Response of Large Tom Turkeys Differing in Growth Characteristics to Divergent Feeding Systems: Performance, Carcass Quality, and Sensory Evaluation

E. T. MORAN, JR.,[1] L. M. POSTE,[2] P. R. FERKET,[1] and V. AGAR[2]

Department of Animal and Poultry Science, University of Guelph, Guelph, Ontario, Canada N1G 2W1

and

Food Research Institute, Research Branch, Agriculture Canada, Ottawa, Ontario, Canada K1A 0C6

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ABSTRACT A feeding system representing North American (NA) circumstance was compared with a successful extreme used in the European Economic Community (EEC) on three strains of large toms [Nicholas, British United (BUT), and Hybrid]. The NA system used six feeds to 24 weeks based on National Research Council (1977) specifications with corn, soybean meal, and fat as primary ingredients. The EEC extreme further employed fish meal, wheat, and barley in five feeds. Each EEC feed had a lower energy level and energy-protein ratio than the respective NA feed with these differences increasing from starting to finish.

The BUT toms had the heaviest final body weight and the EEC system supported better gain with this strain than the NA system. Nicholas and Hybrid toms had equivalent final weights with each feeding system eliciting similar gains. Marketing at 20 and 24 weeks gave the same relative weight results. Additional finish, fleshing, and breast yields by Nicholas at 20 weeks indicated an advanced maturity compared to the other strains. Sensory evaluation on cooked grade A carcasses at 20 weeks favored Nicholas in a comparison with BUT.

Overall results indicated that the strains differed in growth characteristics, particularly between 12 and 20 weeks with the onset of sexual maturity. Interaction between strain and feeding system at this time was attributed to different energy-protein needs rather than involving number of feeds, time sequencing, feedstuffs used, or plane of nutrition.

(*Key words:* turkey, feeding system, meat yield, sensory evaluation)

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INTRODUCTION

The performance of large turkeys grown on commercial farms in the US has not improved over the past several years (Sell, 1983). Nixey (as cited by Smith, 1982 and through personal communication) claimed that turkeys produced in the European Economic Community (EEC) during this same interval not only improved on their rate gain but presently have heavier final body weights than those in the US Feed formulation on both continents generally relies on National Research Council (NRC, 1977) nutrient recommendations; however, the EEC has increased the use of regimens not common to North America that involve fewer feeds each having a reduced energy content. Nixey (Smith, 1982) credits these new feeding systems for the improved production within the EEC more than possible strain or environmental differences in North America.

Present experimentation compared a representative feeding situation used in North America with an extreme considered successful in England (*ca.* 2925 kcal metabolizable energy (ME)/kg as a "fixed" energy level). Both regimens were given to commercial strains of toms known to differ in their growth characteristics. Examination of these variables not only considered live performance but also carcass quality and sensory evaluation of the final product.

MATERIALS AND METHODS

Live Animal Procedures. Male poults were locally obtained to represent the Nicholas Turkey Breeding Farms, Sonoma, CA (Nicholas); British United Turkey Ltd. (BUT), Chester, England; and Hybrid Turkeys Ltd., Kitchener, Ontario (Hybrid). Nicholas poults originated from a 47-week-old breeder flock. The BUT

[1] Department of Animal and Poultry Science.
[2] Food Research Institute.

poults were from a 36-week-old breeder flock. Nicholas and BUT eggs were set together in the same hatchery. Flock age for the Hybrid eggs was not known and they were set at a different hatchery than the Nicholas and BUT but in the same time frame.

The feeding system used to represent North America (NA) employed six feeds from poult placement to termination at 24 weeks of age (Table 1). Protein and energy levels changed with age in approximation to NRC (1977) recommendations, and corn, soybean meal, and fat were the primary ingredients for all feeds. The EEC extreme was provided in a personal communication by C. Nixey, and the EEC extreme largely represented circumstances in England where wheat, barley, and fish meal are prevalent feedstuffs. Five feeds were used from start to finish. The feeds for both systems were given in crumb form until 8 weeks of age and as whole pellet thereafter.

Poults were brooded in floor pens of a controlled environment house for the first 8 weeks (4 replicate pens of *ca.* 50/pen per treatment, 1,200 total birds), then they were transferred to a pole bar for the remainder of the experiment (8 replicate pens of *ca.* 24/pen/treatment). Beak trimming and wingbanding were done at 2 weeks. Environmental conditions while birds were in the pole barn corresponded to June through September. Lighting was continuous at all times with minimal intensity at *ca.* 30 lx.

Carcass Evaluation. One-half of the toms in each pen was commercially slaughtered at 20 weeks of age with the remainder following at 24 weeks. Dressing yield was determined on all toms from their carcass weight immediately after chilling. An Agriculture Canada grader subjectively evaluated each carcass for the individual factors comprising quality (Canada Agricultural Products Act, 1959).

Two sample carcasses from each pen were cut into recognized commercial parts, and yield for each was determined. Breast and thigh were further separated into meat, skin, and bone.

