Evaluation of alternative genotypes and production systems for natural and organic poultry markets in the U.S.

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Interest is growing in the U.S. in natural and organic poultry production. An experiment was conducted to assess the impact of genotype and production system of performance and meat quality. Specifically, a slow-growing genotype (SLOW) (S&G Free Range Slow-growing Hybrid) and a fast-growing genotype (FAST) (Cobb) were raised (females) for 91 and 63 days, respectively. Each genotype was assigned to 4 pens of 20 birds each and raised in indoor floor pens; each genotype was also assigned to 4 floor pens in a small portable facility with outdoor access. The diet was formulated to be low in energy and protein for a slower rate of production. Birds were commercially processed and deboned at 4h postmortem. Data were analyzed by ANOVA. The FAST birds gained more weight than the SLOW birds despite difference in age. The Outdoor birds had a higher feed intake and a poorer feed efficiency than Indoor birds. The FAST birds had a higher breast yield, while SLOW birds had a higher wing and leg yield as a percent of body weight. The SLOW birds had lower mortality than FAST. The Indoor birds had a higher wing yield than birds with Outdoor access. An interaction was evident in which the meat and skin of the SLOW birds became more yellow (higher b*) when the birds had outdoor access; however, this did not occur when FAST birds had outdoor access. The breast meat of the SLOW birds had more protein and less fat than the FAST birds. The SLOW birds were higher in α-tocopherol (per unit of fat) than FAST birds. The SLOW birds were more tender than the FAST birds. The SLOW birds had a higher drip loss than FAST but a lower cook loss and a higher total moisture loss. A descriptive analysis of breast and thigh meat was conducted by a trained panel and data indicated that the breast meat from the Outdoor birds was more cohesive than the meat from the Indoor birds in the first bite stage. In terms of flavor, there were no significant differences for most basic tastes; however, both the breast and thigh meat of the FAST birds tasted more salty than the SLOW birds. The SLOW birds had more dark meat fat flavor than the FAST birds. Results from the consumer panel showed no significant differences between SLOW-Out and FAST-In treatments in overall liking, appearance, texture, and flavor of the breast meat or thigh meat. Overall, the production system had less of an impact than genotype.

Keywords: poultry; organic; free-range; slow-growing; meat quality

Introduction

Consumer interest is growing in poultry production systems, such as free-range and organic, as an alternative to intensive production. In modern, intensive production systems, broilers reach market weight within 42 days and have high yields of breast meat for a variety of reasons including genetic
selection, diets that target nutritional requirements, and proper management and animal husbandry. However, the rapid growth of fast-growing birds leads to concerns about welfare, especially metabolic and leg disorders. In addition, selection for fast growth and high yield may have impacted the sensory and functional qualities of the meat (Le Bihan-Duval et al. 2003; Dransfield and Sosnicki, 1999). The inherent characteristics of the bird, along with environmental influences, are likely to alter postmortem metabolism which largely determines the functional qualities of the meat (Debut et al. 2005). The amount of further processing in the U.S. poultry industry highlights the need for good meat quality.

Although U.S. consumers are accustomed to paying low prices for poultry meat, they are increasingly interested in products that they perceive as naturally-produced or environmentally friendly, provide a high level of nutrition with no contaminants, good flavor, and provide good welfare for the birds. They are interested in traceability in order to have more information about the products they eat. These consumer interests offer opportunities for market segmentation and premium prices for poultry meat in the U.S.

In France, for example, the poultry market is segmented into conventional, Label Rouge, certified, organic, and Appellation D’Origine Controlee (AOC). These products are largely differentiated by the type and age of the bird, because it is considered that fast-growing broilers lack flavor being harvested at a young age (Beaumont et al., 2004). Older birds are considered to have more flavor. The Label Rouge program requires specific slow-growing genotypes and an 81-day growing period, and the products sell for a premium.

