

The impact of breeding on product quality

by Milton L. Boyle, vice president R&D, Hubbard LLC, PO Box 415, Walpole, NH 03608, USA.

In order to select for quality, one must settle on a definition. The Quality Management programme defines quality as conformance to customer requirements (Crosby, 1979). Primary breeders must therefore ask the question "Who is the customer and what do they want?"

Increasingly (and rightfully so), today's customers want everything.

Today's integrators want broiler breeding stock that produces the maximum number of hatching eggs resulting in a fast growing, feed efficient, uniform (both in the broiler house and processing plant), well feathered, bacterial free, universally resistant to disease, high yielding broiler that is free of skeletal and muscular defects, is free of condemnations, is highly adaptable to a plethora of growing and disease challenge conditions, does not die and tastes good.

traits (hatching eggs and growth rate), the negative relationship between the traits proved challenging.

As the breeding programmes became more sophisticated and the traits more numerous (livability, feed efficiency, yield, carcass fat), special management techniques were incorporated to ensure productivity and efficiency.

Today's breeders face even greater challenges as their customers, the integrators, are still faced with an ever increasing need for efficiency, yet are also under pressure to de-industrialise their systems to improve the animal well being.

Genetics can (and will) play a large role in solving these issues but this requires a retooling of the present selection criteria to retain competitive performance for the traditional traits in a less intensive environment.

advances in nutrition, management, health and genetics.

These advances have resulted in dramatic performance improvements in growth rate, feed conversion and white meat yield in chickens. As genetic gain is essentially a function of selection intensity over time, poultry, and chickens in particular, lend themselves to selective breeding programmes due to their relatively short generation interval and their efficient reproductive capacity. The potentially large family numbers also allow for more accurate predictive breeding values for these interacting complex traits.

The structure of the poultry world as a collection of increasingly larger, fully integrated operations has allowed for modern breeders to develop intense and sophisticated selection schemes, even to the point of niche marketing and multi-product development. This increase in size has allowed some integrators to incorporate their own breeding programmes targeted at their own particular needs.

This evolution from a non-systematic large collection of small breeders to a relative few large primary breeders took less than 50 years.

The emergence of companies dedicated strictly to breeding was directly related to the intensification of the production systems, which followed the advances in nutrition, poultry husbandry and health.

In the 1970s some integrators incorporated breeding into their programmes either by buying an existing breeder or starting a new one. Most breeders started out either by developing male lines or female lines. Male lines were derived from the meatier and faster growing Cornish breeds.

The female lines were developed mostly out of the more efficient reproductive White or Plymouth Rock stocks. Later breeders started developing both male and female lines mostly to satisfy their international customers who buy packages at the GP level. However, change is constant, and this trend towards intensification is meeting some resistance from today's consumer, especially in Europe, but increasingly in the USA and the rest of the world.

If quality can be defined by conformance to customer requirements, then as the customer requirements change, so

Continued on page 17

In the USA white meat is sold at a premium while dark meat is relatively cheap. It is exactly the opposite in Asia where customers prefer dark meat and the prices reflect this; bone-in legs cost more per kilo than deboned breast meat. A few years ago, USA producers were thrilled to learn that chicken feet were in demand in Asia. In fact, chicken feet commanded a better price than dark meat for some time. In Brazil the most expensive part of the chicken is the heart. In China there is a black skinned chicken which is sold for medicinal purposes (especially good for pregnant women). Chicken nuggets also take on a special meaning in China. In Japan they sell chicken in what are called Yakitori sticks, which include the preen gland and soft portions of the beak (the preen gland is located at the base of the tail and produces oil for preening purposes).

There is a gourmet market in France where products such as Label Rouge (Red Label) command a premium of up to five times the industrial chicken price. You can also buy chicken intestines at the French supermarket. In some markets in Korea, chickens are sold per unit rather than by weight and, as in many Asian countries, are sold live in what are called wet markets. In Europe, it is not only important that you excel in commercial performance, you must also meet social criteria to satisfy the integrator's customer and the consumer.

Today's consumer increasingly wants assurances about sensory, dietary, and safety quality about the meat they eat as well as the rearing and husbandry conditions of the animal itself.

Engineering breeding stock for the broiler sector has never been a particularly easy task. Breeders have a long product development cycle (3-5 years) coupled with a long production pipeline (4-5 years) that produces a product with an extremely short shelf-life (two weeks).

