protect against salt induced oxidation, but it reduces it well below that of non-supplemented meats.

Rancid oils, which may have been heat damaged(oxidized) during production, depress chick growth and reduce meat stability for long-term storage. They seem to reduce the availability of dietary -tocopherol and therefore reduce tissue concentrations. Supplementation of oxidized oil diets with -tocopherol acetate(200mg/kg feed) significantly increases growth and the subsequent oxidative stability of the meat(Richardson, 1994). It has also been observed that oxidized sunflower oil causes a significant reduction in broiler body and carcass weights, whereas alpha-tocopherol and BHA or BHT dietary supplementation improved growth(Lin et al., 1989). Although antioxidants control tissue lipid oxidation effectively(Lin et al., 1989; Asghar et al., 1990), information about their impact on broiler performance, carcass yield, and fatty acid composition of the lipid classes of white and dark edible broiler meat are limited, complicting, and confined primarily to total lipid fatty acid composition; particularly when the antioxidants are introduced into the muscle through the diet(Ajuyah et al., 1993). Similarly, body weight gain and feed intake of turkeys increased with dietary beta-carotene supplementation(Stevens and Salmon, 1989). It has also been reported that the presence or absence of antioxidants(125μg BHT/g fat) influenced the fatty acid composition and distribution in the phosphatidyl ethanolamine fraction of white meat(Ajuyah et al., 1993). The white meat from birds fed diets containing antioxidants had elevated levels of C18:3n3, C20:5n3, C22:5n3 and C22:6n3 and reduced levels of total saturates and n-6 : n-3 as opposed to the 15% full-fat flax seed (FFS) and corn-soybean meal groups, which means it is more desirable to feed the birds the FFS diet with antioxidant.

Vitamin E levels in the meat make only very small contributions to the daily human intake, but its protective effect in meat is very important. Products of oxidative rancidity produce unpleasant flavors and some of the dietary lipid and cholesterol oxidation compounds have been shown to increase coronary heart disease, strokes and a number of other diseases(Sheehy et al., 1993).

Tocopherol is fat soluble and it concentrates in cell membranes close to the phosholipids which it protect. Feed containing 15 to 20mg tocopherol acetate/kg feed is sufficient to overcome problems such as low egg hatchability, encephalomalacia and exudative diathesis. In order to affect lipid stability higher levels(in the form of -tocopherol acetate) should be fed. An effective dietary concentration of vitamin E is in the range of 100 to 200 mg alpha-tocopherol acetate/kg of feed(Sheehy et al., 1993; Richardson, 1994). These values need to be redefined as new research results become available on how vitamin E affects growth, health and overall metabolism.

Vitamin E has a slow turnover rate in muscle and so it requires several weeks to accumulate. Maximum tissue contents of vitamin E can be obtained during the growth period with 200 to 250mg tocopherol acetate/kg feed and these are obtained in a minimum of five weeks of feeding. Turkeys have a lower accumulating ability so they must be fed higher amounts for longer time. When chickens and turkeys were fed equivalent amounts of tocopherol acetate, the turkey liver and breast muscle had one-fifth and one-third, respectively, of the amount in chicken tissues(Sheehy et al., 1991; Bartov and Kanner, 1996).

Interest has arisen in food derived from plants because of their concentrations of phytochemicals that may reduce lipid peroxidation and protect the body from free radical damage. Phytochemicals are abundant in many plants but research has concentrated on soybeans, garlic, cabbage, ginger, licorice, celery, carrots and flax. The plant phytochemicals include: carotenoids, tocopherols, phenolic and flavonoids. Studies directed to enrich poultry meat and eggs with antioxidant vitamins and phytochemicals could provide additional opportunitics for developing designer foods(Caragay, 1992).

MANIPULATING THE CARCASS FAT OF BROILERS

The quantity of body fat deposited varies within wide limits, from as little as 9.5% of live weight to as much as 23% in broilers at processing age. The site of fat deposition depends on the amount of fat, with the abdominal cavity being the predominant storage area of excess fat. Broiler fat can be manipulated nutritionally by decreasing nutrient densities or increasing protein levels. Fat content can also be manipulated through genetic selection. Genetic methods are complicated and expensive, however, it has been shown that the nutritional program results in increased production costs.

1. Fat synthesis and lipid composition of chicken meat

In poultry, fat is synthesized in the liver primarily and it is transported to the adipose tissue in the form of very low density lipoproteins (VLDL). High deposition of adipose tissue is associated with high circulating levels of VLDL and high rates of hepatic lipogenesis. Significant correlations exist between body fat, hepatic activities of the lipogenic enzymes such as ATP-citrate lyase or malate dehydrogenase and plasma VLDL concentrations(Whitehead, 1985).