While some countries have very specific definitions for free-range and or other specialty production, the U.S. Department of Agriculture (USDA) does not. The term “free-range” is permitted on labels after a review process in which producers submit written descriptions of their production system to ensure it provides outdoor access. In contrast E.U. legislation for “free-range” poultry meat specifies maximum stocking densities for indoor and outdoor areas, age at slaughter, as well as a diet that is at least 70% cereals at finishing, ensuring a low-protein diet for slow growth. In terms of organic production, the USDA’s National Organic Program (NOP) requires outdoor access, organic feeds produced without synthetic chemicals, and prohibits the use of antibiotics, but it does not specify stocking densities or genotypes. In the U.S. slow-growing genotypes are not required in any specialty programs and, in fact, are not widely available. Conventional, fast-growing broilers are typically used in specialty programs.

Because U.S. producers have the option to use any genotype in specialty production and various production practices, it is important to provide information to help them make decisions. It is also important to measure the impact of these practices on consumers. A research program was undertaken at the University of Arkansas to evaluate the impact of alternative genotype, production system, and nutrition on performance and meat quality. There have been few studies of this type under U.S. conditions and with U.S. panelists for sensory evaluation of specialty products. In addition, a domestic slow-growing genotype was used.

**Materials and Methods**

Concurrent experiments were conducted to assess 1) the impact of alternative genotype and production system (Exp. 1) and 2) the impact of genotype and nutrition (Exp. 2) on performance, meat quality, and sensory attributes of specialty meat birds. Specifically, a slow-growing genotype (SLOW) (S&G Poultry Free-Range Slow-Growing hybrid, Clanton, Alabama) and a fast-growing genotype (FAST) (Cobb-Vantress, Siloam Springs, AR) were raised (females) for 91 and 63 days, respectively, or 84 and 56 days in the case of Exp. 2 (males). In each trial, the SLOW birds were placed before the FAST birds in order to achieve a similar final body weight at processing. Each genotype was assigned to four pens of 20 birds each and raised in indoor floor pens in a conventional poultry research facility; each genotype was also assigned to four floor pens in a small facility with outdoor access. The diet was low-nutrient for a slower rate of production as in the French Label Rouge program. In Exp. 2, all birds were raised indoors. The diets compared were a conventional diet (Conv) that met NRC requirements or the low-nutrient (Low) diet. Birds were commercially processed, deboned at 4h postmortem, and meat quality analyses were conducted at 24h postmortem.
or meat was frozen. A descriptive analysis of breast and thigh meat was conducted by a trained panel on treatments in Exp. 1. A consumer analysis was conducted on the SLOW genotype raised with outdoor access and the FAST genotype raised indoors, the two treatments which best represented specialty and conventional products. Data were analyzed by analysis of variance.

Results and Discussion

In Exp. 1, outdoor access had little impact (P > 0.05) on weight gain within genotype, but weight gain of the FAST genotype exceeded (P < 0.05) that of the SLOW birds, even when an attempt was made to reach a similar final body weight (Table 1). Overall feed intake was not affected (P > 0.05) by genotype, but due to the difference in age, there was a large difference in daily feed intake. Outdoor access increased (P < 0.05) feed intake of both genotypes. Feed conversion (feed:gain) worsened (P < 0.05) with outdoor access in both genotypes, and the effect was more pronounced in the slow-growing birds. Cold temperature and exercise can worsen feed efficiency because birds need more energy. In addition, the SLOW birds were much more active than FAST and ventured outside. The low-nutrient diet did not impact (P > 0.05) weight gain of the FAST birds, but reduced (P < 0.05) weight gain of the SLOW genotype. Total weight gain of the SLOW birds fed the conventional diet was similar (P > 0.05) to that of the FAST birds fed either diet. FAST broilers were able to increase (P < 0.05) consumption of the low-nutrient diet to the extent that weight gain was maintained, although feed conversion was worsened (P < 0.05). In contrast, SLOW birds apparently lacked the ability to consume more feed. Overall, the FAST broilers exhibited reduced (P < 0.05) feed intake and improved (P < 0.05) feed conversion compared to the SLOW genotype. The SLOW birds are much less heavily muscled than the FAST and may have lower nutrient requirements especially for amino acids; however, the SLOW may have more feathers which require amino acids. The FAST birds had higher mortality than the SLOW which agrees with other findings (Fanatico et al., 2005a).

