Sensory Attributes of Slow- and Fast-Growing Chicken Genotypes Raised Indoors or with Outdoor Access

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ABSTRACT Consumer interest in free-range and organic poultry is growing. An experiment was conducted to assess the impact of alternative genotype and production systems on the sensory attributes of chicken meat. Specifically, a slow-growing genotype and a fast-growing genotype were raised for 91 and 63 d. The slow-growing birds were placed before the fast-growing birds to achieve a similar final BW at processing. Each genotype was assigned to 4 pens of 20 birds each and raised in indoor floor pens in a conventional research facility; each genotype was also assigned to 4 floor pens in a small facility with outdoor access. The diet was formulated to be low in energy and protein for slow growth. Birds were commercially processed and deboned at 4 h postmortem. A descriptive analysis of breast and thigh meat was conducted on all treatments by a trained descriptive panel. A consumer analysis was also conducted on the breast and thigh meat from only 2 treatments: slow-growing birds raised with outdoor access and fast-growing birds raised indoors. A descriptive analysis indicated that the breast meat from birds with outdoor access was more cohesive than the meat from indoor birds ($P < 0.05$). There were no significant differences for most basic tastes; however, both the breast meat and thigh meat of the fast-growing birds tasted saltier than that of the slow-growing birds ($P < 0.05$). Meat of the slow-growing birds had more dark meat fat flavor than that of the fast-growing birds ($P < 0.05$). Results from the consumer panel showed no significant differences in overall liking, appearance, texture, or flavor of the breast meat or thigh meat. Just-About-Right distributions of consumer responses did not vary between slow-growing birds with outdoor access and fast-growing birds raised indoors for most attributes; however, more panelists found the breast meat of slow-growing birds with outdoor access too dry ($P < 0.05$). Although a descriptive panel detected some differences in texture and flavor among treatments, the consumer panel did not indicate differences in liking between conventional and specialty products.

Key words: meat chicken, organic, free range, sensory

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INTRODUCTION

Consumers in the United States are increasingly interested in products that they perceive as naturally produced or environmentally friendly, that provide a high level of nutrition, that offer good flavor, that improve the welfare of the birds, and that provide information about how the food was produced. These interests have led to specialty markets for poultry produced in alternative systems such as free range or organic. The organic market has strong growth, at about 28% annual growth in the United States, with the organic meat, fish, and poultry category showing the highest growth, at 55% (Heller, 2006). These market trends, like the shift to further processing in the meat industry, are ways to add value to carcasses and open new markets for poultry products.

Although some countries have very specific requirements for specialty poultry production, definitions in the United States are relatively vague. Currently, the USDA allows the term "free range" on product labels after a review process in which producers submit written descriptions of their production system to ensure outdoor access; however, production systems vary widely, from stationary houses with permanent yards to portable houses that are moved frequently to new pasture. In contrast, European Union legislation for free-range poultry meat has detailed standards that specify maximum stocking densities for indoor and outdoor areas, age at slaughter, and a diet with at least 70% cereals at finishing. Likewise, the USDA's National Organic Program standards are more vague for poultry compared with European Union standards, and although the National Organic Program requires outdoor access, it does not specify stocking densities or the use of slow-growing poultry genotypes.

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An additional well-known program in France, Label Rouge, also requires specific slow-growing genotypes, a low-nutrient diet at finishing, and an 81-d growing period (Ministère de L'Agriculture, 1996), and produces poultry that sells for a premium.

In the United States, fast-growing broilers are used in both conventional and specialty poultry production. These modern broilers reach market weight as early as 42 d, but their rapid growth has led to concerns about welfare, especially regarding metabolic and leg disorders. In addition, selection for fast growth and high yield may have an impact on the sensory and functional qualities of the meat (Le Bihan-Duval, 2003; Milosevic et al., 2005). In fact, the French poultry market is segmented according to the age of the bird at slaughter (Appellation D'Origine Controlee, Label Rouge, organic, Certification de Conformite, and conventional) on the basis that older birds have more flavor (Beaumont et al., 2004). These programs use slower-growing birds that take up to 12 wk to reach market weight. Label Rouge products are reported to have more flavor and be more firm than conventional products (Touraille et al., 1981; Castellini et al., 2002b).

In conventional production, broiler diets are typically formulated to meet NRC (1994) recommendations; however, these recommendations were developed for fast-growing broilers in indoor production. European specialty programs use a low-protein diet that supports a slower rate of growth, which is believed to result in higher quality meat (Komprda et al., 2000; Dreisigacker, 2005; Sundrum, 2006).