The total lipid content of white meat is approximately half of dark meat, and skin contains the highest proportion of lipid (Ratnayake et al., 1989). The total fat content of light muscle with skin has therefore been quoted as approximately 10 times higher(11.1g/100g muscle) than muscle without skin (Decker and Cantor, 1992). The triacylglycerol content of white meat was virtually half that of dark meat. In contrast, phospholipid and cholesterol were appreciably higher in white than in dark meat. In both muscle types, free fatty acids and diacylglycerols were present in only trace amounts. In contrast to the muscle tissues, the skin showed an almost total preponderance of triacylglycerol with traces of diacylglycerol, free fatty acid and phospholipid.

The principle fatty acid in all tissues has been found to be oleic acid, followed by palmitic and linoleic acids(Ratnayake et al., 1989). The levels of total saturates, total monosaturates and total polyunsaturates in the muscle tissues assumed an approximate 33% distribution of each. Monounsaturated fatty acids were higher in white meat. In contrast, total polyunsaturated fatty acids were higher in white meat. This difference is a reflection of the higher levels of both the total n-6 and total n-3 polyunsaturates in the white muscle. Among the long chain polyunsaturated fatty acids(both n-6 and n-3), arachidonic acid was the most prominent. In comparison with the muscle tissues, the skin contained much higher levels of oleic and palmitoleic acids, which substituted for stearic acid and long chain polyunsaturated fatty acids.

2. Nutritional factors that influence fat content

Some well known non-nutritional factors that influence body fat are age, sex and ambient temperature. Since a report on the nutritional effects of varying dietary ingredients on broiler carcass fat were described(Fraps, 1943), numerous studies have reported that as the dietary calorie/protein(C/P) ratio is widened, carcass lipids increase. This effect appears to be independent of calorie source since fat substitution for carbohydrate, at constant CPR, has little effect on carcass fat.

3. Energy and protein requirements

Research studies have shown that increasing the levels of energy as well as protein results in improved growth rates and feed conversion. Increasing the levels of energy increases the carcass fat content, while increasing protein levels decreases carcass fat content.

A high energy density diet(H-H) throughout the growing period has been shown to result in a greater overall carcass meat yield, but the rate of gain was lower than when a low energy density phase was followed in the later stages of growth by a high energy density diet(Walker et al., 1995). The growth of fat was always greater with the H-H regime which contributes to the heavier carcass and greater return in a "whole bird market" irrespective of carcass composition. Furthermore, a narrow protein/energy ratio fed throughout the life of the bird compared with a widening ratio as the bird aged resulted in the greatest breast meat yield(665g compared with 570g) and also the greatest percentage breast meat yield(22.9% versus 21.7%). Results obtained from experiments to test the effects of different methionine plus cystine levels(0.60~0.95% of the diet) at two different levels of protein concentrations offered to Ross broiler males from 15 to 35 days indicated that increasing dietary protein by 3 to 4 percentage points had no effect on breast meat yield, and the breast meat proportion of the carcass was determined by the dietary content of sulfur amino acids(Degussa, 1995). These examples show that the distribution of protein as muscle in the carcass of the bird is sensitive to diet composition and therefore the nutrition of the bird must be adjusted to account for target meat production and not only for the growth rate or feed efficiency.

Energetic efficiency of ME use for tissue gain is dependent on many variables. The efficiency varies with the substrate source for lipogenesis at approximately 75, 84 and 61% for carbohydrates, fats and protein, respectively(Hoffman and Shiemann, 1971). Utilization of protein for tissue energy gain is dependent upon the biological value of the protein source and should not be constant(De Groote, 1973). The energetic efficiency of the bird for any substrate is the net result of partitioning the energy into maintenance needs as well as protein and fat accumulation.

4. Amino acid supplementation

Supplementation of poultry diets with amino acids such as methionine, lysine, glycine, tryptophan and amino acid mixtures can reduce body fat deposition(Takahashi et al., 1994). In one series of experiments, increasing the total sulphur amino acid content(TSAA) from 0.7% to 0.95% of the diet reduced the abdominal fat content of the carcass from 4.00% to 3.30%. In one review where different experiments were combined, the relative fattiness could be reduced by 28% and was minimum at a dietary TSAA content of 0.85%(Fisher, 1994). Reducing the crude protein content of the diet from 23% to 19.6% in young chicks reduced the level of response obtained from the TSAA supplementation(Takahashi et al., 1994).