Sensory Evaluation. Nicholas and BUT strains that had received the EEC and NA feeding systems were examined for eating quality. Carcasses having an average "A" grade for conformation, fleshing, and finish were selected from the birds slaughtered at 20 weeks of age. Each carcass was vacuum packaged in a shrinkable vapor-proof film bag and stored at −20 C for 4 months prior to evaluations.

Four carcasses represented each strain and feeding system. All treatments were evaluated on each of 4 test days. Frozen carcasses were allowed to thaw under refrigeration at 4 C for 6 days prior to each test day. Thawed carcasses, covered with foil were simultaneously cooked in four electric ovens (163 C) until the internal breast temperature reached 85 C. At an internal temperature of 70 C the foil was removed. Cooking loss was recorded 10 min after removal from the oven. Cooling ensued at room temperature for 2 hr, then 6 slices of meat from the pectoralis major on each side of breast were portioned (5 cm^2 and .5 cm thick). All meat from both thighs was used and each panelist received the same sized piece and muscle from the respective treatments.

Mechanical tenderness assessments were only made on the breast and with meat not portioned for sensory evaluation. Five 1-cm cylindrical cores were cut parallel to the grain of the meat. A modified Warner-Bratzler device (Voisey and Hansen, 1967) measured the maximum force required for shearing.

A laboratory panel of 12 judges experienced with sensory evaluation of poultry products evaluated flavor, juiciness, tenderness, and off-flavor using descriptive analysis with scaling. Perceived intensities were marked on an unstructured 15 cm line with anchor points having descriptive terms at 1.5 cm from each end. Judges were asked to score off-flavor only if it was perceived.

Statistics. Data from live performance and carcass evaluations were analyzed in a randomized complete block design as a factorial arrangement of the main factors. Blocks corresponded to areas in buildings used for brooding and rearing. All grade and yield measurements were found to have homogeneity of variance between 20 and 24 weeks of age; thus, age was included as an additional main factor for these parameters. Percentages were transformed to arcsin $\sqrt{\%}$ prior to analysis. A completely randomized design was used on line length and shear weight for analysis of parameters relating to eating quality.

RESULTS

A significant strain effect on poult weight was observed at initiation of experimentation and again at 2 weeks of age (Table 2). These differences for the most part can be attributed to egg size effects from the breeder flocks and

TABLE 1. *Composition of experimental rations used to represent "average" North American and an "extreme" European Economic Community (EEC) circumstance, %*

Ingredient	North American (age fed, weeks)						EEC (age fed, weeks)				
	0–2	2–6	6–10	10–14	14–18	18–24	0–4	4–8	8–12	12–20	20–24
Corn	32.65	38.95	42.25	50.50	58.05	64.00	24.85	29.40	...	...	...
Wheat, hard	...	10.00	15.00	15.00	15.00	15.00	27.50	30.00	61.45	47.80	36.05
Barley	...	...	...	...	...	...	...	...	10.00	30.00	45.00
Soybean meal	54.00	42.25	31.50	26.50	19.00	11.75	31.50	26.75	16.00	11.00	10.00
Fish meal	...	...	...	...	...	...	10.00	8.00	6.00	4.00	2.00
Meat meal	2.00	2.00	2.00	2.00	2.00	2.00	2.50	2.00	2.00	2.00	1.00
Animal-vegetable fat	6.00	2.00	2.00	2.00	2.00	4.00	1.00	1.00	1.00	2.00	3.00
Dicalcium phosphate	2.50	2.25	2.00	1.75	1.75	1.60	1.00	1.25	1.25	1.25	1.00
Limestone	1.50	1.25	1.00	1.00	1.00	.50	.35	.35	.35	.75	.75
DL-Methionine	.20	.15	.10	.15	.10	.05	.25	.20	.10	.05	.05
L-Lysine HCl	...	...	...	...	...	...	...	...	.10	.05	.05
Coccidiostat[1]	.05	.05	.05	...	...	...	.05	.05	...	...	...
Constant[2]	to 100%										
Calculated analysis[3]											
Crude protein, %	30.0	26.1	22.0	20.0	17.0	14.0	28.1	25.0	21.2	18.2	16.3
kcal metabolizable energy/kg	2,972	2,904	2,992	3,059	3,124	3,300	2,943	2,983	2,931	2,923	2,911
Lysine, % total	1.87	1.51	1.24	1.08	.86	.64	1.62	1.43	1.19	.93	.78
Lysine, g/16 g N	6.2	5.8	5.6	5.4	5.1	4.6	5.8	5.7	5.6	5.1	4.8
TSAA,[4] % total	1.21	1.08	.91	.78	.71	.57	1.19	1.05	.85	.70	.65
TSAA, g/16 g N	4.0	4.1	4.1	3.9	4.2	4.1	4.2	4.2	4.0	3.9	4.0
Calcium, %	1.37	1.19	1.04	.99	.98	.74	1.30	1.19	1.08	1.04	.77
Phosphorus, % total	.96	.90	.80	.75	.72	.67	.99	.94	.88	.80	.64

[1] Amprolium, Merck and Co.