The FAST birds had higher breast yield than SLOW (P < 0.05), but there was no impact (P > 0.05) of outdoor access on breast yield (Table 1). This study and previous research (Fanatico et al., 2005a) showed that slow-growing genotypes have a lower percentage of white meat yield and higher percentage of dark meat. Outdoor access resulted in increased leg yield probably due to increased activity (P < 0.05); the impact was greater in the SLOW birds (data not shown). Breast yield was reduced (P < 0.05) in birds fed the Low diet, and the effect on breast yield was more pronounced in the FAST broilers.

In terms of meat quality, the breast meat of the SLOW birds had more protein (P < 0.05) and less fat than the FAST birds, with only one half the amount of intramuscular fat (IMF) in the breast than the FAST birds (P < 0.05). Fat in poultry is mainly subcutaneous or in the abdomen rather than in the meat, but modern domestic poultry selected for rapid growth show excessive body fat deposition (Leclercq, 1988). Outdoor access also resulted in lower fat than indoor (P < 0.05). This is consistent with other studies that have shown that additional space provided in free-range and organic production can increase leanness in poultry, most likely due to activity (Castellini et al. 2002).

Color of the skin is an important feature for whole carcasses, while color of the meat is important for boneless, skinless parts and is an indicator of meat quality. The skin of the SLOW birds had higher b* values (more yellow) than FAST, and when the SLOW had access to the outdoors, their skin became even more yellow than when indoors (P < 0.05). This interaction was in agreement with previous research (Fanatico et al., 2005b) and attributed to the fact that the SLOW birds spent more time outdoors and were more active than the FAST and foraged more. The meat of the SLOW birds was also more yellow (higher b* value) than the meat of FAST birds and showed the same interaction.

The SLOW birds had higher drip loss than the FAST (P < 0.05), which agrees with earlier findings (Fanatico et al., 2005b), but the FAST birds lost more water than the SLOW during cooking (P < 0.05). This is probably due to the fact that the fillets from the FAST birds were larger in size than the SLOW and took longer to cook. In addition, fat was also lost along with moisture in the cooking process, and the FAST were higher in fat. When total moisture loss is considered, the SLOW birds had more moisture loss than the FAST. Castellini et al. (2002) attributed poor water-holding capacity
in slow-growing birds to their tissue being less mature metabolically at harvest than the fast-growing birds.

Texture, particularly tenderness, is a crucial consumer attribute. The SLOW birds were more tender (lower total energy) than the FAST birds in both experiments (P < 0.05). It was expected that the SLOW birds would be less tender than the FAST because the SLOW were older, and in older birds, more of the collagen is cross-linked (Fletcher 2002). Birds with large muscle mass accrete protein through reduced protein catabolism (Dransfield and Sosnicki, 1993). Since they have reduced proteolytic potential, there is less postmortem proteolysis, and therefore, reduced tenderization in the meat. The differences in tenderness due to genotype may be related to the rate of rigor development relative to the time of deboning (4h postmortem). Outdoor access has been shown to result in meat that is more firm than indoor production (Castellini et al. 2002). In this trial, there was a trend for outdoor access to cause the meat to be more firm but only in the case of the SLOW birds. Feed restriction in quantity and quality leads to decreased muscle fiber diameter which can impact texture (Gordon and Charles, 2002; Rehfeldt et al. 2004). However, in the present trial, the Low nutrient diet did not have a significant impact on tenderness (P > 0.05). Although some producers use a low energy diet to raise birds more slowly to improve the meat quality (Dreisigacker 2005), there were no meat quality advantages from using a low nutrient feed in this study.

