Featherless Broilers may Lower the Costs and the Environmental Impact of Poultry Meat Production under Hot Conditions

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Introduction

Total life-cycle environmental impact of broiler meat production consists of materials and energy inputs and emissions during feed production, on-farm broiler rearing, and processing. Feed provision accounts for ~80% of total impact (Pelletier 2008) and therefore it is desired to improve (lower) the feed conversion ratio (FCR) which is the amount (weight) of feed consumed per weight unit of the live broiler at marketing. Rapid growth is the main factor of good FCR, because it reduces the total amount of feed consumed for body maintenance rather than for body weight (BW) gain. Indeed, more rapid growth has been the main objective of broiler breeding programs (Deeb and Cahaner 2002; Havenstein, Ferket and Qureshi 2003) as well as the developments in management and nutrition practices.

More rapid growth is driven by higher rate of feed intake, and higher rate of metabolism and internal heat production (Deeb and Cahaner 1999). Hot conditions are a major burden for broilers from contemporary fast-growing stocks (see Cahaner 2008 for a thorough review), because their feathers hinder the dissipation of the excessive internal heat, and consequently their body temperature (BT) is elevated (Deeb and Cahaner 1999; Yaron, Hadad, Druyan *et al.* 2004). To avoid lethal elevation in BT, standard broilers under hot conditions reduce the rate of feed intake (Cooper and Washburn 1998), but consequently growth rate is reduced and they need more days to reach marketing BW. The longer rearing period leads to poorer FCR, i.e. more kg of feed consumed per kg BW of marketed broilers. Longer rearing period and poorer FCR significantly reduce the economical efficiency of broiler meat production under hot conditions (Cahaner 2008) and increase its negative environmental impact.

The negative effects of heat on broiler performance can be avoided by ventilation and cooling systems that allow to maintain comfortable conditions inside the broiler houses even when the outside temperatures are very high (e.g., May, Lott and Simmons 2000). However, this approach requires costly broiler houses and equipment, and the cooling systems are characterized by high energy consumption, which in turn increases polluting emissions. The negative effects of heat can be partially avoided by marketing the broilers at lower final BW (e.g. 1.5 kg instead of >2 kg) because up to that BW, heat effects are much lower and FCR is reasonable. However, lower marketing BW increases the costs and environmental impacts of processing (slaughter, plucking, evisceration, cut-up, deboning) per kg of edible products.
Hot conditions negatively affect genetically fast-growing broilers because with lower

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gradient of temperatures between the feather-covered body surface and the ambiance, they cannot dissipate all the excessive internal heat. Many studies during the 1980's and 1990's (e.g. Deeb and Cahaner 2001; reviewed in Cahaner 2008) indicated a reduction of 20-40% in feather coverage due to the naked neck gene provided fast-growing broilers with partial tolerance to heat. Based on these results, it was hypothesized that a complete elimination of feathers is required in order to maximize heat tolerance of fast-growing broilers under hot conditions. Featherless broilers were derived from the recessive spontaneous mutation called *'Scaleless'* (Abbott and Asmundson 1957). The mutated allele (***sc***) was found in the New Hampshire breed, characterized by lower GR and BW than meat-type chickens. Due to their low GR, the original featherless mutants were not considered for practical purposes. The development of fast-growing featherless broilers was initiated in the year 2000 by crossing original scaleless mutants with contemporary fast-growing broilers, followed by a series of backcrossing accompanied by intensive selection on BW (Cahaner and Deeb 2004).

Material and methods

Over the years, many trials (e.g., Cahaner and Deeb 2004; Yaron, Hadad, Druyan *et al.* 2004; Yadgari, Kinereich, Druyan *et al*. 2007; Cahaner, Ajuh, Siegmund-Schultze, *et al.* 2008) were conducted with broilers from the experimental line that segregates for the *sc* gene. As a routine, *sc/sc* (featherless) males were mated with *+/sc* females, carriers of the *sc* allele. The trials were conducted with progeny of these matings, segregating 1:1 to featherless (*sc/sc*) and normally-feathered (*+/sc*) but sharing the same genetic background with regards to all the other traits. Some trials included also commercial broilers, as industry reference.