Because US producers have a relatively large amount of freedom in their decisions about genotypes, production systems, and diets in specialty poultry programs, it is important to evaluate the effects on sensory attributes to help producers make informed decisions about production and to evaluate consumer preferences. Very little research of this type has been conducted in the United States. The objectives of this study were to assess the impact of genotype and production system on sensory attributes. Specifically, slow- and fast-growing genotypes were compared, as well as a conventional indoor production system and an alternative system with outdoor access.

MATERIALS AND METHODS

An experiment was conducted at the University of Arkansas Poultry Research Farm from August to November 2004; all procedures were approved by the University of Arkansas Institutional Animal Care and Use Committee. A slow-growing genotype (S & G Poultry LLC, Clanton, AL) and a fast-growing genotype (Cobb, Siloam Springs, AR) were compared, and only females were used. Because of the difference in growth rate, chick placement dates were staggered in an attempt to reach a similar final BW at the time of processing, as previously reported (Fanatico et al., 2005b). Slow- and fast-growing genotypes were raised for 91 or 63 d, respectively.

The 4 treatments consisted of 1) slow-growing birds given outdoor access (**SO**), 2) slow-growing birds that were confined indoors, 3) fast-growing birds given outdoor access, and 4) fast-growing birds that were confined indoors (**FI**). Four replicate pens per treatment, containing 20 birds per pen, were used.

Birds in indoor treatments were raised in floor pens in a conventional poultry research facility that contained a concrete floor, side curtains, and fans for ventilation and cooling. A thermostatically controlled heater and gas brooders, which extended along the length of the house, were used to provide additional heat during brooding. The indoor pens measured 1.8×1.8 m (6.2 birds/m^2) and contained 1 bell waterer and a hanging tube feeder. Pens contained new wood shavings, and a constant photoperiod of 24 h was provided.

Birds with outdoor access were raised in a small facility measuring 3.7×5.5 m; the facility was portable but not moved during the trial. The facility was insulated and naturally ventilated, but had no access to power. Propane space heaters were used to keep nighttime temperatures above 15.5°C inside the house. No artificial lighting was used; the photoperiod was limited to natural daylight. The house was subdivided into 8 indoor pens that opened onto 8 separate yards, which were surrounded by electric net fencing. The indoor area of each pen measured 1.2×1.5 m (11.1 birds/m^2); all pens allowed outdoor access to grassy yards through bird exits (0.6 m wide $\times$ 0.5 m high). Birds were allowed access to the outdoors during daytime hours unless the outdoor temperature was less than 4.4°C. The outdoor portion of each pen had an area of 9.3 m^2 and was completely covered with grassy vegetation. The indoor portion of each pen contained 1 fount-type waterer and a hanging tube feeder, and the floor was covered with fresh wood shavings. The outdoor portion of each pen contained 1 waterer and a range-type tube feeder with a rain shield.

All chicks were brooded in the indoor facility; chicks in the treatments with outdoor access were moved to the portable facility after 3 wk of age. All birds were provided with multistage diets (Table 1) that were formulated to be low in protein and energy, similar to diets (Lewis et al., 1997; Grashorn, 2006) used in extensive production in Europe. All diets were devoid of animal by-products; anticoccidial medication was included. Feed and water were freely available.

At trial termination, all birds were commercially processed at the University of Arkansas Pilot Processing Plant. Feed was withheld for 10 h before slaughter and birds were weighed individually at the plant. Automated equipment was used for stunning, scalding, picking, vent opening, and evisceration. Birds were electrically stunned (11 V, 11 mA, 10 s) followed by scalding at 53°C for 120 s. Carcasses were prechilled at 12°C for 15 min and chilled (immersion) at 1°C for 1 h. After chilling, the carcasses were aged on ice for an additional 2.5 h before hand deboning at 4 h postmortem. Pectoralis major samples were then collected for evaluation of sensory attributes.

Table 1. Composition of the experimental diet

Item	Starter	Grower I	Grower II	Finisher
Ingredient	%			
Corn	61.5	64.8	69.9	72.1
Soybean meal	29	21	15	10.5
Wheat middlings	6	11	12	14.3
Corn oil	0	0	0	0
Dicalcium phosphate	1.4	1.2	1	1
Limestone	1.3	1.3	1.4	1.4
NaCl	0.4	0.3	0.3	0.3
Vitamin mix[1]	0.2	0.2	0.2	0.2
Mineral mix[1]	0.1	0.1	0.1	0.1
Choline Cl (60%)	0.1	0.1	0.1	0.1
DL-Met	0	0	0	0
Sacox salinomycin[2]	0.05	0.05	0.05	0.05
Calculated composition				
ME (kcal/kg)	2,886	2,902	2,956	2,956
CP (%)	20.5	17.7	15.5	13.9
Digestible Lys (%)	0.94	0.76	0.76	0.76
Digestible Met (%)	0.31	0.27	0.28	0.28
Digestible Cys (%)	0.31	0.28	0.29	0.29
Digestible Thr (%)	0.65	0.55	0.53	0.53