The sensory attributes of slow-growing French Label Rouge birds at 81 days are expected to include a firmer texture and more flavor than the meat of conventional broilers. Texture analysis was conducted on the breast meat only in this study. In the descriptive analysis, there were few texture differences due to genotype. The descriptive analysis indicated that the breast meat from the Outdoor birds was more cohesive than the meat from the Indoor birds in the first bite stage (P < 0.05) (Table 2). The trained descriptive panel did not note differences in moisture release among any of the products. However, when the consumer panel focused on the appropriateness of the degree of juiciness of the breast meat, significantly more consumers considered the specialty product “much too dry” compared to the conventional meat (P < 0.05). The lower juiciness of the SLOW may be related to the lower content of fat in the meat of the SLOW birds and the higher total moisture loss.

There were no significant differences for most basic tastes; however, both the breast and thigh meat of the FAST birds tasted more salty than the SLOW birds (P < 0.05) (Table 2), although no salt was added to product. There were more flavor differences in the dark meat than white, which is not surprising because the dark meat has more fat and flavor is associated with fat. The thigh meat of the FAST birds had a saltier taste than SLOW birds. The SLOW birds had more dark meat fat flavor than the FAST birds (P < 0.05). Meat flavor increases with age; flavor increases after growth inflection occurs when flavor precursors are deposited in the muscle (Gordon and Charles, 2002). In conventional production, growth inflexion is not reached because the fast-growing birds are slaughtered at a young age. The outdoor access affected the genotypes in different ways, most likely due to the fact that the SLOW birds foraged more actively than the FAST. Forage from pasture may have the potential to contribute to flavor, particularly if it is designed for poultry.

Although a trained descriptive panel detected some texture and flavor differences among products, the untrained consumer panel did not indicate differences in overall liking, appearance, texture, and flavor of the breast meat or thigh meat between specialty and conventional poultry products (P > 0.05) (data not shown). It is important to determine U.S. consumer preferences for specialty poultry products. Long-term exposure to the mild flavor of conventional broiler meat may cause resistance to stronger flavors. Preferences are linked to what customers are accustomed and their habits, and consumer education will need to be part of specialty poultry programs.

We thank U.S. Poultry & Egg Association and USDA SARE for funding for this research.
Table 1. Impact of genotype, production system, and diet on performance and breast meat quality

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Weight gain</th>
<th>Feed intake</th>
<th>Feed:Gain</th>
<th>Breast yield</th>
<th>IMF</th>
<th>b * value</th>
<th>Cook loss</th>
<th>Shear energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exp. 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SLOW-Out</td>
<td>2,254&lt;sup&gt;b&lt;/sup&gt;</td>
<td>8,459&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.75&lt;sup&gt;a&lt;/sup&gt;</td>
<td>18.9&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.47&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7.55&lt;sup&gt;b&lt;/sup&gt;</td>
<td>13.37&lt;sup&gt;d&lt;/sup&gt;</td>
<td>111.16&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>SLOW-In</td>
<td>2,105&lt;sup&gt;b&lt;/sup&gt;</td>
<td>6,752&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3.21&lt;sup&gt;b&lt;/sup&gt;</td>
<td>18.8&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.25&lt;sup&gt;b&lt;/sup&gt;</td>
<td>6.32&lt;sup&gt;b&lt;/sup&gt;</td>
<td>14.58&lt;sup&gt;c&lt;/sup&gt;</td>
<td>102.57&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>FAST-Out</td>
<td>3,370&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8,087&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.40&lt;sup&gt;c&lt;/sup&gt;</td>
<td>30.1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.90&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.84&lt;sup&gt;c&lt;/sup&gt;</td>
<td>22.10&lt;sup&gt;a&lt;/sup&gt;</td>
<td>149.88&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>FAST-In</td>
<td>3,389&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7,402&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.19&lt;sup&gt;d&lt;/sup&gt;</td>
<td>30.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8.86&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.29&lt;sup&gt;b&lt;/sup&gt;</td>
<td>22.10&lt;sup&gt;a&lt;/sup&gt;</td>
<td>149.88&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Pooled SEM</td>
<td>54</td>
<td>172</td>
<td>0.06</td>
<td>0.41</td>
<td>0.33</td>
<td>0.20</td>
<td>0.38</td>
<td>5.10</td>
</tr>
</tbody>
</table>