The featherless and feathered broilers in these trials were compared under hot conditions vs standard conditions. In most trials the difference in conditions was induced by ambient temperatures (30-35ºC vs ~25ºC). In some trials variable heat stress was achieved by varying stocking densities, ranging from 7 to 22 birds/m^2.

In two trials, diet composition was added as a 3rd factor to the combinations of feathered vs. featherless broilers under temperate vs. hot conditions. Experimental diets with between 5% to 20% lower content of amino acids or energy or both were tested. The experimental diets were formulated based on reported effects (e.g., Gonzales-Esquerra and Leeson 2005, 2006) of heat stress on nutrient utilization. The reduction in amino acids contents reflected the hypothesis that because about 15% of dietary nutrients consumed by broilers are used for building their feathers, the requirement for these amino acids in the featherless broilers must be lower. This hypothesis was evaluated in trials under temperate (26ºC) and hot (32ºC) conditions and varying stocking densities – which further accentuate the heat stress. Commercial 3rd (days 17-31) and 4th (days 31-46) diets were used as control.

In all these trials, the measurements included the major performance traits: BW gain and feed consumption (to calculate FCR), BW at marketing, breast meat yield and also meat quality. Body temperature was measured in several trials and survival following accidental exposure to acute heat stress was recorded.

Results and discussion

The results of the earlier trials clearly indicated that being featherless provides full tolerance to ambient temperatures up to 35ºC. This tolerance was expressed in broiler performance (growth and meat yield) and also in body temperature and livability under acute heat stress (Cahaner and Deeb 2004; Yaron, Hadad, Druyan *et al.* 2004). Later trials showed that due to their heat tolerance, the featherless broilers can be reared in high stocking densities, even under ambient temperature >30ºC, with no negative effect on their welfare and performance (e.g., Yadgari, Kinereich, Druyan *et al*. 2007)

The hot conditions depressed the performance of standard broilers to a similar extent in all diets, due to lower feed intake of all diets, but had no negative effect on the feed intake and performance of the featherless broilers. Under temperate conditions, the diluted diets with lower protein and energy contents reduced body weight and breast meat yield in the feathered broilers, but not in the featherless broilers. Under the hot conditions, the featherless broilers had better FCR than their feathered counterparts because they gained more weight per unit of feed intake. Their advantage over the standard broilers was higher when feed price was considered, because their performance was not depressed by the cheaper diluted diets. These results supported the hypothesis that the featherless broilers have lower protein requirement. It appears that by rearing featherless broilers, the costs as well as the environmental impact of poultry meat production in hot-climate regions and seasons can be reduced due to their lower requirement for costly feed grains, and their ability to withstand hot conditions without costly housing and energy-consuming cooling systems.

Under temperate conditions, lower protein and energy contents in the diluted diets reduced body weight and breast meat yield in the feathered broilers, but not in the featherless broilers. It appears that the featherless broilers have lower protein requirement, as could be expected because they do not need the amino acids used to build the feathers in standard broilers. The hot conditions reduced the performance of standard broilers to a similar extent in all diets, due to lower feed intake of all diets. The heat did not depress feed intake and performance of the featherless broilers.

Conclusion

The costs and the negative environmental impact of broiler meat production increase substantially under hot conditions, either because the heat depresses the growth rate and feed efficiency of the broiler, or because costly cooling systems are used to avoid heat stress inside the broiler houses. In contrast, trials with experimental broiler stock that segregates for the *sc ("scaleless")* gene, indicated that the featherless *(sc/sc)* broilers do not need cooling because they maintain normal body temperature, good appetite, rapid growth and good FCR under hot conditions. Moreover, the performance of the featherless broilers was not negatively affected by diet with lower protein and energy content, because they do not need the feather-building nutrients. With the lower requirement for protein and energy, being featherless improves also the economic FCR (cheaper feed), and also reduces the environmental impacts of processing, by avoiding the plucking and dumping of the feathers.

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