The TSAA requirement has been found to be higher for maximum efficiency of feed utilization and breast meat yield than for obtaining maximum weight gain(Schutte and Pack, 1995). Based on feed conversion efficiency and breast meat yields, the requirements for TSAA was estimated to be at least 0.88% for the age period of 14 to 34 or 38 days. It was calculated that the estimated TSAA requirement was equivalent to approximately 0.75% apparent digestible SAA or 0.78% true digestible SAA.

These research results prove that level and balance of essential amino acids(EAA) can have a significant effect of feed intake, thereby influencing weight gain, carcass composition of fat and the protein content of the edible meat (Summers et al., 1992).

Carcass quality of broilers is adversely affected by inadequate dietary levels of lysine in the feeds. In one trial, broilers were provided feeds formulated to be submarginal in lysine(0.85%), marginal(0.95%) and adequate(1.05%) dietary levels(Moran, 1991). As the dietary lysine levels increased, the percent fat in the skin and thigh meat decreased. Fat in the breast meat was low, however, and remained part unchanged. The breast was most affected, with increasing meat as the lysine levels were increased.

5. Dietary fat

Carcass fattiness does not increase with an increasing content of dietary fat within normal nutritional limits at constant ME(Griffiths et al., 1977). A wide body of evidence suggests that adding fat to a diet, without changing the total dietary energy content, has little influence on the amount of body fat deposited(Deaton et al., 1981), because the higher fat content of a diet depresses lipogenesis in the bird. Although the dietary fat itself does not influence body fat content, the use of fat in diets is often associated with fatter birds. This is because diets that include higher fat levels are also diets of higher nutrient density.

The effects of dietary PUFA on the regulation of lipid metabolism and the level and composition of body fat appears to be diverse. Vegetable oils containing high levels of PUFA, such as soybean oil, are known to inhibit lipogenesis (Donaldson, 1985). It has been reported that soybean oil supplementation depressed body fat in broiler chickens selected divergently for high or low abdominal adipose tissue(AAT) content (Keren-Zvi et al., 1990). In terms of dietary fat supplementation, this work contradicts that of others who have reported that body fat increases with the amount of dietary tallow which is composed essentially of saturated fatty acids(Deaton et al., 1981). The difficulties in interpreting such result are comprehensive.

The fatty acid(FA) composition is determined largely by the relative importance of hepatic lipogenesis and exogenous dietary fat as sources of FA deposits in the body. The supplementation of dietary fat influences both of these parameters such that they may act in the same or in opposite directions depending on the composition of the diet. Endogenous fat, measured in chickens fed a fat-free diet, is composed mainly of FA C16:0 and C18:1 with smaller amounts of C16:1 and C18:0(Bottino et al., 1970). FA C18:2 and C18:3 are essential and not synthesized but rather introduced into the tissues through dietary fat. The addition of soybean oil has been shown to significantly increase the concentrations of C18:2 and C18:3 in carcass fat(Nir et al., 1988). The biochemical pathway of FA biosynthesis may be influenced by the availability of dietary FA.

It may be hypothesized that increased PUFA input plays a role in FA biosynthesis, reducing body fat deposition in the chicken. The FA composition of body or adipose tissue fat does not necessarily express the utilization rate of dietary FA, because unlike PUFA, saturated and monosaturated FA are synthesized in the body or incorporated from the diet. A mixture of vegetables oils(soybean to sunflower oil; 1 : 1, vol/vol) and beef tallow were used to supplement the broiler male chick diet to provided different PUFA(grams per 100g dietary fat) (Pinchasov and Nir, 1992). This research showed that a significant linear effect was observed between PUFA and feed utilization. FA profiles in abdominal adipose tissue(AAT) and total body fat were correlated to dietary PUFA content, with the main effect of higher PUFA being a reduction in monoenoic FA (C16:1 and C18:1) and an increase in C18:2. The effect of dietary PUFA on the saturated FA(C16:0 and C18:0) was small and not statistically significant. Increased dietary PUFA modified FA composition such that C18:2, rather than C18:1 became the dominant FA in AAT, showing greater changes in FA composition of AAT rather than the whole carcass.

Selection of specific strains or lines of animals have proven valuable in evaluating the effects of nutrients on metabolism and physiology. Chickens from the low-weight(LW) line had greater In Vivo lipogenic capacities compared with those from the high-weight(HW) line (Calabotta et al., 1983). A difference in hepatic FA metabolism was found between the HW and LW lines than was unaffected by dietary n-6 or n-3 PUFA(Phetteplace and Watkins, 1992). The fed soybean oil, rich in n-6 or 50g/kg of basal diet each to female chicks in two genetic lines (LW and HW), showing that concentrations of C18:1 FA isomers and total monosaturates were highest in liver and heart tissues of HW chickens. Feeding menhaden oil enriched the plasma, liver and heart with n-3 PUFA in both genetic lines.