[2] Iodized salt, .35%; vitamin mix .50% (supplies the following per kilogram of complete feed: vitamin A, 8000 IU; vitamin D_3, 1600 IU; vitamin E, 11 IU; riboflavin, 9 mg; d-calcium pantothenate, 11 mg; vitamin B_{12}, 13 μg; niacin, 20 mg; choline chloride, 900 mg; vitamin K, 1.5 mg; folic acid, 1.5 mg; biotin, .25 mg; ethoxyquin, 125 mg); mineral mix .25% (supplies the following per kilogram of complete feed: manganese as MnO, 55 mg; Zinc as ZnO, 50 mg; copper as $CuSO_4$, 5 mg; iron as FeO, 30 mg; selenium as SeO_2, .1 mg).

[3] Nutrient values used for calculation: corn 3370 kcal ME/kg – 8.5% crude protein; soybean meal 2510 kcal – 48.5%; wheat 3190 kcal – 12.5%; meat meal 2900 kcal – 50%; barley 2650 kcal – 11.5%; fish meal 2865 kcal – 60%.

[4] Total sulfur amino acids (methionine plus cystine).

TABLE 2. *Early performance of commercial strain heavy toms given feeding circumstances found in NA and an EEC extreme*[1,2]

Treatment		Starting	0–2 Weeks			2–4 Weeks			4–6 Weeks			6–8 Weeks		
Strain	Feed	weight	Weight	Gain	F/G[3]	Weight	Gain	F/G	Weight	Gain	F/G	Weight	Gain	F/G
		(g)	(g)	(g)		(g)	(g)		(g)	(g)		(g)	(g)	
Nicholas	NA	58	301	243	1.29	917	615	1.55	1,975	1,154	1.74	3,214	1,190	2.10
	EEC	59	308	250	1.26	980	658	1.46	2,085	1,107	1.74	3,515	1,356	1.99
British United	NA	53	279	227	1.31	852	569	1.56	1,869	1,011	1.74	3,079	1,197	2.04
	EEC	52	285	238	1.29	953	663	1.40	2,051	1,089	1.72	3,471	1,398	1.90
Hybrid	NA	50	300	250	1.30	874	562	1.53	1,860	962	1.78	2,925	1,048	2.12
	EEC	50	298	248	1.31	928	617	1.43	1,995	1,017	1.70	3,272	1,248	2.00
Statistics														
Strain (S)		**	**	NS[4]	NS	*	*	NS	**	**	NS	***	*	NS
Feed (F)		NS	NS	NS	NS	***	***	***	***	***	NS	***	***	**
S × F		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
SEM (11 df)		1.1	6.3	7.1	.014	17.5	11.8	.019	26.5	11.9	.028	45.9	42.9	.039

[1] NA = North American, EEC = European Economic Community.

[2] All data are the average of 4 pens (1.5 m × 5.0 m) of *ca.* 50 birds/pen.

[3] Feed consumed/body weight gained.

[4] NS = Nonsignificant ($P>.05$).

*$P<.05$.

**$P<.01$.

***$P<.001$.

possible variation in incubation between hatcheries. Hen effects on poult body weight have been shown to be greatest at hatch and to progressively dissipate thereafter (Moran and Reinhart, 1981).

From 2 through to 8 weeks of age and the end of controlled environment housing, Nicholas toms had the heaviest body weight because gain by this strain up to 6 weeks was consistently the greatest. The strains had equivalent feed conversion. However, feeds representing the EEC extreme supported better conversions from 2 to 4 weeks and 6 to 8 weeks than the North American representation, as well as better gains throughout.

Strain performance and their response to feeding system changed during the 8- to 14-week developing period from that observed earlier (Table 3). BUT toms now exhibited the greatest gains and eventually had the heaviest body weight. Feed conversion was the poorest with Nicholas toms during the 8- to 10-week and 12- to 14-week intervals, regardless of feeding system. Turkeys on the EEC system entered this midproduction phase in advantageous position and ended it with lower gains and poorer feed conversions than toms on the North American system.

Interactions appeared between strain and feeding system during the last 10 weeks of production (Table 4). The EEC feeds at this time had substantially lower levels of metabolizable energy than the corresponding North American feeds, particularly as contributed by fat; thus, their conversions were expected to be low. Nicholas toms used their feed less efficiently than the other strains, especially during the 14- to 18-week interval when the EEC representative was particularly poor. Gain supported by this EEC feed was greatest for BUT and poorest for Nicholas. Hybrid was generally intermediate between the other two strains for each parameter.