[1]Provided (per kilogram of diet): vitamin A, 7,715 IU (retinyl acetate); cholecalciferol, 2,204 IU; vitamin E, 16.5 IU (DL-α-tocopheryl acetate); thiamin, 1.54 mg; niacin, 38.6 mg; riboflavin, 6.6 mg; D-calcium pantothenate, 9.9 mg; vitamin B_{12}, 0.013 mg; vitamin B_6, 2.8 mg; D-biotin, 0.07 mg; folic acid, 0.88 mg; menadione dimethylpyrimidinol bisulfite, 3.30 mg; choline, 400 mg; ethoxyquin, 125 mg; Se, 0.1 mg; $MnSO_4 \cdot H_2O$, 308 mg; $FeSO_4 \cdot 7H_2O$, 250 mg; $ZnSO_4 \cdot 7H_2O$, 440 mg; $CuSO_4 \cdot 5H_20$, 39.3 mg; MgO, 43.9 mg; $Ca(IO_3)_2 \cdot H_2O$, 3.2 mg (Emmert et al., 1999).

[2]Sacox 60 (Hoechst-Roussel Agri-Vet. Co., Somerville, NJ). Provides 66 mg/kg of salinomycin activity.

The left breast and thighs were frozen at 48 h postmortem and stored at −26°C until sensory analysis. After thawing the meat, breast fillets were cooked on racks in aluminum-lined, covered pans to an internal temperature of 76°C. Thigh meat was cooked with the skin on, which was removed prior to presentation to panelists. Meat was cut into 0.75-inch, bite-size cubes and was not seasoned or salted. Descriptive analysis was conducted on breast and thigh meat at the University of Arkansas Department of Food Science sensory facility.

A descriptive analysis was conducted by a trained meat descriptive panel (15 to 17 members; Sensory Spectrum Inc., Chatham, NJ). An initial orientation was held to refine flavor and texture definitions. The trained panel used descriptive textural attributes to evaluate tenderness characteristics of breast meat. Initial hardness, cohesiveness, and moisture release were evaluated in the first-bite stage, whereas hardness of mass, cohesiveness of mass, fibrousness, and number of chews to swallow were evaluated in the chew-down stage. Intensities of each of the texture attributes from each breast sample were compared with references of assigned intensities (Cavitt et al., 2004). All intensities were expressed to 1 significant digit on 15-point numerical scales, with higher scores indicating higher attribute intensities.

The descriptive panel used 16 descriptive flavor terms to describe the white meat: sweet, salty, sour, bitter, cooked white meat, white meat fat, blood serum-metallic, sweet aromatic, other, astringent, metallic, and associated aftertastes. Dark meat flavor was described with 18 similar flavor terms.

Panelists were randomly presented samples from all treatment groups in duplicate. Between each sample, panelists were instructed to cleanse their palates with distilled water and unsalted crackers. A 15-min break period was allocated to the panelists halfway through the session.

A consumer test was conducted on the breast and thigh meat from the SO and FI birds. These treatments were chosen for consumer testing because they best represented the alternative and conventional systems. Consumer panelists were recruited via a panelist database housed at the University of Arkansas Food Science Department, and selection of panelists (81) was based on consumption patterns of white and dark poultry meat and on the consumption of natural or organic poultry products, or both. The sensory facility had individual booths with computerized data collection, and panelists were served through a hatch door. Breast fillets and thighs were prepared by using the same cooking parameters and procedures as described for the descriptive analysis.

Consumer panelists were each served samples from the different treatments 1 at a time and were instructed to cleanse their palates between samples. They were asked to evaluate their overall liking of the product; liking of appearance, texture, and flavor; and appropriateness of color, tenderness, juiciness, and flavor. They were also asked to indicate the likelihood that they would buy the product and if they would pay more for the product than for their usual poultry product. Nine-point hedonic scales were used to assess overall liking and liking of appearance, texture, and flavor (1 = dislike extremely, 5 = neither like nor dislike, 9 = like extremely). Just-About-Right (**JAR**) scales were used to assess the appropriateness of color (1 = much too light, 2 = too light, 3 = just about right, 4 = too dark, 5 = much too dark), the appropriateness of tenderness (1 = much too tough, 5 = much too tender), the appropriateness of juiciness (1 = much too dry, 5 = much too juicy), and the appropriateness of flavor (1 =

Table 2. Impact of genotype (G) and production system (PS) on intensities[1] of texture attributes of breast meat (descriptive panel)