In an evolving marketplace, the proper target and vision is critical. Even in the early days of modern broiler breeding, when there were essentially only two

The narrative inset below illustrates the diversity of the global chicken markets primary breeders need to satisfy.

Up until recently, very few consumers recognised the level of complexity that lies behind the meat they buy. They may notice that the chicken breasts are bigger than they used to be but how this is accomplished is unknown to most. The poultry sector in particular has made tremendous improvements in the quantity of meat and the efficiency of production to the point where chicken is significantly cheaper than it was 30 years ago (adjusting for inflation). These improvements were made through

Continued from page 15

does the definition of quality. This is not to say that modern breeding is vanishing but it is being affected by consumer pressure as delivered by supermarkets and fast food chains to the integrators.

The challenge

In the October 2003 annual meeting of the NCC in the USA, four industry leaders were asked to look into the future of the poultry industry. Two of the companies represented, if they were countries, would represent the fourth and fifth largest chicken producing nations in the world! There was agreement that the bird weights were going to continue to get heavier, that breast meat and yield were going to be of increasing importance, that further consolidation would continue in the industry, that automation technology and cost control were going to be the hallmarks of the successful companies.

There was also consensus that animal welfare, food quality, and safety issues were going to continue to be of increasing importance. This is where the paradigm lies; integrators need to maintain business efficiencies without retaining any practices which compromise the well being and quality of the animal.

The premise of this article is that, through the application of science and ingenuity, this is not an impossible task.

Meat quality characteristics and issues

A number of years ago, I had the good fortune to visit a retired breeder who was lamenting that today's chicken did not have any flavour. As a result, he showed me some coloured birds he was raising under special conditions to improve the flavour.

At the time, I thought it was interesting but did not dwell on it. After all, the world wanted feed efficient, white chickens that grew fast with increased white meat yield. In retrospect, he was before his time as today's consumer is increasingly looking for a more wholesome, tastier product.

Remignon and Le Bihan-Duval (2003) divide the quality of a meat product into five areas – organoleptic (taste, colour, flavour, tenderness), dietary (nutritional profile), safety (freedom from food borne pathogens or toxins), technological (processing characteristics), and psycho-social (consumer concerns and preferences).

Up until recently, meat quantity was the trait of interest without much regard for quality except in extreme cases where muscle abnormalities, such as deep pectoral myopathy (formerly only seen in turkeys), appeared. As a result,

there is still much to learn about the genetic nature of these traits, the appropriate selection criteria to utilise and the proper way of integrating them into the commercial breeding programmes.

One of the first questions that comes to mind is what have we done to meat quality characteristics as a result of recent breeding programmes?

Surprisingly, and contrary to popular belief, there is no conclusive evidence that the intense selection for growth, feed efficiency and yield has changed the sensory aspects of meat when the different genotypes are slaughtered at the same age. Instead, this seems to be more of a result of the reduced slaughter age of the modern breeds.

Touraille et al. (1981) reported that the most significant factor affecting flavour and tenderness is age at slaughter.

Chambers et al. (1989) reported that as age at slaughter increases, dark meat flavour intensifies and there is a reduction in tenderness. Touraille et al. (1981) also reported that myoglobin content is lower in birds slaughtered earlier (9 vs. 16 weeks). Le Bihan-Duval et al. (1999) reported a reduction in breast meat colour and lower drip losses associated with selection for reduced fat and increased breast meat yield. Berri et al. (2001) reported that commercial selection did result in higher protein content and less moisture in breast meat.

In this study, Berri and co-workers compared an experimental and commercial selected line with appropriate controls for meat quality traits.

The selected lines had significantly higher pH levels (at 25 minutes, 1 hour and 24 hours), significantly lighter coloured meat, significantly less redness, significantly less yellowness after one day, but no significant difference in drip loss was detected. Increased growth does result in bigger muscle fibres in higher numbers. While fast growth does not seem to affect the nature of the white meat myofibres, which contain reduced fat and myoglobin levels, it does seem to increase the number of white myofibres in mixed muscles.

Intuitively, it follows that the fat content of meat has a positive effect on flavour and tenderness. However, it has been reported that selection against abdominal fat did not significantly affect the sensory properties of meat.

Chambers et al. (1989), however, reported that the flavour, tenderness and juiciness of dark meat were significantly enhanced by carcass fat.