The effect of feeding system on final body weight was dependent upon the strain, regardless of whether marketing was at 20 or 24 weeks. The BUT toms were heavier when given the EEC feeds than NA feeds. This difference was less apparent with Hybrid and was absent for Nicholas. Total feed conversion at each market-

TABLE 3. *Performance of developing commercial strain heavy toms when given feeding circumstances found in NA and an EEC extreme*[1,2]

Treatment		8 to 10 Weeks			10 to 12 Weeks			12 to 14 Weeks		
Strain	Feed	Weight	Gain	F/G[3]	Weight	Gain	F/G	Weight	Gain	F/G
		(g)	(g)		(g)	(g)		(g)	(g)	
Nicholas	NA	4,860	1,694	2.24	6,558	1,711	2.43	8,306	1,742	2.96
	EEC	5,161	1,708	2.32	7,000	1,875	2.42	8,578	1,578	3.35
British United	NA	4,810	1,731	2.15	6,504	1,710	2.37	8,416	1,908	2.79
	EEC	5,218	1,746	2.19	7,167	1,941	2.33	8,873	1,673	3.22
Hybrid	NA	4,605	1,655	2.13	6,231	1,645	2.34	7,957	1,690	2.90
	EEC	4,917	1,648	2.29	6,621	1,713	2.41	8,225	1,576	3.02
Statistics										
Strain (S)		***	NS[4]	*	***	***	NS	***	**	*
Feed (F)		***	NS	**	***	***	NS	***	***	***
S × F		NS	NS	NS	*	NS	NS	NS	NS	NS
SEM (23 df)		33.3	46.3	.040	49.6	35.6	.034	60.1	43.7	.075

[1] All values are the average from 8 pens (4 × 4 m) of *ca.* 25 birds/pen.

[2] NA = North American, EEC = European Economic Community.

[3] Feed consumed/body weight gained.

[4] NS, Not significant (P>.05).

*P<.05.

**P<.01.

***P<.001.

TABLE 4. *Performance of commercial strain heavy-type toms during the finishing period when given feeding circumstances found in NA and an EEC extreme*[1,2]

Treatment		14–18 Weeks			18–20 Weeks			20–24 Weeks		
Strain	Feed	Weight	Gain	F/G[3]	Weight	Gain	F/G	Weight	Gain	F/G
		(g)	(g)		(g)	(g)		(g)	(g)	
Nicholas	NA	11,541	3,321	3.43	12,925	1,384	3.55	15,973	3,048	3.92
	EEC	11,533	2,955	3.95	13,044	1,510	3.57	15,977	2,933	4.58
British United	NA	11,899	3,492	3.30	13,513	1,614	3.20	16,824	3,311	3.92
	EEC	12,422	3,537	3.54	14,221	1,829	3.17	17,807	3,586	4.26
Hybrid	NA	11,219	3,302	3.29	12,703	1,559	3.18	15,689	2,985	4.02
	EEC	11,360	3,196	3.54	12,902	1,592	3.36	16,153	3,250	4.18
Statistics										
Strain (S)		***	***	***	***	***	***	***	***	NS[4]
Feed (F)		**	**	***	***	**	NS	***	NS	***
S × F		*	**	*	**	NS	NS	**	NS	NS
SEM (23 df)		84.9	48.9	.053	90.6	42.2	.088	136.4	96.9	.106

[1] Data are the average of 8 pens (4 × 4 m) of *ca.* 24 birds/pen to 20 weeks and *ca.* 12 birds/pen from 20 to 24 weeks.

[2] NA = North American, EEC = European Economic Community.

[3] Feed consumed/body weight gained.

[4] NS, Not significant ($P>.05$).

*$P<.05$.

**$P<.01$.

***$P<.001$.

ing age was poorest with Nicholas toms and when they were given the EEC system (Table 5). This difference between systems was greater for Nicholas toms than the other strains at the end of 24 weeks.

Assuming the feedstuff values used in ration calcuation are correct, a more accurate estimation of feed utilization considers ME and protein consumption per unit gain. Nicholas toms consumed more ME than either BUT or Hybrid to support gain but used the energy provided by EEC and NA feeds equivalently. An interaction in this respect at 24 weeks inicated that BUT and Hybrid birds consumed fewer calories with the EEC system for growth than the NA system. Toms given the EEC system consumed more protein than those on the NA system and this occurred more with Nicholas than other strains by 24 weeks.

Behavior of toms and litter conditions in pens of the pole barn were observed to be different between feed treatments. As body weight per unit area increased, birds receiving the EEC feeds had litter that was difficult to manage. The NA feeds led to acceptable litter conditions, but toms consumed cecal excreta and all small feathers from the pen. The BUT was particularly prone to pica. Both abnormalities can be related to dietary protein. Brewer and Ward (1980) examined feeding schedules for turkeys where various quantities of starter, growers, and finisher were given, whereas total metabolizable energy consumption was fixed. Schedules that led to a low total protein intake facilitated feather eating and coprophagy. High protein intake avoided the pica but created wet litter conditions.

Mortality was not siginificantly different between feeding systems; however, deaths during 0 to 8 and 8 to 20 weeks were higher than commercially acceptable, particularly with BUT and Hybrid. The reason for this result is unknown, because the flock appeared healthy at all times and necropsies did not reveal any prominant disease or leg problem.