	PS[2]					ANOVA, *P*-value		
Attribute	SO	SI	FO	FI	RMSE[3]	G	PS	G × PS
Initial hardness	5.52	5.37	5.50	5.57	0.87	0.5787	0.7771	0.4828
Cohesiveness	6.30	5.81	5.88	5.80	0.80	0.1435	0.0534	0.1698
Moisture release	0.66	0.74	0.69	0.76	0.48	0.7323	0.4037	0.9697
Cohesiveness of mass	6.38	6.48	6.05	6.39	0.82	0.1606	0.1480	0.4313
Hardness of mass	5.11	4.82	4.80	4.91	0.82	0.4770	0.5483	0.1911
Fibrousness	3.49	3.51	3.64	3.6	0.70	0.3623	0.9376	0.8347
No. of chews to swallow	21.6	20.5	21.9	21.9	2.7	0.0740	0.2359	0.2935

[1]Intensities are based on 15-point scales; higher numbers are associated with higher intensities. There were no differences among treatments ($P > 0.05$).

[2]SO = slow-growing birds given outdoor access; SI = slow-growing birds that were confined indoors; FO = fast-growing birds given outdoor access; FI = fast-growing birds that were confined indoors.

[3]Root mean square error.

much too weak, 5 = much too strong). Samples were randomized by product type and then by meat type (breast meat or thigh meat). The JAR scales are useful for diagnostics, because hedonic scales do not allow determination of the appropriateness of intensity of the attribute (Meilgaard et al., 1999).

Statistical Analysis

The descriptive panel sensory data were analyzed as a completely randomized design with a 2 × 2 factorial treatment structure (genotype, production system). Genotype and production system were treated as fixed effects, and panelist was treated as a random effect. Treatment means were separated by Fisher's protected least significant differences. The consumer panel sensory data were analyzed as a paired *t*-test, with panelist as the blocking variable. The JAR scores were compared with a χ^2 test for equality of distributions, except in those cases in which small expected counts may have substantially affected the approximate *P*-value from the χ^2 test. In those cases, Fisher's exact test was used (Fleiss, 2003). *P*-values of less than 0.05 were considered to be statistically significant. All statistical analyses were carried out with SAS, version 9 (SAS Institute Inc., Cary, NC).

RESULTS AND DISCUSSION

Texture

Texture is the most important attribute in consumers' final satisfaction with poultry meat (Fletcher, 2002). Texture is a multidimensional attribute and is described in several stages: partial compression, first bite, chew-down, and residual (Meilgaard et al., 1999). Texture analysis was conducted on the breast meat only in this study.

The descriptive panel found a trend for breast meat from the outdoor birds to be more cohesive than that from the indoor birds in the first-bite stage ($P = 0.053$; Table 2). Cohesiveness refers to the degree to which the sample deforms rather than rupturing when chewing (Meilgaard et al., 1999). This result is in agreement with other research showing that outdoor access results in meat that is more firm than meat produced indoors (Castellini et al., 2002b; Santos et al., 2005). Exercise may cause a strengthening of connective tissue fiber structure (Aberle et al., 2001) and can also affect fiber type proportions. Pingel and Knust (1993) found that free-range ducks had more red fibers than indoor ducks, and the diameters of both red and white muscle fibers were smaller in free-range birds. The diameter of the muscle fiber is positively related to the tenderness of the meat; however, according to Dingboom and Weijs (2004), the impact of exercise on meat quality is minor and ambiguous.

In the current study, few texture differences were due to genotype, although numerically more chews were needed to swallow breast meat of the fast-growing birds compared with that of slow-growing birds. This trend corresponds to instrumental tests, in which the meat of slow-growing birds was significantly more tender than that of fast-growing birds (Fanatico et al., 2005c). Although this result agrees with some studies (Farmer et al., 1997; Grashorn, 2006), in other studies the meat of slow-growing or older genotypes was found to be less tender compared with that of fast-growing birds (Touraille et al., 1981; Castellini et al., 2002a; Wattanachant et al., 2004; Fanatico et al., 2005a). Although all treatments were deboned at 4 h postmortem, it is possible that fast- and slow-growing genotypes have different rates of rigor caused by their different BW. Tenderness is influenced by both the maturity of connective tissues and the contractile state of myofibrillar proteins (Fletcher, 2002), and tenderness tends to decrease as animals age because of cross-linking of collagen (Fletcher, 2002; Aberle et al., 2001). Because conventional broilers are marketed very young, maturity is not an issue; however, specialty birds are usually older.