6. Salt and water

The carcass fat content is inversely related to the water content. This correlation has led to suggestions that increasing the water consumption by broilers may inhibit fat deposition. Experiments have shown that adding salt in higher than normal amounts to the diet, or to the drinking water, is associated with decreased body fat contents(Lightsey et al., 1983).

7. Feed restriction

One method of reducing body fattiness that has been studied is quantitative food restriction. A severe restriction(less than 75% of normal intake) was necessary to depress body fat content between two and four weeks of age but there was also depressed growth(Nitsan and Petihi, 1984). Other studies have examined the effect of food restriction during the final week and have shown similar responses, depressed body fat content but also a depression in non-fat body weight(Arafa et al., 1983). Therefore, there needs to be a commercial advantage for lean carcasses in order for this technique to be economical.

8. Fatty acid composition in the diet

Ingested fatty acids(FA) are subjected to modification by chain elongation and desaturation. FA deposited in the body are a combination of synthesized and partially modified dietary FA. When the fat content of the diet is increased, its contribution to fat deposition increases and the overall composition of body fat more closely resembles that of the diet. The FA composition of adipose tissue of various areas of the body are quite similar. Palmitic and oleic acids are the main long-chain FA synthesized during lipogenesis(Whitehead, 1985).

Scientists have observed that there was a considerable dietary effect on FA composition of genetically lean or fat broilers fed diets containing low(25g/kg) or high(80g/kg, provided partially by maize oil) total fat contents(Bartov and Borenstein, 1976). When diets contained high concentration of linoleic acid, as with the diet containing 150g maize oil/kg, the proportions of linoleic acid in adipose tissue can increase. In contrast, the addition of tallow to a maize/soybean diet decreased the proportion of linoleic acid and increased the proportion of oleic acid deposited in adipose tissue.

Tissue FA compositions can interact with the processing of carcasses. High proportions of unsaturated FA accelerates the liquification of subcutaneous and other fat depots during processing. This is disadvantageous, especially with "Oily Bird Syndrome". The tissue composition is not the only cause of this syndrome, since environmental temperature during rearing as well as other unknown factors appear to be involved(Hofman, 1994; Pesti, 1994).

9. Minerals, vitamins and drugs

Minerals such as sodium, potassium, chlorine, calcium, phosphorus and magnesium can affect carcass quality indirectly by influencing the occurrence of leg problems or water intake. These factors will influence carcass quality via the effects on hockburn, etc. and litter condition. Deficiencies or imbalances of certain vitamins(e. g., vitamin A and D, nicotinic acid, panthothenic acid, pyridoxine, biotin, folic acid and choline) and trace elements(e.g. manganese and zinc) will also affect the incidence of leg problems(Combs, Jr., 1982, Wilson, 1987).

Certain anticoccidial drugs(the monovalent ionophores) and growth promoters may reduce water intake and hence improve litter conditions. The ionophores generally may help to control the incidence of Clostridia scours and the growth promoters also have a general antibacterial effect. The effects on litter condition and carcass quality may be particularly relevant on sites with a high bacterial challenge and if long withdrawal periods are used. One chemical coccidiostat(robenidine) may cause taint if fed without a withdrawal period. It has also been reported recently than feeding dietary garlic(1.4, 3.0 or 4.5% of a commercial garlic powder to the corn-soy control diet) and/or copper(63 or 180mg/kg copper) for 21 days reduced dietary cholesterol levels of broiler meat without altering growth of the chickens or feed efficiency(Sosnicki and Wilson, 1991; Golden and Ramdath, 1993).

10. Environmental temperature

Bird maintenance energy needs are lower at higher temperatures and hence more of the feed consumed is available for fat deposition(Bary, 1982). The calculated relationship between temperature and fat deposition is 1.9g fat/kg body weight per degree celsius.

Heat-exposed birds, like mammals, decrease feed intake in order to reduce metabolic heat production and maintain homeothermy, resulting in slower growth. Enhanced fatness has been observed in heat-exposed chickens(Geraert et al., 1996). Decreased growth and an enhanced fatness in heat-exposed chicken could seem contradictory.