Yield of the chilled carcass from commercial processing was similar among strains and unaffected by feeding system (Table 6). Typically, carcasses from older birds showed greater yield than younger birds. Fleshing grade also increased with age. Feeding system did not influence fleshing of Nicholas and Hybrid, but BUT had a greater proportion of high grades when given the EEC feeds than NA feeds.

Differences between strains for fat covering would not appear to be as extensive as indicated for fleshing because of the high proportions of grade A finished carcasses. However, the grader noted that Nicholas had more fat in the main feather tracts used for grading than other strains. Also, NA feeds facilitated a more extensive finish than EEC feeds, particularly with early marketing.

Toms accentuate fat deposition in the skin covering the crop area as a secondary sex characteristic. Incidence of "stag breast" was not observed at 20 weeks but over 50% of the birds were exhibiting this characteristic by 24 weeks. Strain and feeding system were without apparent effect on the degree of expression of the "stag breast" condition.

The proportion of carcasses downgraded to "utility" status because of mars in appearance was more extensive in BUT than in the other strains (Table 7). Extent of marring decreased with marketing age for all strains. The EEC system provoked more of a problem than NA system with the 20-week marketing age than at 24 weeks. Litter condition was considered to be the primary predisposing factor for these observations. Litter at 20 weeks was generally caked and damp in pens of toms receiving the EEC feeds, especially for BUT. These conditions dramatically improved when the pen population was halved (i.e., 20 to 24 weeks; .67 m^2/tom to *ca.* 1.3 m^2/tom).

Conformation grades of the chilled carcasses were different between strains and decreased with marketing age. "Rocker" (curved) keel and "rocker" (curved) back were the primary defects encountered. Strain differences largely involved rocker keels with BUT having the least problems. Downgrading with age was mainly due to an increase in rocker back. Breast cysts occurred in high proportion with BUT; however, the number decreased from 20 to 24 weeks. This defect was considered to reflect more the accentuated poor litter conditions occurring with this strain than any genetically inherent problem.

The proportion of breast obtained from the chilled carcass increased with age at the expense of all other parts (Table 8). Nicholas had the greatest breast yield at 20 weeks while Hybrid was the poorest at 24 weeks. A strain effect observed for drumsticks and thighs was generally the converse for breast portions. Wings were in greater proportion when using the NA than EEC system. Thoracic back, pelvic back, and neck were only significantly affected by

TABLE 5. *Accumulative utilization of feed, energy, and protein to marketing at 20 and 24 weeks by commercial strain heavy toms when given feeding circumstances found in NA and an EEC extreme*[1,2]

Treatment		0–20 Weeks			0–24 Weeks			% Mortality, weeks of age		
			Consumption/g gain			Consumption/g gain				
Strain	Feed	F/G[3] 1	(kcal ME)	g Protein	F/G	(kcal ME)	(g Protein)	0–8	8–20	20–24
Nicholas	NA	2.69	8.29	.52	2.92	9.17	.52	1.0	2.1	1.0
	EEC	2.83	8.30	.56	3.15	9.22	.59	3.0	2.1	2.7
British United	NA	2.61	8.05	.50	2.85	8.93	.50	3.5	7.3	1.0
	EEC	2.67	7.84	.53	2.99	8.75	.56	9.2	6.6	2.1
Hybrid	NA	2.62	8.06	.49	2.88	9.04	.51	5.1	7.2	3.1
	EEC	2.69	7.89	.54	2.98	8.73	.56	11.8	4.5	2.2
Statistics[4]										
Strain (S)		***	***	***	***	***	***	*	*	NS[5]
Feed (F)		***	**	***	***	***	***	NS	NS	NS
S × F		NS	NS	NS	*	*	*	NS	NS	NS
SEM (23 df)		.016	.050	.004	.019	.058	.004	. . .	. . .	. . .

[1] Data are the average of 8 pens (4 × 4 m) of *ca.* 24 birds/pen to 20 weeks and 12 birds/pen from 20 to 24 weeks.

[2] NA = North American, EEC = European Economic Community.

[3] Feed consumed/body weight gained.

[4] Data analyzed as arc sin $\sqrt{\%}$ and SEM relevant to actual percentages are not available.

[5] NS, Not significant (P>.05).

*P<.05.

**P<.01.

***P<.001.

TABLE 6. *Chilled carcass yield and evaluations for fleshing and finish of commercial strain heavy toms when marketed at 20 and 24 weeks of age after given feeding circumstances found in NA and EEC extremes*[1,2]

Treatment		Chilled carcass yield[3]		Fleshing,[4] % Grade A		Finish[5] Grade A		Finish[5] Stag breast[6]	
Strain	Feed	20 weeks	24 weeks	20 weeks	24 weeks	20 weeks	24 weeks	20 weeks	24 weeks
		(%)							
Nicholas	NA	81.7	83.3	66.8	80.8	99.0	100.0	0	51.1
	EEC	81.1	83.3	66.8	81.5	94.4	100.0	0	52.9
British United	NA	81.2	83.2	43.8	68.9	94.8	100.0	0	55.2
	EEC	81.1	83.7	59.0	86.8	94.3	100.0	0	63.1
Hybrid	NA	80.9	83.4	30.0	63.7	90.9	100.0	0	57.6
	EEC	80.5	83.2	33.2	69.2	74.7	100.0	0	59.9
Statistics[7]									
Strain (S)		NS[8]		***		***		NS	
Feed (F)		NS		NS		**		NS	
Age (A)		***		***		***		****	
S × F		NS		*		NS		NS	
S × A		NS		NS		***		NS	
F × A		NS		NS				NS	

[1] All data are the average from 8 pens of *ca.* 12 birds/pen and expressed relative to Agricture Canada standards.