Muscle fiber size is associated with genotype and, as already discussed, can influence tenderness. Muscle fibers in fast-growing lines are more numerous and have a wider diameter than muscle fibers in slower-growing lines (Rémignon et al., 1994). Extreme hypertrophy of muscle fibers is an indicator of poor meat quality (Rehfeldt et al., 2004), and selection for a more moderate fiber

Table 3. Comparison of sensory attributes of specialty and conventional poultry products (consumer panel)[1]

Product	Specialty, SO	Conventional, FI	RMSE[2]	P-value[3]
Breast				
Overall	6.68	6.67	1.6737	0.9622
Appearance	7.05	7.30	1.1179	0.1586
Texture	6.52	6.68	1.7484	0.5559
Flavor	6.48	6.73	1.4956	0.2907
Thigh				
Overall	6.05	6.41	1.6292	0.1755
Appearance	5.67	5.95	1.79	0.3312
Texture	6.22	6.60	1.72	0.1832
Flavor	6.22	6.32	1.50	0.6726

[1]9-point hedonic scales were used to assess overall liking and liking of appearance, texture, and flavor (1 = dislike extremely, 5 = neither like nor dislike, 9 = like extremely). There were no significant differences between treatments ($P > 0.05$). SO = slow-growing birds given outdoor access; FI = fast-growing birds that were confined indoors.

[2]Root mean square error.

[3]P-values for no difference in mean score.

size is needed. The low-nutrient diet used in extensive production in Europe may result in smaller fibers, because feed restriction in quantity or quality leads to decreased muscle fiber diameter (Rehfeldt et al., 2004). According to Farmer et al. (1997), small muscle fiber results in more tender breast meat. Furthermore, Roy et al. (2006) found that a high-nutrient diet contributes to a wider layer of perimysial connective tissue, which may influence meat tenderness.

Although the trained descriptive panel found some differences in texture among treatments, the untrained consumer panel found no significant differences in the texture of the breast meat or thigh meat of SO (specialty) or FI birds (conventional; $P > 0.05$; Table 3). The distributions of consumer responses on the JAR scales used to assess the appropriateness of attributes did not vary for tenderness between the SO and FI treatments ($P > 0.05$). Because consumers are not trained, as a descriptive panel is trained, to detect subtle differences in texture, it is not surprising that the consumer panel found no differences in texture. In previous research with specialty poultry products, consumers found that medium-growing genotypes had a higher intensity of tenderness than slow- and fast-growing genotypes and that birds raised with outdoor access were less tender than those raised indoors; however, they indicated no difference in liking of texture or tenderness in specialty genotypes or production systems (Fanatico et al., 2006).

Juiciness

Juiciness is a crucial sensory attribute (Latter-Dubois, 2000). The descriptive panel did not note differences in moisture release among any of the products ($P > 0.05$; Table 2). However, when the consumer panel focused on the appropriateness of the degree of juiciness of the breast meat, 8.9% of consumers considered the specialty product "much too dry" compared with 0% who considered the conventional meat "much too dry" ($P < 0.05$; Table 4). This agrees with previous research in which breast meat from slow-growing birds was considered too dry in JAR analyses (Fanatico et al., 2005a). This may be explained in part by the size of the breast fillet. Because the fillets from the slow-growing birds are smaller and thinner in dimension, they had relatively more surface area in relation to muscle mass exposed to the air, which likely caused higher drip loss (Fanatico et al., 2005c).

The lower juiciness of the breast meat of the slow-growing genotype may also be related to the lower content of intramuscular fat. In the present study, the slow-growing birds had half the amount of intramuscular fat of the fast-growing birds (Fanatico et al., 2005c). However, Chartrin et al. (2006) found that although breast muscle with higher lipid levels had higher tenderness scores, juiciness was not associated with fat levels, but rather with water levels in breast muscle. In samples in which differences in fat content exist, juiciness may need to be evaluated early (initial) and later (sustained) in the chewing process (American Meat Science Association, 1995).

In this study, more than 20% of panelists felt that both the specialty and conventional products were "too dry" or "much too dry." It is important to note that these were not enhanced poultry products with added water, salt, and phosphates to which consumers are accustomed, nor were the products prepared with ingredients such as salt or other seasonings that stimulate saliva.

Flavor

Flavor is a combination of taste and smell. Taste buds principally taste sweet, sour-acid, salt, bitter, and umami, because of compounds present in meat (Farmer, 1999). In contrast to the taste compounds, aroma compounds are largely formed by chemical reactions during cooking (Farmer, 1999). There was a trend for breast meat of the fast-growing birds to be considered more salty than that of the slow-growing birds ($P = 0.0545$; Table 5) even though no salt was added to the product, which may be related to the fat content of the fast-growing birds. There were more differences in flavor among treatments in dark meat than in breast meat, which is not surprising, because the dark meat has more fat and flavor is positively correlated with the lipid level (Chartrin et al., 2006). The thigh meat of the fast-growing birds also had a saltier taste than that of slow-growing birds, as well as a more astringent sensation ($P < 0.05$). The thigh meat of the slow-growing birds had more dark meat fat flavor than that of the fast-growing birds ($P < 0.05$).