There has also been a report that unsaturated fatty acids as a percentage of total fatty acids were decreased, expecially oleic(C18:1) and linoleic(C18:2) acids in fat tissues, although saturated fatty acid proportions, particularly palmitic acid(C16:0), were increased in heat-exposed birds(Baziz et al., 1996). Under ad libitum feeding conditions, these scientists proved that heat exposure significantly decreased the unsaturated to saturated fatty acid ratio in the abdominal and subcutaneous fat tissues, but not in intermuscular and intramuscular fats.

11. Genetic manipulation

The faster growth seen in certain birds is influenced by an ability to increase nuclei in their muscle cells, which produce more RNA and more muscle protein(Marple et al., 1982). Faster growing birds are more physiologically mature at a younger age and contain higher proportions of body fat. In one study when chicks from both broiler and Leghorn groups were 42 g at the start of the study, the broiler chicks weighed twice as much as the Leghorns at eight weeks of age. After week two, the broiler chicks consistently had higher percentages of carcass fat than the Leghorns and consistently greater length, volume and weight of wing muscles(Marple et al., 1982). As a result of greater DNA and RNA concentrations, broiler chicks are able to synthesize more muscle protein per day, and this results in their faster growth. The dietary fat also had little effect on the total body lipid contents of the two lines. The proportion of abdominal fat was slightly higher in birds fed the low-fat diet, but the difference was not statistically significant(Whitehead and Griffin, 1984). Chickens from the lean line have much lower percentages of fatty tissue but their meat is just as flavorful because the amount of fat within the meaty tissues has not changed.

A genetic and breeding approach may be a more feasible long-term solution for reducing body fat. A selection program to reduce abdominal fat deposition and increase meat in broilers was undertaken(Lavis, 1989). This study showed that the response to the first cycle of selection was highly significant; percentage of abdominal fat of the high fat(HF) line exceeded that of the low fat(LF) line by about one-half (51 to 57%) and one third(33 to 38%) in the White Rock and Cornish stocks, respectively. Response of abdominal fat during the first cycle was similar in males and females, and there was practically no correlated response in body weight among lines. Also, the relative distribution of percentage abdominal fat within lines, as well as the differences between line means, were similar in both stocks. The proportion of the lean parts, however, was higher in the low fat line than in the high fat line. Differences between the lines in relative weight of the valuable lean part(thighs, drumsticks and breast) were 1.8 times higher than differences in abdominal fat. As can be seen from this study, a certain degree of genetic selection can provide a leaner product.

Broiler meat is composed of two major muscle types, i. e., light(breast) and dark(thigh and leg) muscles. The two types of muscle differ in biochemical properties, sensory characteristic(e. g., flavor and palatability), and economical value and marketability. These differences exist between light and dark muscles of broilers as related to genetic strains. There were also significant differences found among strains in chemical composition, pH and protein extractability for both breast and thigh muscles(Xiong et al., 1993). The correlation between percentage protein and fat was positive in the breast and negative in the thigh muscle. However, no significant correlations were observed between the chemical constituents of breast muscle with respective constituents of the thigh muscle.

IMPROVING MEAT QUALITY BY NUTRITIONAL CONTROL OF STRESS

Scientists have suggested that poultry breast muscle can exhibit the same pale soft exudative

(PSE) characteristics as seen in pork(Van Hoof, 1979 and Barbut, 1993). Normal stress leads to muscular damage in these animals. They also may hyperventilate, develop tachycardia or cyanosis, or develop muscular paralysis(Wilson, 1990).

1. Effect of stress on the inside of muscle

Disruption of cell membranes due to various stresser from the environment, feed, management practices or other factors, leads to erythrolysis and increased levels of plasma pyruvate and creatinine kinase. Stressed birds also have increased endogenous mitochondrial camodulium and fatty acid concentrations, elevated phospholipase A_2 activity and higher mitochondrial and sarcoplasmic Ca^{2+} concentrations(Cheah et al., 1986). The phospholipase A_2 enzyme causes an increase of Ca^{2+} in the muscle. The sarcoplasmic reticulum releases additional Ca^{2+} in response to mitochondrial release of Ca^{2+} and oxidized phospholipids(Cheah and Cheah, 1985). The increased sarcoplasmic Ca^{2+} is responsible for increased glycolysis through the activation of myofibrillar ATPase and phosphorylase kinase(Scopes, 1974). At this time, glycolytic activity results in the depletion of adenosine triphosphate(ATP) and accumulation of lactate in the sarcoplasm reticulum loses its ability to control cytosolic calcium concentration, resulting in up to a 10-fold Ca^{2+} concentration increase(Goll et al., 1983). This increase activates myosin adenosine triphosphates, resulting in contraction of the muscle(rigor mortis).