[2] NA = North American, EEC = European Economic Community.

[3] Full-fed live weight *versus* chilled eviscerated carcass with neck and without giblets.

[4] Subjective assessment only relating the degree of fleshing over the whole breast area.

[5] Subjective assessment only relating the degree of fat infiltration and thickening along the main feather tracts of the breast.

[6] Incidence of excessive fat deposition in the crop area typifying maturity with the tom.

[7] All data were analyzed as arc sin $\sqrt{\%}$ and SEM relevant to actual percentages were not available. There were no significant S × F × A interactions.

[8] NS = Nonsignificant (P>.05).

*P<.05.

**P<.01.

***P<.001.

TABLE 7. *Assessment of carcass physical characteristics of commercial strain heavy toms when marketed at 20 and 24 weeks of age after given feeding circumstances found in NA and an EEC extreme*[1,2]

Treatment		Utility carcasses[3]		Conformation[4] % Grade A		Incidence of carcass defects[5]					
						Rocker keel		Rocker back		Breast cyst	
Strain	Feed[2]	20 weeks	24 weeks	20 weeks	24 weeks	20 weeks	24 weeks	20 weeks	24 weeks	20 weeks	24 weeks
		(%)									
Nicholas	NA	17.5	18.3	91.0	82.4	52.6	50.7	67.4	89.2	3.0	4.7
	EEC	25.9	17.5	90.2	73.2	50.1	54.2	71.7	86.6	8.9	1.1
British United	NA	32.0	26.0	95.1	92.8	26.1	41.8	66.8	74.1	16.1	6.1
	EEC	37.3	25.1	89.9	91.8	27.8	30.0	76.3	74.6	15.8	8.5
Hybrid	NA	12.4	16.7	86.5	78.2	63.0	77.8	73.4	72.8	1.0	0
	EEC	24.0	17.2	85.7	74.4	66.3	76.6	78.2	81.0	2.9	1.4
Statistics[6]											
Strain (S)		***		**		***		***		NS[7]	
Feed (F)		NS		NS		NS		NS		NS	
Age (A)		*		**		NS		**		*	
S × F		NS		NS		NS		NS		NS	
F × A		*		NS		NS		NS		NS	

[1] All data are the average from 8 pens of *ca.* 12 birds/pen and expressed relative to Agriclture Canada standards.

[2] NA = North American, EEC = European Economic Community.

[3] Subjective assessment only relating the extent of on-the-line trimming, skin tears, bruising, broken bones, discolorations, etc.

[4] Subjective assessment only relating the extent to which the basic shape and structural characteristics deviate from optimum.

[5] Incidence of carcass defects that influenced conformation grade.

[6] All data were analyzed as arc sin $\sqrt{\%}$ and SEM relevant to actual percentages were not available. There were no significant S × A and S × F × A interactions.

[7] NS = Nonsignificant ($P>.05$).

*P<.05.

**P<.01.

***P<.001.

TABLE 8. *Yield of parts cut from raw chilled carcasses of commercial strain heavy toms when marketed at 20 and 24 weeks after given feeding circumstances found in NA and an EEC extreme*[1,2]

Treatment		Breast[3]		Thighs[4]		Drumsticks		Wings	
Strain	Feed[2]	20 weeks	24 weeks	20 weeks	24 weeks	20 weeks	24 weeks	20 weeks	24 weeks
		(%)							
Nicholas	NA	38.2	42.4	16.8	16.5	11.9	11.5	11.1	9.7
	EEC	38.1	43.0	16.6	16.3	12.0	11.3	10.8	9.6
British United	NA	36.3	42.6	17.1	15.8	12.8	11.8	11.4	9.9
	EEC	37.5	43.4	17.5	15.7	12.6	11.5	10.4	9.6
Hybrid	NA	36.3	41.1	17.3	16.7	12.6	12.0	11.3	10.2
	EEC	36.9	41.5	17.1	16.4	12.8	11.7	10.9	9.4
Statistics[5]									
Strain (S)		**		***		**		NS[6]	
Feed (F)		NS		NS		NS		***	
Age (A)		***		***		***		***	
SEM (47 df)		.57		.32		.29		.21	

[1] All data are the average of 2 representative carcasses from each of 8 pens of 12 birds/pen.

[2] NA = North American, EEC = European Economic Community.