Meat flavor increases with age, likely because of the increased concentration of nucleotides in muscle, which degrade to inosinic acid and hypoxanthine after death (Aberle et al., 2001). According to Farmer (1999), age has a consistent effect on flavor, whereas genotype, sex, weight, and production system have more varying effects. Flavor increases after growth inflection occurs (the age at which gain is maximum) when flavor precursors are deposited in the muscle (Gordon and Charles, 2002). In conventional

Table 4. Distribution of Just-About-Right responses for sensory attributes of specialty (SO) and conventional (FI) poultry products (consumer panel)[1]

	Breast meat			Thigh meat		
Item	SO (%)	FI (%)	P-value[2]	SO (%)	FI (%)	P-value[2]
Color			0.4645			0.3745
Much too light	2.53	0		0	0	
Too light	16.46	18.99		53.16	54.43	
Just about right	77.22	79.75		53.16	54.43	
Too dark	3.80	1.27		40.51	37.97	
Much too dark	0	0		6.33	3.80	
Tenderness			0.9858			0.2534
Much too tough	5.06	3.80		2.53	0	
Too tough	18.99	21.52		21.52	11.39	
Just about right	70.89	69.62		67.09	75.95	
Too tender	3.80	3.80		6.33	8.86	
Much too tender	1.27	1.27		2.53	3.80	
Juiciness			0.0073*			0.9309
Much too dry	8.86[3]	0[3]		0	0	
Too dry	37.97	27.85		15.19	12.66	
Just about right	49.37	62.03		72.15	75.95	
Too juicy	2.53	8.86		11.39	10.13	
Much too juicy	1.27	1.27		1.27	1.27	
Flavor			0.4033			0.9510
Much too weak	5.06	1.27		3.80	1.27	
Too weak	26.58	32.91		17.72	17.72	
Just about right	58.23	59.49		63.29	65.82	
Too strong	10.13	6.33		12.66	12.66	
Much too strong	0	0		2.53	2.53	
Purchase			0.2894			0.2617
Definitely would not buy	11.39	3.80		16.46	12.66	
Probably would not buy	26.58	21.52		24.05	22.78	
May or may not buy	16.46	20.25		13.92	24.05	
Probably would buy	26.58	36.71		29.11	32.91	
Definitely would buy	18.99	17.72		16.46	7.59	
Price			0.9126			0.0325*
Definitely would not pay more	3.65	26.58		30.38	26.58	
Probably would not pay more	26.58	26.58		20.25	17.72	
May or may not pay more	22.78	27.85		27.85	32.91	
Probably would pay more	16.46	15.19		10.13	21.52	
Definitely would pay more	2.53	3.80		11.39[4]	1.27[4]	

[1]SO = slow-growing birds given outdoor access; FI = fast-growing birds that were confined indoors.

[2]P-values for test of equality of distribution.

[3]P = 0.0136 based on Fisher's exact test.

[4]P = 0.0177 based on Fisher's exact test.

*Distributions differ for SO and FI (P < 0.05).

production, growth inflexion has not yet been reached when fast-growing birds are slaughtered at 42 d, although in the present study the fast-growing birds were 63 d at slaughter. The conventional bird is generally young, very tender, and juicy but has a less intense flavor (Le Bihan-Duval, 2003). Touraille et al. (1981) compared slow- and fast-growing genotypes and found more flavor in breast and thigh meat in the slow-growing birds when the genotypes were compared at different ages (63 and 144 d), but when the genotypes were compared at the same age, there were no differences. Species flavor and aroma are also thought to come from materials in fat, which volatilize when heated (Aberle et al., 2001). More than 450 components have been characterized in cooked poultry meat, with lipid-derived compounds, such as aldehydes, participating in reactions that result in chicken flavor (Chen and Ho, 1998).

Outdoor access affected the genotypes in different ways. When the slow-growing birds had outdoor access, their thigh meat tasted sweeter (P < 0.05; Table 5). The fast-growing birds had a stronger intensity of blood serum-metallic aromatic when they had outdoor access; the intensity was stronger for the slow-growing birds when they were raised indoors (P < 0.05). When the slow-growing birds had outdoor access, their dark meat was sweeter aromatic, but in the fast-growing birds, the sweet aromatic was more intense when the birds were indoors (P < 0.05). These interactions between genotype and production system are likely because the slow-growing birds foraged more than the fast-growing birds. Meat from animals that have the opportunity to exercise, including game animals, may have more flavor, because inosine monophosphate and hypoxanthine are breakdown products of adenosine triphosphate and enhance flavor (Aberle et al., 2001). Large energy stores in muscle also contribute to flavor (Aberle et al., 2001).