Because rigor develops much faster in avian than in mammalian muscle(Sams and Janky, 1991), broiler carcasses are usually in the early stages of rigor when they emerge from the chiller and the muscles are rigid, firm and inextensible.

There are two main theories that explain the tenderigation process. The first suggests that the increased ionic strength of the sarcoplasm due to the post-mortem influx of calcium ions solubilizes myofibrillar structaral elements, resulting in their degradation(Ouali, 1990). The second theory supports the notion that endogenous calcium-activated proteinases(calpains) are activated by the reflux of calcium ions and that they subsequently proteolyze some of the structural elements, leading to degradation of the myofibrillar matrix(Koohmaraie, 1992). There is no preponderance of evidence to support either view, but results indicate that proteolysis is, at least in part, reponsible for post-mortem tenderization(Whipple and Koohmaraie, 1991; Kendall et al., 1993). Several attempts have been made to take advantage of the ability of the calpains to hasten tenderization of mammalian muscle tissue(Koohmaraie et al., 1989, 1990). Recently, Young and Lyon(1997) reported that the treatments had no effect on meat pH either before or after cooking, but a calcium concentration increased, the normal post-mortem conversion of adenosine triphosphate(ATP) to inosine monophosphate(IMP) increased, according to the IMP : ATP ratios (R-values). They found that calcium treatment at all levels tested improved meat tenderness, but both marinade absorption and cooking losses increased as the calcium concentration in the marinades increased.

Malignant hyperthermia is the rapid rise in body temperature that occurs during periods of stress when glycolysis acceletates, blood pH decreases, lactate and pCO2 concentrations rise and oxygen saturation decreases(Duthie et al., 1987). One study (Judge et al., 1972) concluded that the body temperature increases and acidosis results from heat and lactate produced by muscular anaerobic glycolysis.

2. Impact of stress on meat quality

Meat quality may be affected by preslaughter management practices such as catching, crating, loading and transportation. The increased production and utilization of epinephrine and glucocorticosteroid in animals exposed to antimortem stressors can affect post mortem metabolism and meat quality. Dark, firm and dry meat(DFD) in beef and PSE in pork are two commonly encountered problems in the meat industry. Preslaughter stress could be important factor in causing these conditions(Lawrie, 1966).

On the basis of post-mortem pH declines, PSE and DFD have been identified in chicken breast muscle(Kijowski and Niewiarowicz, 1978b). This condition causes problems with the texture, cohesiveness, color, and juiciness of processed turkey and broilder breast meat. This PSE like condition, which has been observed to affect as much as 40% of market tom flocks, is thought to be related to anaerobic muscle metabolism and growth alterations in the musculoskeletal system(Cherel et al., 1992). Histopathological observations have indicated that PSE-like breast meat of turkey has muscle fibrils rupturing out of the muscle fiber bundles, which is unlike PSE in pork meat(Sosnicki and Wilson, 1992). In turkeys, PSE seems to be related to poor cell membrance or collagen connective tissue integrity. Like pork PSE, this PSE-like problem in turkey breast meat is likely from stress susceptible turkeys.

3. The possible modulation of nutrients in PSE

Feed manufacturers may be able to use nutrient modulation to control PSE, even though it is genetically induced. Mineral and vitamin recommendations for controlling PSE are by Coelho(1994) for turkeys and broilers. The recommendation of each micronutrient for turkeys at 3 weeks preslaughter are: <75mg Cu/kg, >50mg Fe/kg, >1000mg Mg/kg, >150mg Mn/kg, 0.1mg Se/kg, >175mg Zn/kg, >50mg ascorbic acid/kg, >50mg riboflavin/kg and >100IU vitamin E./kg Suggested recommendations for young broiler at 2 weeks preslaughter were: <50mg Cu/kg, >80mg Fe/kg, >1000mg Mg/kg, >110mg Mn/kg, 0.1mg Se/kg, >120mg Zn/kg, >50mg ascorbic acid/kg, >50mg riboflavin/kg and >100IU vitamin E/kg (Coelho, 1994).