[3] Breast was severed from the back along the costrochondral rib junction and includes the neck skin.

[4] Thighs include the gluteus complex.

[5] There were no statistically significant interactions.

[6] NS = Nonsignificant (P>.05).

**P<.01.

***P<.001.

age and decreased from 9.5, 7.0, and 5.8% of the chilled carcass at 20 weeks to 8.6, 6.7, and 4.6% at 24 weeks, respectively.

Age was the most dominant factor affecting breast tissue distribution. Meat and bone decreased from 20 to 24 weeks while skin increased (Table 9). There was also an interaction between marketing age and feeding system with proportions of meat and skin. Most obvious in this respect was with BUT where the meat and skin changed to a greater extent when toms had been given the NA system than EEC system.

Marketing age also had the greatest influence on thigh tissue yield (Table 10). Unlike the breast, meat increased and skin response was small. Nicholas had the least meat and the most skin. Feeding system did not affect the thighs.

Eating quality was only ascertained on Nicholas and BUT toms given each feeding system to 20 weeks (Table 11). All carcasses evaluated were judged to be equivalent for conformation, fleshing, and finish. Paralleling earlier observations on live weight, the ready-to-cook carcasses representing BUT were heavier than Nicholas. No differences were found in relative cooking time or total cooking and drip losses.

Sensory evaluation of the cooked breast by an experienced laboratory panel indicated that there was a strain effect. In this respect, meat from Nicholas toms was judged to be more juicy, tender, and acceptable than BUT toms. Mechanical shear values were in agreement with the panel for tenderness (r = −.816). Differences in the extent of "turkey" flavor and perception of off-flavor were not detected.

Sensory evaluation of the thighs differed from that of the breast because strain had no influence. Feeding system was also without effect other than an indication of off-flavor with meat from both strains that had received the EEC system. Presumably, use of fish meal was the reason. Webb *et al.* (1973) reported that fish meal in excess of 5% of the final feed has a detrimental effect on the flavor of turkey

TABLE 9. *Meat, skin, and bone yield from raw breast of commercial strain heavy toms when marketed at 20 and 24 weeks after given feeding circumstances found in NA and an EEC extreme*[1,2]

Treatment		Meat		Skin		Bone	
Strain	Feed	20 weeks	24 weeks	20 weeks	24 weeks	20 weeks	24 weeks
Nicholas	NA	70.6	67.5	15.6	19.7	13.8	12.8
	EEC	71.1	68.7	14.4	19.0	14.2	12.2
British United	NA	71.5	66.6	13.0	21.2	15.4	12.2
	EEC	70.6	69.0	15.2	18.7	14.2	12.2
Hybrid	NA	71.4	68.3	13.2	18.5	15.3	13.2
	EEC	70.1	68.2	14.5	18.8	15.4	13.0
Statistics[3]							
Strain (S)		NS[4]		NS		**	
Feed (F)		NS		NS		NS	
Age (A)		***		***		***	
F × A		*		*		NS	
S × F × A		NS		*		NS	
SEM (47 df)		.77		.71		.42	

[1] All data are the average of two representative carcasses from each of 8 pens of 12 birds/pen and from the same parts described on Table 7. Meat, skin, and bone does not total 100%, respective of strain, feed, and age, because of rounding errors and cutting losses.

[2] NA = North American, EEC = European Economic Community.

[3] There were no statistically significant S × F and S × A interactions.

[4] NS = Nonsignificant (P>.05).

*P<.05.

**P<.01.

***P<.001.

TABLE 10. *Meat, skin and bone from raw thighs of commercial strain heavy toms when marketed at 20 and 24 weeks after given feeding circumstances found in NA and EEC extreme*[1,2]

Treatment		Meat		Skin		Bone	
Strain	Feed	20 weeks	24 weeks	20 weeks	24 weeks	20 weeks	24 weeks
		(%)					
Nicholas	NA	82.2	82.4	8.6	9.8	9.2	7.6
	EEC	82.1	83.2	8.5	9.2	9.3	7.6
British United	NA	82.5	84.1	7.9	7.8	9.6	8.0
	EEC	83.1	83.5	8.0	7.8	8.3	8.6
Hybrid	NA	82.7	83.4	7.5	8.2	9.8	8.4
	EEC	83.0	83.2	8.1	7.9	8.9	7.9
Statistics[3]							
Strain (S)		*		**		NS	
Feed (F)		NS		NS		NS	
Age (A)		**		*		**	
SEM (47 df)		.44		.43		.30	

[1] All data are the average of two representative carcasses from each of 8 pens of 12 birds/pen and from the same parts described on Table 7. Meat, skin, and bone does not total 100%, respectively of strain, feed, and age, because of rounding errors and cutting losses.

[2] NA = North American, EEC = European Economic Community.

[3] There were no statistically significant interactions.

[4] NS = Nonsignificant (P>.05).

*P<.05.

**P<.01.

***P<.001.

meat. Feed from 12 to 20 weeks on the EEC system contained 4% fish meal and progressively higher levels back to the starter.