Pasture may have the potential to contribute to flavor, particularly if it is designed for poultry. However, most pasture used in free-range poultry production is designed to be hard-wearing lawn, as in the present study. Diet

Table 5. Descriptive panel analysis of genotype (G) and production system (PS) effects on flavor attributes[1]

	PS					ANOVA, *P*-value		
Item	SO	SI	FO	FI	RMSE[2]	G	PS	G × PS
Breast								
Sweet	0.08	0.12	0.11	0.08	0.1450	0.8719	0.2907	0.6443
Salty	2.36	1.61	2.51	2.83	0.9774	0.0545	0.1141	0.1014
Sour	1.22	1.19	1.20	1.37	0.7886	0.4248	0.4176	0.4530
Bitter	1.66	1.96	1.80	1.86	2.0485	0.7544	0.6809	0.8828
Cooked white meat	4.36	4.30	4.61	3.99	2.02	0.8460	0.3920	0.5118
White meat fat	1.78	1.54	1.51	2.02	1.6021	0.7053	0.6609	0.2848
Blood serum-metallic	2.61	2.03	2.14	18.5	1.5933	0.3294	0.2196	0.5353
Sweet aromatic	0.35	0	0.13	0.27	0.7202	0.8980	0.4992	0.1121
Other	1.65	1.95	2.21	1.98	2.4900	0.4906	0.9180	0.7690
Astringent	4.85	4.95	5.07	5.24	2.3314	0.6861	0.6119	0.5754
Metallic	1.36	1.82	1.64	1.10	1.2427	0.6975	0.8787	0.1241
Aftertaste								
Cooked white meat	2.69	2.76	3.10	2.57	1.4849	0.9371	0.4266	0.2984
White meat fat	0.93	1.01	1.06	1.38	1.3276	0.3353	0.4688	0.5981
Blood serum-metallic	1.35	1.30	1.24	0.92	1.2837	0.3604	0.5354	0.7165
Sweet aromatic	0.26	0.04	0	0.24	0.5503	0.6555	0.8486	0.0851
Other	1.59	2.25	1.79	3.13	4.0226	0.2951	0.2016	0.5209
Thigh								
Sweet	0.18[a]	0.07[b]	0.07[b]	0.08[b]	0.1734	0.1058	0.1299	0.0426
Salty	3.15[3]	3.14[3]	3.43[3]	3.30[3]	0.5910	0.0440	0.5179	0.5380
Sour	0.72	0.89	0.82	0.81	0.5976	0.9272	0.4838	0.4114
Bitter	0.35	0.31	0.33	0.33	0.3599	0.9596	0.7615	0.8033
Cooked dark meat	5.79	5.85	5.77	5.89	0.6148	0.9057	0.4418	0.7671
Dark meat fat	4.17[3]	4.12[3]	3.68[3]	3.60[3]	0.7731	0.0005	0.6631	0.8969
Brothy	1.63	1.52	1.26	1.40	0.8137	0.1093	0.9287	0.4083
Blood serum-metallic	3.16[b]	3.78[a]	3.71[a]	3.44[ab]	0.7256	0.4827	0.2113	0.0016
Sweet aromatic	0.66	0.34	0.46	0.60	0.6577	0.8139	0.4470	0.0600
Other	0	0	0.1	0	0.2739	0.3197	0.3197	0.3197
Astringent	5.47[3]	5.39[3]	5.69[3]	5.93[3]	0.7544	0.0069	0.5626	0.2384
Metallic	1.29	1.41	1.57	1.50	0.6682	0.1291	0.8487	0.4144
Aftertaste								
Cooked dark meat	3.62[3]	3.62[3]	3.76[3]	3.97[3]	0.6242	0.0328	0.3515	0.3515
Dark meat fat	2.76	2.81	2.64	2.58	0.6678	0.1649	0.9999	0.6485
Brothy	0.42	0.47	0.44	0.50	0.6967	0.8140	0.6569	0.9583
Blood serum-metallic	2.25[b]	2.74[a]	2.59[ab]	2.31[ab]	0.8374	0.7608	0.5006	0.0130
Sweet aromatic	0.31	0.33	0.33	0.33	0.4472	0.8706	0.8706	0.8706

[a,b]Means within a row lacking a common superscript differ ($P < 0.05$).