| Exp. 2        |             |             |           |              |     |           |           |              |
| SLOW-Low      | 2,593<sup>b</sup> | 7,994<sup>a</sup> | 2.96<sup>a</sup> | 18.1<sup>c</sup> | NA  | 3.92<sup>a</sup> | 25.07<sup>a</sup> |
| SLOW-Conv.    | 2,888<sup>b</sup> | 7,959<sup>a</sup> | 2.76<sup>a</sup> | 18.9<sup>c</sup> | NA  | 4.38<sup>a</sup> | 23.92<sup>ab</sup> |
| FAST-Low      | 2,888<sup>b</sup> | 6,404<sup>b</sup> | 2.22<sup>b</sup> | 25.1<sup>c</sup> | 7.23<sup>b</sup> | 2.48<sup>b</sup> | 22.13<sup>b</sup> |
| FAST-Conv     | 2,808<sup>a</sup> | 5,546<sup>c</sup> | 1.97<sup>c</sup> | 27.3<sup>a</sup> | 5.08<sup>b</sup> | 2.85<sup>b</sup> | 18.35<sup>c</sup> |
| Pooled SEM    | 38          | 143         | 0.08      | 0.37          | 0.43 | 0.21      | 0.68      |              |

<sup>1</sup> Genotype and Production System  
<sup>2</sup> Genotype and Diet  
<sup>3</sup> Measured on breast meat  
<sup>4</sup>a-d Means within a column lacking a common superscript differ (P < 0.05)

Table 2. Impact of genotype and production system on texture and flavor attributes<sup>1</sup>

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Initial hardness</th>
<th>Cohesiveness</th>
<th>Number of chews</th>
<th>Salty</th>
<th>White Meat Fat</th>
<th>Sweet Aromatic</th>
<th>Salty</th>
<th>Dark meat fat</th>
<th>Sweet Aromatic</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLOW-Out</td>
<td>5.52&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.30&lt;sup&gt;a&lt;/sup&gt;</td>
<td>21.57&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.36&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.78&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.35&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.15&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.17&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.66&lt;sup&gt;a&lt;/sup&gt;</td>
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<tr>
<td>SLOW-In</td>
<td>5.37&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.81&lt;sup&gt;b&lt;/sup&gt;</td>
<td>20.47&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.61&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.54&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.00&lt;sup&gt;f&lt;/sup&gt;</td>
<td>3.14&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.12&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.34&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>FAST-Out</td>
<td>5.50&lt;sup&gt;c&lt;/sup&gt;</td>
<td>5.88&lt;sup&gt;c&lt;/sup&gt;</td>
<td>21.93&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.51&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.51&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.13&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.43&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3.68&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.46&lt;sup&gt;a&lt;/sup&gt;</td>
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<tr>
<td>FAST-In</td>
<td>5.57&lt;sup&gt;c&lt;/sup&gt;</td>
<td>5.80&lt;sup&gt;b&lt;/sup&gt;</td>
<td>21.87&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.83&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.02&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.27&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.30&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3.60&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.60&lt;sup&gt;a&lt;/sup&gt;</td>
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<tr>
<td>RMSE</td>
<td>0.87</td>
<td>0.80</td>
<td>2.68</td>
<td>0.98</td>
<td>1.60</td>
<td>0.72</td>
<td>0.59</td>
<td>0.77</td>
<td>0.66</td>
</tr>
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</table>

<sup>1</sup> Descriptive analysis was conducted by a seventeen-member trained meat descriptive panel.  
<sup>4</sup>a-d Means within a column lacking a common superscript differ (P < 0.05)

References


