New Production Systems: Evaluation of Organic Broiler Production in Denmark

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Primary Audience: Researchers, Veterinarians, Flock Supervisors

SUMMARY

In Denmark organic production of broilers (chickens for meat production) has expanded since 1996, when only a few farmers produced approximately 6,000 broilers. At that time, the broilers were sold directly to customers. At present, the yearly production is 350,000 broilers, and professionals organize the sale. Organic broiler production should comply with the overall goals for organic farming. This new production system differs from the conventional system due to specified standards. The production period is prolonged because broilers need to be at least 81 d old when slaughtered, and these chickens are genetically programmed to be slower growing with a maximum growth rate of 30 g/d. Additionally, daily access to roughage, organic feed without coccidiostats, and outdoor pasture areas is required. In the present paper the organic production system and data concerning growth, feeding, animal health, and slaughter quality is described based on an investigation conducted on 9 Danish farms in 1998. This investigation is the first of organic broiler production in Denmark.

Key words: broiler, ecological farming, feed intake, growth, ISA 657, organic farming, slow-growing chicken

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DESCRIPTION OF PROBLEM

Organic (or ecological) production of broilers in Denmark has expanded from about 6,000 in 1996 to more than 100,000 broilers produced on 20 farms in 1998 [1]. In 2001, 350,000 organic broilers were produced [2]. However, this number is small in comparison with conventional production in Denmark, which produced approximately 134 million broilers in 2000 [3].

Organic broiler production in Denmark should comply with the overall goals of organic farming, as expressed by the International Federation of Organic Agriculture Movements (IFOAM) [4]. Some of the principle aims are to encourage and enhance biological cycles within farming systems, to use—as much as possible—renewable resources in locally organized production systems, to create a harmonious balance between crop production and animal husbandry,

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and to provide livestock conditions that respect basic aspects of innate animal behavior.

When the present investigation was completed, production was regulated by a set of standards at the national level [5] inspired by European Union regulation 1894 [6] that came into force in August 2000. These rules stipulated the use of chicken genetic lines with slower growth (maximum growth capacity: 30 g/d), a minimum age of 81 d before slaughter, daily access to roughage, organic feed without coccidiostats, and access to outdoor areas. Additionally the participating farmers followed rules stated by the National Board for Organic Farming, a Danish organization for organic farmers [7]. At that time, the rules included demands for perches, access to outdoor areas covered with pasture, restrictions on the stocking rate (indoor: maximum 25 kg/m^2 or 40 kg/m^2 in mobile houses, outdoor: minimum 2 m^2/broiler), and restrictions on the number of birds in one group (maximum 2,000 broilers).

Because of the requirement for using slow-growing birds, chickens from conventional production systems, e.g., Ross 208 (growth rate up to 60 g/d) cannot be used. In contrast, "Label Rouge" production in France is based on slow-growing chickens [8] and corresponds with the rules for organic farming concerning age at slaughter and access to outdoor areas [9]. On the basis of results from the "Label Rouge" production [10, 11] and results from investigations of slow-growing chickens [12], the expected results from an organic broiler production are chickens weighing approximately 2,200 to 2,300 g at 81 d of age. The feed requirement ranges from 6 to 8 kg/broiler [9, 10, 11], which is larger than in conventional production due to the longer production period (83 to 87 d). Birds have greater requirements for maintenance with increasing age [13].

Changes in production that have influences on animal health and welfare occur with organic methods compared with conventional broiler production. The risk of coccidiosis is expected to be greater in organic broiler production. This disease is common when no preventive treatments are given [14]. Also the risk of introducing pathogens with reservoirs in the wild fauna will obviously increase with outdoor production, e.g., infections such as Newcastle disease, influenza, and infectious laryngotracheitis. Conversely, access to outdoor areas and a longer lifespan can positively influence the health of broilers. For example, birds have the opportunity to build up immunity to infections.

In this study, an investigation of 9 Danish organic broiler farms was conducted to document and increase knowledge of this new production system and to evaluate results from these farms, especially regarding growth rates, feed conversion efficiency, health status, and slaughter quality.

MATERIALS AND METHODS

Selection of Farms and Production Periods

An on-farm investigation was conducted on 9 Danish farms with organic broiler production. At the beginning of 1998, a total of 12 organic farmers in Denmark had developed plans for broiler production. Nine of these farms were selected based on time for start of production (May to August) and the geographic location (Jutland and Funen). Data were obtained from May to November in 1998.

