Turkey breast meat development – maximising the genetic potential

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Breast meat is the most profitable part of the turkey carcase (60-70% of the income) even though it only represents 23-26% of the liveweight. For that reason the breast meat yield (BMY) is one of the most valuable genetic traits in the poultry industry.

Therefore maximising BMY percentage is a key aim of the turkey industry in terms of weight of breast meat per bird and also of the percentage that it takes up in the carcase. In order to maximise breast meat it is necessary to understand the muscle development and to have a simple and repeatable BMY assessment methodology before trying to look at the possible way to improve its deposition.

Breast muscle development

First of all breast muscle development, like all the other muscles, takes two different phases: prehatch and posthatch periods (Fig. 1). During the prehatch period (hyperplasia), the embryonic muscle growth is characterised by proliferation and differentiation of myoblasts, which then merge to form muscle fibres.

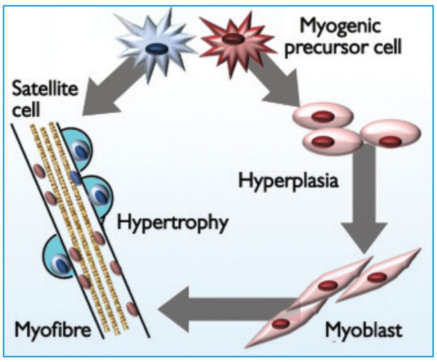
Muscle fibre formation is nearly completed at the time of hatching, thereafter muscle fibre number remains constant. For that reason the posthatch period of muscle growth is mediated through activation, proliferation, and differentiation of the additional satellite cells which stimulates the thickening of the muscle fibres (hypertrophy).

During embryonic growth not all the myoblasts form myotubes as some become satellite cells that lie inactive around the edges of the muscle fibres.

These satellite cells (Fig. 2) can be activated in the muscle after the bird has hatched and are important to contribute to the nuclear material to support the growth and repair of muscle fibres.

To allow the growth of muscle fibres there must be a net accumulation of protein (synthesis must exceed break-down) and this is achieved by the fusion of satellite cells with the muscle fibre.

Fig. 1. Myofibre development (courtesy of Dr Velleman).



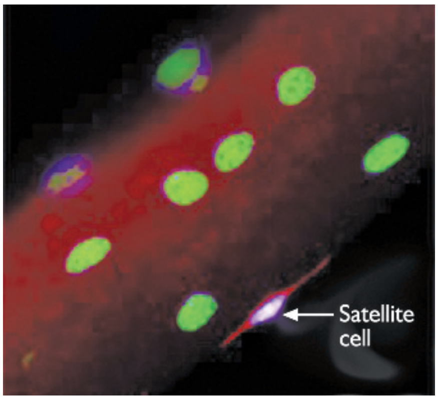


Fig. 2. Satellite cell on myofibre (Terry Partridge, Muscle Cell Biology).

What is breast muscle?

Breast muscle is a skeletal muscle which is formed by a set of juxtaposed parallel fibres, organised into bundles surrounded by vascularised connective tissue known as the epimysium.

Each of the muscle fibre bundles are surrounded by a finer connective tissue called the perimysium. The perimysium supports the vascular network and also surrounds all the nervous elements in the muscle.

Each muscle fibre is then further surrounded by a thin sheath of connective tissue called the endomysium, which extends from the perimysium.

Due to their role in movement and locomotion, muscle fibres are white fibres in the Pectoralis major muscle (limited access to oxygen due to less blood vascularisation). The breast fibres are 99.8% fast twitch glycolytic, type IIB (FTG) in order to produce energy in those anaerobic conditions in response to stress.

Breast integrity depends on the number and the size of muscle fibres. However, due to the anaerobic way in which these fibres work, breast integrity also depends on the connective tissues and the fat infiltration between and inside the bundles of muscle fibres for essential removal of by-products, especially lactic acid.