DISCUSSION

The feeding systems in this study differed in feedstuffs, number of feeds, protein-energy relationships and age sequencing. All feedstuffs employed were of high quality. Previous research has shown that number of feeds through production, energy-protein relationships, and energy level have little influence on growth of the tom as long as all nutrient requirements have been met. Salmon *et al.* (1982a,b) compared the use of 2, 4, and 8 feed changes through 18-, 20-, and 22-week production periods with two strains of large toms. Their results led them to conclude that as long as the protein requirement was met over the interval each feed was given, there was no need for frequent changes other than to improve the efficiency of protein utilization. Other studies have demonstrated that the tom can readily adjust consumption to cope with reduced energy level and maintain growth provided other nutrients are balanced accordingly (Thayer *et al.*, 1965; Moran *et al.*, 1969; Dunkelgod, 1980).

The only differential growth response in the present experiments to feeding system occurred with BUT and favored the EEC extreme. Both of the other strains grew equivalently, regardless of system. This interaction exclusively appeared during 14 to 18 weeks with the onset of sexual development. Presumably BUT toms were immature at this time and had added growth demands for protein which was better provided by the EEC feed than the NA feed. Carcass grades and yields of these strains at the 20-week marketing age are consistent with a difference in maturity (Moran *et al.*, 1970). The sensory advantage of Nicholas over BUT also indicates an advanced maturity. Larmond *et al.* (1971) have reported that grade A toms increase in eating quality when secondary sex characteristics have become established.

TABLE 11. *Preparation and eating quality of Nicholas and British United (BUT) toms given North American (NA) and European Economic Community (EEC) feeding circumstances to 20 weeks*[1]

	Orthogonal contrast				
	Strains		Feed		
Parameter	Nicholas	BUT	NA	EEC	SEM
Preparation					
Oven-ready (OR) weight, kg	9.8[b]	10.5[a]	9.6[b]	10.7[a]	.28
Cooking loss, %	29.0	29.1	28.8	29.3	1.11
Drip loss, % OR weight	11.1	12.4	11.9	11.6	.79
Cooking time, min/kg	46.7	45.4	48.9	43.3	2.67
Eating quality[2]					
Breast					
Flavor, cm	7.6	7.7	7.8	7.4	.27
Juiciness, cm	6.0[a]	5.2[b]	5.4	5.8	.24
Tenderness, cm	9.8[a]	8.8[b]	9.2	9.4	.19
Acceptability, cm	7.0[a]	6.4[b]	6.7	6.8	.18
Off-flavor, no./82 obs[3]	6	6	7	5	. . .
Shear, g	804.0[b]	1,007.8[a]	946.5	865.3	38.97
Thigh					
Flavor, cm	8.8	8.4	8.8	8.4	.20
Juiciness, cm	7.8	7.9	7.8	7.8	.22
Tenderness, cm	8.7	8.9	8.5	9.2	.25
Acceptability, cm	7.5	7.4	7.7	7.1	.23
Off-flavor, no./82 obs[3]	13	16	9	20	. . .

[a,b]Mean values in any row of a contrast not followed by the same letter are significantly different, ($P<.05$) by Duncan's multiple range test.

[1] Results are based on 16 total carcasses, 4 for each strain and feed. There were no interactions between strain and feed, and data are given as orthogonal contrasts for each factor. The standard error of the mean refers to either contrast.

[2] Sensory evaluations were scaled on a 15-cm line with anchor points 1.5 cm from each end. These points correspond to "lacking turkey flavor" to "intense turkey flavor" for flavor; "dry" to "juicy" for juiciness; "very tough" to "very tender" for tenderness, and "unacceptable" to "highly acceptable" for acceptability. Increased length of the line in each case corresponded to improved quality for the respective characteristic.

[3] Incidence of perceived "off-flavor" with 82 individual observations.

[4] *Average maximum weight necessary to shear 5 cylinders of breast meat 1 cm in diameter.*

The NRC (1977) nutrient recommendations for the large tom form the basis of the feeding systems representing NA. These energy and protein values are expected to be most applicable to Nicholas because of its market dominance and use in research to establish nutrient requirements. Environmental changes such as those that could occur between Europe and NA would not appear to alter these recommendations. An evaluation of protein and energy needs for Nicholas toms grown in Germany by Herz *et al.* (1975) gave values that agree with NRC (1977).

BUT was genetically developed in England where feedstuff array and associated economics favored feeds to be higher in protein and lower in energy than those least-cost formulated in North America. The EEC market is oriented to further processing where heavy weight is generally advantageous. Selection for heavy weight under these terms is expected to encourage delayed sexual development and eventually to establish feeding circumstance as the "requirement". Presumably, other strains genetically assembled under similar conditions may not perform satisfactorily when confronted with a feeding strategy based on NRC (1977) specifications. Propensity to heavy weight in conjunction with reduced energy-high protein feeding systems may explain the apparent disparity in performance cited to exist between continents.

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