[1]Intensities with a higher number are stronger (15-point scales). SO = slow-growing birds given outdoor access; SI = slow-growing birds that were confined indoors; FO = fast-growing birds given outdoor access; FI = fast-growing birds that were confined indoors.

[2]Root mean square error.

[3]Genotype main effect was significant ($P < 0.05$).

manipulation could offer the potential to enhance poultry flavor, and some forages, such as rosemary, may result in distinctive flavors (Gordon and Charles, 2002).

Although the descriptive panel detected some flavor differences among products, the consumer panel did not indicate differences in liking of flavor between specialty and conventional poultry products ($P > 0.05$; Table 3). Nor did the distributions of consumer responses for the JAR analyses differ for flavor between the SO and FI treatments ($P > 0.05$; Table 4).

In this trial, breast meat was cooked without the skin, following the usual protocol in sensory methodology for both the descriptive and consumer panels; however, in the future, it may be useful to cook the breast meat with the skin on, because much of the flavor is in the fat, which is predominantly in the skin.

Overall Sensory and Consumers

The experience of eating meat does not cause separate impressions of tenderness, juiciness, and flavor, but rather an overall impression (Aberle et al., 2001). Although the descriptive panel detected some differences, especially in flavor of dark meat, the consumer panel showed no significant differences in overall liking, appearance, texture, and flavor of the breast meat or thigh meat of SO (specialty) or FI birds (conventional; $P > 0.05$). Interestingly, in this blind test, 11% of consumers indicated they would pay more for the specialty product dark meat compared with only 1% who would pay more for the conventional product ($P < 0.05$; Table 4). This is likely related to the higher flavor intensities detected by the descriptive panel in the dark meat of the slow-growing birds.

Overall, genotype had more impact on sensory attributes than does production system. This is in agreement with Ristic (2003), who compared fast- and slow-growing genotypes raised in conventional and organic production systems and found that although the production system did not affect sensory attributes, length of grow-out and genotype did. In contrast, Castellini et al. (2002a) found that organic production resulted in better sensory attributes than conventional production in terms of overall acceptability and juiciness.

Some studies have compared products at retail rather than isolating the impact of factors such as production system and genotype. Jahan et al. (2005) compared corn-fed, organic, and free-range breast fillets and found that corn-fed fillets were distinguished on the basis of appearance but not flavor, likely because of the accumulation of pigments in corn. Organic fillets were distinguished on the basis of texture. Free-range fillets were generally similar to conventional products, probably because the birds at 56 d were only a little older than those produced conventionally. Only some assessors were able to differentiate organic from other products on the basis of aroma and flavor (Jahan et al., 2005). Lawlor et al. (2003) compared sensory attributes of chicken breasts from organic, corn-fed, free-range, and conventional birds and found that consumers preferred free-range products. Grashorn and Serini (2006) found that organic breast and thigh meat were juicier and less tender than conventional chicken meat, but exhibited a superior flavor.

Consumers may buy specialty poultry for other reasons besides eating quality, such as a concern about the environmental impact or the welfare of the birds, or consumers may believe that meat from free-range birds is healthier than meat from birds raised indoors. Many consumers want more information about how their food is raised. In a survey by Latter-Dubois (2000), the main reasons Canadian consumers bought specialty (grain-fed) poultry were because of "better flavor" (34.16%), "raised without medicine/hormones" (27.23%), "less fat" (15.84%), "methods more humane" (12.87%), and "higher protein" (9.90%).

It is important to determine US consumer preferences for specialty poultry products. Preferences are linked to what customers are accustomed to and their habits. Long-term exposure to the tender texture of conventional broiler meat may cause resistance to a firmer meat texture. In fact, no upper limit to the amount of tenderness desired by US consumers has been found (Jean-Francois Meullenet, University of Arkansas, Fayetteville, personal communication). Likewise, consumers are accustomed to mildly flavored broiler meat instead of a more intense, rich flavor. Experience with eating different types of poultry products will help consumers develop their preferences. A large part of the success of the Label Rouge product in France is attributed to the very successful education and marketing program in France (Fanatico and Born, 2002). Grashorn and Serini (2006) have suggested new quality criteria for organic chicken meat, because consumer panels are not as familiar with specialty meat as conventional meat.

In conclusion, although the descriptive panel found some differences among the treatments, the consumer panel did not detect differences between SO and FI, which represented specialty and conventional products, respectively. However, 8.9% of consumer panelists considered the breast meat of the specialty product to be "much too dry" compared with conventional meat, whereas 11% of consumer panelists indicated they may be willing to pay more for specialty dark meat than for conventional dark meat. In some markets, other attributes besides sensory characteristics may appeal to consumers, such as the type of production system (e.g., free-range, organic) or type of poultry (e.g., slow-growing, fast-growing).

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