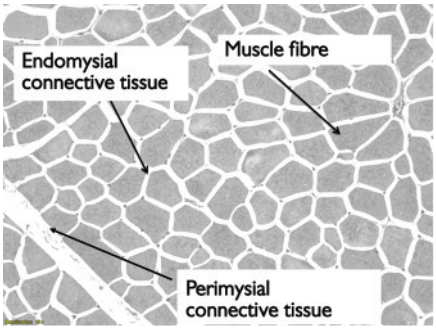


Fig. 3. Cross section of muscle tissue.

The assessment of muscle characteristics is required to understand breast development and qualify the right muscle structure.

Aviagen Turkeys has studied turkey breeds using an index based on five criteria:

- Fibre uniformity.
- Immune cell infiltration.
- Perimysial fat bundle.
- Endomysial fat bundle.
- Epimysial spacing (Fig. 3).

The breast muscle of the modern turkey has been selected for increased size. This is almost entirely due to increased muscle fibre size, not increased number of muscle fibres. Theoretically this may lead to an increased incidence of giant fibres, increased risk of necrotic fibres and reduced perimysial and endomysial space.

In reality, comparison between BUT6 and

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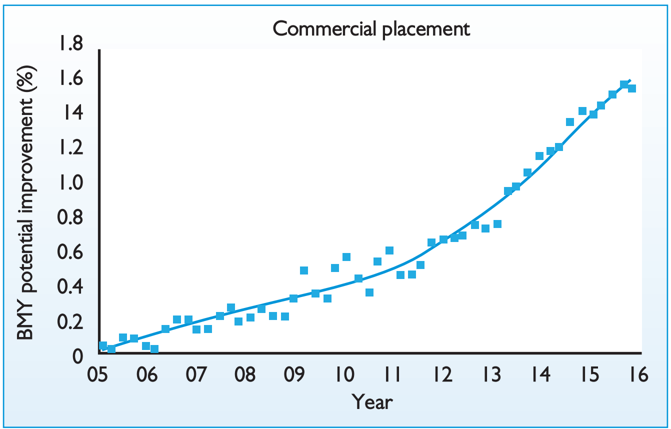

Fig. 4. Breast meat yield potential over the last 10 years.

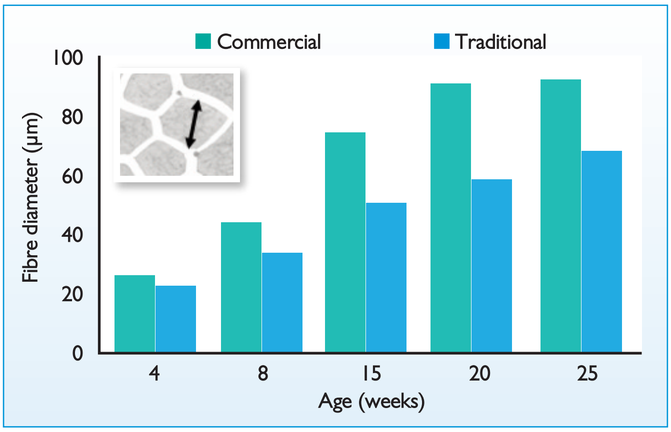

Fig. 5. Measurement of muscle fibre diameter as an indication of hypertrophy during muscle growth.

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free range type birds shows no differences in term of degenerated or giant fibres (%).

Indeed sampling done across lines within the Aviagen Turkeys operations have shown good muscle morphology across all the lines tested.

Breast meat yield

There are many ways to measure BMY in the plant and the method employed will depend on the interest of the processor, the individual plant set-up, staff available, space to carry out the work and time.

To be able to do some comparisons it is important to develop a standardised protocol in order to obtain comparable measures of BMY.

First of all BMY percentage should be measured as a proportion of liveweight and not only on carcase weight. In reality even if the gastrointestinal tract (650g at 20 weeks) is always removed from the bird, some other part of the dead bird could be partially removed or retained on the carcase at the primary cutting before chilling depending on the plant (tail, neck, feet).