Supplemental trace minerals such as manganese, copper, zinc and selenium, as well as riboflavin maximize the superoxide dismutase, glutathione peroxidase and glutathione reductase preventative systems. Poor membrane integrity(PSE-like meat) in stress-suseptible turkeys could be ameliorated by a surfeit of dietary vitamin E. A deficiency of the antioxidant enzyme, glutathione(GSH)-peroxidase has been observed in stress-suseptible pigs(Schnaus et al, 1981). In this study, it was postulate that PSE was consistent with an antioxidant disorder leading to oxidative damage of cell membranes. Both stress-susceptible pigs and vitamin E-deficient animals have elevated activities of pyruvate kinase and creatinine kinase in the plasma and increased erythrocyte lysis due to free radical mediated damage to the cell membrance(Duthrie et al., 1987). Similar results were provided for turkey meat(Sheldon et al., 1997). These research reports showed that the 10 X and 25 X NRC(1994) diets produced the most typical and acceptable turkey meat flavors with the fewest oxidized off-flavor notes for both fresh and frozen samples(NRC 1994, recommendations). Mean color scores also increased, indicative of less pale meat, as the level and duration of feeding dietary vitamin E increased.

The antioxidants vitamin E and riboflavin should be added to feed at a rate of 100IU and 50mg, respectively, per kg of feed. Ascorbic acid should be supplemented at 50mg per kg to regenerate vitamin E that may be oxidized. An inverse relationship was observed between the antioxidant vitamin /mineral model supplementation and PSE in turkeys. PSE was reduced from 30 to 2% when vitamin E supplementation was 100 to 200IU /kg in turkey diets (Ferket, 1993, Personal communication).

FREE RANGE CHICKENS

1. What is a free range chicken?

All birds that are considered free rage chickens are fed a natural diet containing no antibiotics or coccidiostats. When were compared to conventionally raised chickens, the free -range chickens had similar growth rates and feed consumptions (Simopoulos and Salem, 1989; Leskanich and Noble, 1997). Neither group was found to have effected in their intestine as determined by fecal flotation and inspection of the intestine for lesions. More research should be done about the production costs, growth rates and feed conversion.

2. Taste of free range chicken meat

A taste test was conducted to determine if a distinction in taste could be detected, but there was no difference in this test detected by the taste panel(Speake et al., 1996; Leskanich and Noble, 1997), even though age, diet, strain or breed may originally have effected the taste tests. Farmers must experiment with creating a product unique to their own farm with the above ideas.

3. Disease susceptibility

Free rage hens are basically susceptible to the same disease as intensively kept birds, and they are more prone to disease syndromes seldom seen in caged birds. While birds in cages seldom suffer from infestations of parasites, the conditions of the ground frequently found in free rage houses is contaminated with high levels of excrement. This leads to the buildup of worms and coccidia to the detriment of the bird's health. Wild birds, vermin and insects also aid in the spread of diseases in free rage systems. Often soil type could also contribute as well. Producers should aim to provide 929cm^2 (1 square foot) per bird in the housing, excluding space for feeders, water and nest boxes(Noble et al., 1996; Leskanich and Noble, 1997).

COMPLETE QUALITY ASSURANCE (CQA) FOR POULTRY PRODUCTS

Poultry production must center on producing quality products under the most healthy and hygienic conditions, without adding harmful additives or using undesirable techniques. Public health concerns and consumer safety must be in the minds of producers at all times since public health relies on the quality and safety of the food available. The food supply must be safe, free from Salmonella or *E. coli* contamination, without chemical or drug residues and without any risk to our health (Nahm, 1996).

Raghavan (1993) and Mulder (1993) have suggested that the various steps to be supervised through a CQA program for poultry production for the market include: breeder farms and the production of day-old chicks; feed management; farm management; use of feed additives, residue problems and their control measures; and microbiological problems in poultry products.

Raghavan(1993) insisted that breeder farms must ensure the production of quality day-old chicks in order to compete in the marketplace. Breeder farms must not overproduce as this creates oversupplies which are harmful to the industry. Supply and demand will determine overproduction.

The performance of chickens in regards to weight gain, egg production and feed conversion ratios is determined by the feed quality. Consumers need to feel that what they buy is wholesome, satisfying and safe, with assurance that the poultry meat they buy was fed only quality feed.

No poultry producer will achieve quality poultry production if the farm management is substandard, no matter how good the feed is or how good the quality of th chicks are. Proper management programs must include vaccination programs for disease control and prevention.

Most feed additives such as anticoccidial drugs, chemotherapeutic agents, growth promoters and antibiotics follow a pattern of usage in manufactured feeds. Feed millers must advise farmers on the pattern of feeding these additives and the use of withdrawal feeds. The period of time needed for feeding withdrawal feeds must be based on the types of additives used and the withdrawal time needed for each additive.