Most consumers would agree that dark meat, with its higher fat content, tastes different to white meat. This may also be partially due to the fact that it is easier to dry out white meat than dark meat by overcooking. Nonetheless, the product

of choice for western markets is white meat, most notably for its health characteristics. A better understanding of this relationship is necessary to meet the consumer's desire for better tasting and healthier meat.

When a bird is processed, sensory and physical qualities are significantly affected by the rate and extent of rigor mortis. This process results in changes in pH, variation in which can have marked effects on meat quality. A higher pH results in an increase in pigmentation and firmer, less tender meat. A low pH is lighter in colour with a higher drip loss rate. A rapid drop in pH initiating a rapid onset of rigor mortis can result in PSE (pale, soft, exudative meat) resulting from protein and pigment denaturation. The role of gas versus electrical stunning on meat quality needs further study.

The parameters of meat quality are muscle structure (fibre size and number), fat content, glycogen content at slaughter, muscle metabolism (rate and extent of pH fall), calpain/calpastatin activity (tenderness), meat colour, water holding capacity and flavour (taste panels).

These serve as possible selection criteria for meat quality, however; only sib selection can be accomplished. For this reason, marker assisted selection may be particularly appropriate for improving meat quality. The prospects of affecting meat quality genetically are encouraging. Le Bihan-Duval (1999) investigated the genetic parameters of selecting for carcass quality and found moderate to high heritabilities for all traits measured.

The heritabilities for ultimate pH (0.49), lightness (0.75), redness (0.81) and yellowness (0.61), coupled with the notion that industrial selection does not affect the sensory aspects of the product, implies that meat quality and modern selection programmes need not be mutually exclusive.

Food safety

In today's world, it is a given that if you are going to compete internationally as a primary breeder, you have to be able to produce stock free of all salmonellas. While food safety is a critical issue for all points in the meat production chain, primary breeders more than likely will focus on their biosecurity programmes rather than genetics to keep their birds free of foodborne pathogens, such as salmonella or listeria.

While one can imagine producing a salmonella or campylobacter resistant chicken, the ability of these pathogens to mutate and engineer around the host's resistance is formidable. Nature tends towards a balance, it is not in a patho-

Continued on page 18

Continued from page 17

gen's interest to be 100% effective, as it will eventually no longer have a host or 100% ineffective, and thus it will re-engineer itself. Similarly, it is not necessarily in the host's interest as a species to be 100% immune either (overcrowding, increased competition for resources.)

The more consumers become aware of how food gets to their table, the more animal welfare becomes a trait of interest for poultry breeders. Faure et al. (2003) lists three phases of the selection for animal well-being. Phase I was the selection of the appropriate species for domestication. Phase II was the exaggeration of the favourable characteristics (social, preco-

scious, calm adaptable) through natural and unconscious artificial selection. Phase III is a relatively new phase where breeding companies, particularly table egg breeders, are consciously selecting for traits conducive to animal well being.

This concern for animal welfare is particularly true in Europe, but consumer awareness in this area is becoming increasingly important in the USA as well. In the USA, pressure from consumers and animal rights groups has resulted in the fast food chains auditing their suppliers to ensure that the rearing conditions meet their standards. The FMI (Food Marketing Institute) issued animal welfare guidelines for chicken suppliers

in April 2001. The National Chicken Council (NCC) published animal welfare standards in March 2003 in response to this rising concern and includes guidelines for education and training, hatchery practices, nutrition and feeding, comfort and shelter, health care, bird placement density, catching transportation, and processing.

Vareity of welfare issues

Animal welfare issues are far reaching and range from husbandry practices (beak trimming, toe trimming, bird density, lighting programmes, feeding programmes) to behavioural issues (feather pecking, cannibalism, aggression). While the layer sector's intense selection for reproductive traits has required counterbalancing selection against extreme behavioural traits, such as aggression, feather picking and hysteria, the intense selection for growth has resulted in more docile, less active birds. Intense selection for growth requires counterbalancing selection against skeletal problems or birds will be less active and more prone to sitting. Potential skeletal deformities include crooked toes, tibial dyschondroplasia (TD) and long bone deformities.

It becomes a 'Catch-22' situation, as the birds are reducing activity due to leg and bone issues and the reduced activity tends to work against normal bone formation as the normal wear and tear of regular activity is necessary for normal bone formation.