Then, it is recommended that the birds sampled for BMY assessment should be representative of the flock average and then, within the plant, to have a separate workstation and accustomed team to do the cutting.

The weight of the two components of breast meat measurements: M. pectoralis superficialis and the M. pectoralis profundus without the shoulder and with all skin removed, is then expressed as a percentage of the liveweight of the turkey prior to processing.

Typically the BMY potential improvement since 2005 and for 2016 is close to 1.6% (Fig. 4).

Genetic potential

The rate of muscle growth is influenced by a combination of the number of fibres, the number of satellite cells available to fuse for protein synthesis, the activity of the satellite cells and the rate of protein turnover. After hatch the increase in muscle fibre size is thought to be determined by the total DNA gained from the fusion of satellite cells, and the rate of this muscle deposition is determined by the rate of protein turnover in the muscle.

Comparisons of modern commercial and traditional turkey genotypes through phenotypic selection have indicated that much of the advances in weight and meat yield have been achieved through an increase in post-hatch muscle growth (hypertrophy as shown by the increase in fibre diameter, Fig. 5).

The same comparison in terms of breast meat mass between traditional birds and modern commercial strains shows bigger fibre diameter per kg of breast in the traditional strain (Fig. 6).

Consequently, it is interesting for a primary breeder company to look at the genotype X environmental interactions to influence the structure and growth of the muscle, in particular the fibres number.

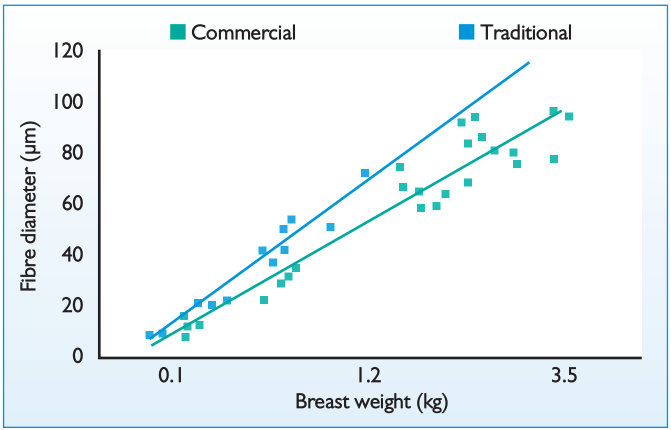


Fig. 6. Fibre diameter per kg of breast muscle.

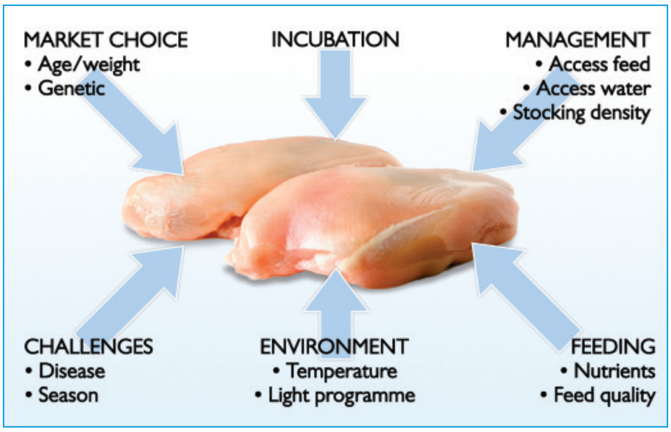


Fig. 7. Factors affecting breast meat yield.

Influencing factors

In commercial turkey production, the deposition of breast meat is going to occur in the second half of the growing cycle and there are many factors that can influence growth and muscle development in this period (summarised in Fig. 7).

After assuming that the choice of the breed is in agreement with the chosen killing age according to the market and assuming also that no disease challenges affect the fitness of the birds, it is possible to focus on environmental and rearing factors which could affect the development and growth of the muscle to influence breast meat yield.