And Muldar (1993) said that the numbers of microbial flora present on the processed chicken is an indication of the hygienic measures on the farm, during transport and at slaughter. Some microorganisms found on the farms and processing plants include those responsible for spoilage (i.e. Acinetobacter, Brochotrix, lactic acid bacteria and Pseudomonas) and potentially pathogenic microorganisms (Salmonells, Campylobacter, Listeria, Escherichia coli and Staphylococcus aureus). Rapid and safe marketing of poultry products is essential due to the presence of spoilage and pathogenic microorganisms. The whole production process utilize good hygienic practices to ensure safety.

CONCLUSION

Carcass fat in broiler chickens is responsible for a considerable loss to the poultry industry as well as consumers. The trend in the 21st century toward increased consumer demand to leaner poultry products at nominal costs will necessitate producers to insure the quality and condition of market-age birds, control preslaughter events, and strive for leanness and uniformity by implementing nutritional and management programs that improve flock health.

The actual eating quality of poultry meat is the combination of texture, succulence and flavor. The eating quality is influenced by many factor such as reckless handling of live birds, improper house litter, fed and water withdrawal programs, improper electrical stimulation of the meat, and color problems.

Even though non-nutritional factors (age, sex and ambient temperature) influence the body fat deposition, broiler body fat deposition, broiler body fat is manipulated nutritionally by decreasing nutrient densities or increasing protein levels. Manipulating through genetic selection has possibilities, but it is also known to be very complicated and expensive.

Poultry breast muscle can exhibit the same pale soft exudative(PSE) characteristics as seen in pork. Feed manufacturers are able to use nutrient modulation with mineral (Cu, Fe, Mg, Mn, Se and Zn) and vitamins (ascorbic acid, riboflavin and vitamin E) recommendations to control PSE.

Some consumers have started to consider free rage chickens that are fed a natural diet containing no antibiotics or coccidiostats, since they may be a healthier source of poultry meat. More research needs to be done, however, concerning the production costs, growth rate, feed conversion and meat quality of these birds.

Finally, producing quality poultry products must be done under the most healthy and hygienic conditions, with no harmful additives fed or undesirable techniques for handling or processing the birds used. Poultry meat supplies, like other food supplies, must be safe and free from Salmonella and E. coli contamination.

적 요

닭고기를 비롯한 육질에 대한 연구는 육지방조작과 식품으로서의 개선에 많은 진전이 되어 왔다. 실제로 식품으로서의 질을 이야기할 때는 생육기간동안 육질의 안정성에 관한 것은 물론 고기의 맛, 고기에 대한 외부요인의 영향, 그리고 씹기에 부드러워야 하고 씹을수록 육즙이 많이 나오며 향기가 좋은 고기를 생산할 수 있도록 전 사양기간을 통하여 늘 관심을 가져야 한다. 닭고기 질을 부드럽게 하는 데에도 도살시 높은 전기자극(820V)을 이용하고 또 요리전에 냉장상태로 보관해 주는 일이 필요하다. 도살전에 사료와 물을 철거시킬 때는 육량을 최대로 할 수 있고 또 고기의 감염이 생기지 않도록 전 생산과정이 일정한 계획하에 이루어져야 한다. 또 양계사료중에 식물성 기름이나 생선기름에 비타민 E의 전구물질인 -tocopherol을 첨가하여 먹이면 도살 후 닭고기의 부패(rancidity)나 생선 냄새 같은 것을 막을 수 있으며 영양함량이 높은 불포화 지방산(PUFA)의 함량이 높아진다. 양계사료의 영양소 함량 역시 닭고기 내의 지방함량에 영향을 미친다. 즉 사료 중의 에너지 수준을 높이면 닭고기 중의 지방함량이 높아지며 반대로 단백질 수준이 높아지면 닭고기 중의 지방함량은 낮아진다. 또 양계 사료중의 각종 아미노산 수준 즉 메티오닌, 라이신, 글라이신, 트립토판 또는 아미노산의 혼합물 보충 역시 닭고기중의 지방함량을 감소시킨다. 스트레스 역시 닭고기의 육질 저하 원인이 되며 이러한 현상은 도살전에 이루어지는 관리상태의 정도가 결정적으로 작용한다. 또 사료제조업자들은 사료중의 영양을 잘 조합하면 pale soft exudative (PSE)증후군을 막을 수 있다. 마지막으로 양질의 닭고기를 생산하기 위해서는 육질 개선을 위한 노력이 끊임없이 이루어져야 한다. 육질 확인 검사는 양질의 육을 생산할 수 있도록 그 생산체계와 검사실시 및 확인 과정이 함께 확대되어져야 한다

(Key Words: 육지방, 육질, 스트레스, PSE, 영양소 조작)

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