The genetic solution is selection on a growth curve which allows for proper bone formation and activity early in life, to ensure proper leg strength as the stress of the additional weight is added. This will be made easier as bird weights continue to increase and fewer birds will be processed at lower weights, eliminating the need for rapid early growth. This will also improve the bird's health by reducing the ascites incidence (commonly seen in rapid growing young birds) as well as improving the bird's feed efficiency.

In addition, skeletal traits tend to be highly heritable, thus proper selection intensity should allow for reductions in deformities. As always, management techniques also can be important, such as putting in ramps and perches may help alleviate the leg issues.

Another primary issue for broiler breeders is the feed restriction programmes breeders are subjected to. Chickens naturally spend a great deal of time foraging for food but under feed restriction programmes, feed is fed as a three hour meal (this can range from 45 minutes to six hours depending on the genotype and feed presentation). The intense selection for growth has greatly increased the bird's appetite and it is estimated that the

HIPRAGUMBORO-CH/80

There are only advantages

High immunogenic capacity with no immunosuppression

50 1950-2004

HIPRA

www.hipra.com

HIPRAGUMBORO-CH/80

The advertisement features a large, fluffy yellow chick standing on a blue background. Below the chick, there is a box and a vial of the product, HIPRAGUMBORO-CH/80. The text is in white and blue, with a large '50' logo indicating a 50th anniversary from 1950 to 2004. The HIPRA logo is also present.

bird's are receiving somewhere between 25-50% of what they would consume on an ad libitum basis.

These programmes are designed to maximise reproductive performance because if the birds were provided feed ad libitum, a large percentage would soon become obese while the flock in general would be poor due to increased prolapse and a lack of persistency of lay.

The males as well would become overweight and while still willing, be unable to successfully mate, resulting in poor fertility and hatch. One non-genetic solution to this would be bulk up the feed, so as to allow for more consumption without causing obesity. This would allow the bird to eat longer and more without adversely affecting productivity.

Feed restriction is also believed to increase male aggression in breeder flocks. As previously stated, broiler breeds tend to be fairly docile and less active. However, the intense selection for growth and indirectly appetite, coupled with feed restriction later in life, has resulted in male aggression towards females, not a normal behaviour.

In extreme cases, one can walk into a breeder house and only see males in the scratch area as all the females are up on the slats. When you walk through the house, the cause is apparent as the males start charging you as well. Some companies have put small barriers in the floor area (they look like little soccer goals) to provide protection for the females. Such behaviour results in increased mortality and poor hatch.

Conclusions

Today's consumer wants improved quality in their meat products but they are also accustomed to a falling price for chicken meat in real terms, except in niche or gourmet markets. As a result, the broiler sector continues to face significant challenges in terms of meeting consumer demands for improved quality without increasing the cost. Breeders can continue to play a significant role in providing solutions by developing birds with enhanced quality traits. The heritabilities of meat quality traits and the apparent lack of conflict with traditional commercial traits, provides opportunities for breeders to develop selection tools to enhance the sensory aspects of chicken meat.

However, a clear understanding of regional preferences in reference to tenderness and flavour is required. The use of marination by integrators also needs to be factored into any marketing studies, for example natural versus added flavour.

The continuing concern for the bird's welfare will also influence breeding schemes and management programmes.

Modifying the feed to allow for more gut fill without causing obesity can be a feasible solution for the well being and behavioural concerns induced by feed restriction.

The cost implications of transporting more feed can perhaps be partially offset by the reduced cost of the feed and the improved livability and hatch. Skeletal deformities and locomotion issues can be addressed through increased selection intensities for leg strength, selection for a growth curve conducive for adequate bone and organ development, and pen modifications to encourage exercise.

While today's consumer environment presents unique challenges to the broiler

sector, it is clear that the science based approach, which has served the industry and consumer so well in the past, will continue to offer creative solutions for the future.

Chicken meat is a very cost effective protein source that, through a proper understanding of the markets, the genetics and the management of the birds, will continue to be uniquely attractive to consumers for both health and quality reasons. Primary breeders will continue to be a significant source of future solutions for these and other challenges. ■

A list of references is available from the author on request.

the second shell...

...the chick emerged from the protection of its shell.

IZO can provide the second protective shell that is necessary to sustain healthy growth.

At IZO we can safeguard chicks against disease... at day old and in later life with our full range of poultry vaccines.

IZO Veterinary Biological Specialties

IZO S.p.A. Via A. Bianchi, 9 • 25124 Brescia • Italy • www.izo.it