Incubation

It is possible to influence both muscle fibres number and the number of myonuclei within fibres by applying slightly higher incubation temperatures (+1°C) during the first part of incubation (5-12 days).

One hypothesis is that application of temperature treatment at the appropriate time in incubation prolongs the proliferation phase or delays the signal for differentiation in the premyoblasts.

During the late incubation stage the number of the muscle fibres is still increasing. Adverse conditions – high temperature and low oxygen at the end of incubation may have a detrimental effect on the diameter of breast fibres that develop later. For that reason it is important to adapt the incubation programme to breed type.

Nutrition and feed effects

Feed deprivation in chicks and poults early post-hatch has a negative impact on satellite cell proliferation and a decrease in muscle weight later in life.

Starvation increases satellite cells becoming preadopocytes rather than premyoblasts. In contrast, offering nutrients to poults immediately after hatch improves body weight and BMY.

The large influence of feed on the amount of breast meat on the carcase could be summarised by access to the valuable nutrients. Turkeys can adapt to different types of feeding systems but inside each program they require consistency. They could react badly to variation in component quality and feed presentation with reduced feed consumption and a poor growth pattern, which will influence breast meat deposition. The amount of nutrients that a turkey absorbs into its body to convert into tissue is affected by the accessibility to feed, the feed consumption, the feed presentation and the digestibility of nutrient components.

All feed ingredients should be fresh without moulds or mycotoxins and if they contain some anti-nutritive factors these should have been properly heat processed to inactivate these.

The most influential period of growth on breast meat deposition was found to be the latter part after 12 weeks.

Physical environment

To allow turkeys to express their genetic potential they need to be grown in an environment that has the least amount of limits to their development. Factors that limit the turkey's ability to access the feed, such as the stocking density and feeding space, need to be resolved.

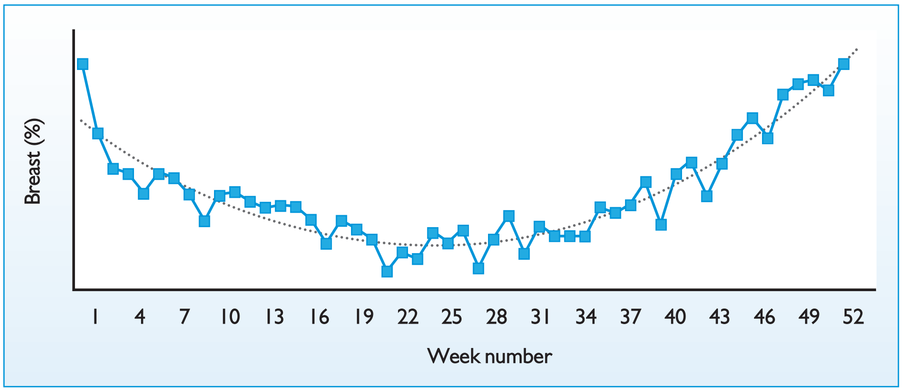
Factors like house temperature and ventilation, which could be controlled by the grower, need to be managed to keep the turkey close to their thermoneutral zone.

This will reduce energy wasted from the feed to maintain their thermoregulation and will also stimulate feed consumption.

Without a good control of environmental conditions it is possible to see big differences (1-2%) on BMY between seasons (Fig. 8).

The optimum lighting programme should include a period of 6-8 hours of darkness, which perhaps delays sexual maturity ensuring maximum utilisation of nutrients for growth and meat deposition instead of sexual tract maturation.

Fig. 8. Breast meat yield during the year.



Conclusion

Production operations need to take account of the interest of maximising meat yield on individual birds to ensure that production costs are competitive with other meats.

The combination of breeds with a higher meat yield potential, good quality feed and expertise in farm management can maximise the breast meat output and profitability. Breeder companies are focusing on these opportunities to support the turkey industry. ■

References are available from the author on request