In Denmark in general, some organic farmers use production that includes 1-d-old chicks through slaughter, whereas others have specialized in producing 4-wk-old chickens or in finishing broilers from 4 wk of age to slaughter. Therefore the production period of organic broiler production and consequently recordings in this study can be divided into 3 periods:

1. Starting period: delivery from the hatchery until broilers are moved to other farms or until they are moved to a house with access to an outdoor area (approximately at d 20 to 24).
2. Transition period: from initial move (approximately d 24) until d 50.
3. Finishing period: from d 50 until slaughter (approximately at d 81).

History and General Farm Data

A general description of each of the 9 farms was collected by interview. These data included number of years in organic production, other production on the farm (livestock or cultivation of plants), housing facilities, and descriptions of the land and layout.

Data on stocking rate and housing conditions were obtained at 3 visits during the production period. The indoor and outdoor stocking rates (broiler/m^2) were calculated as the total number of chickens at the start of the period divided by the total floor area (m^2) and total outdoor area (m^2), respectively. The feeder space per broiler (cm/broiler) was calculated as total length (cm) of access available on all automatic feeders divided by the total number of chickens at the start of the period. No differentiation was made regarding the shape of the automatic feeders (round or square trough). The number of broilers per watering point was calculated on all farms with bell drinkers. Finally the length of perches per broiler was calculated as the total length of all perches (cm) divided by the total number of chickens at the start of the period. All recordings were made at the beginning of each period, except for the outdoor stocking rate and the length of the perches per broiler, which were made in the transition and finishing periods only.

Flock Recordings and Sampling

Feed consumption was recorded daily by the farmer and included noting the amount of concentrate, whole wheat, and roughage (kg) fed to the groups. Data on the nutritional value of the concentrate were obtained from the feed mill. Feed conversion (kg of feed/kg of weight gain) was estimated on the basis of amount of feed offered and on calculated weight gains of the broilers. When calculating the feed intake and feed conversion the amount of whole wheat supplementation was included.

Three times during the production period (at 24, 50, and 81 d) 100 broilers were randomly selected from each group and weighed with an electronic balance (±1 g). However, due to practical circumstances the weighing of some groups was not performed exactly on the days planned. When calculating mean live weight gains within periods, these weights were corrected to d 24, 50, and 81, respectively, by linear regression. All weight measurements were made during the night to avoid excitement among birds. In 16 of 24 groups, the sex of each broiler was determined at weighing during period 3.

Mortality, including those found dead or culled, was recorded daily by the farmer. Farmers were requested to submit dead birds for postmortem examination. At slaughter, clean, whole chickens with no dirt, blood, foreign smell, severe blood extravasations, or open fractures were approved for quality class A or B. Additionally, class A chickens were required to be well built with plump musculature with no or only few remaining feathers. Only small damaged sites, blood extravasations, or discoloring could be accepted, unless found on the breast and leg. Broilers that could not be classified as A or B (as described) were rejected. At the veterinary inspection, pathological causes of rejection were noted in the following groupings: 1) emaciation/abnormal smell/discoloring, 2) ascites, 3) joints/bones, 4) skin, 5) heart, 6) lungs, 7) liver, 8) kidneys, 9) peritoneum/oviduct, and 10) other illness. Data on these parameters were missing from several groups due to different places of slaughter, or data were not made available by the farmer.

Statistical Analysis

Mean weight gain of broilers (g), feed consumption (kg/animal), feed conversion (kg feed/kg weight gain), and mortality (%) of up to 23 broiler groups were analyzed using the general linear models procedure of SAS software [15]. Independent variables included farm (class variable), stocking rate (SR; number of birds/unit area), feeder space, and broilers per watering point. Feed consumption was included as an independent variable in some analyses. One analysis was made per production period, and backward stepwise elimination of variables was done. Additionally, an analysis was performed on the uncorrected live weights (d 79 to 87) with sex as the dependent variable.

The live weight curve was modeled using the Gompertz function [16]: $y = \alpha \times e\ (-\beta \times e\ (-\gamma \times t))$, where y = weight of broiler (g); α = maximum weight of broiler (g); β, γ = Gompertz exponents; and t = age of broiler (d). Additionally, the weight gain curve was modeled using the derived equation $y' = [\alpha \times e\ (-\beta \times e\ (-\gamma \times t))]'$.

RESULTS AND DISCUSSION

The investigation included a total of 36,516 broilers that started in 16 groups on 4 different farms. At age of approximately 24 d of age, the broilers were moved within the farm (55%) or moved to another farm (45%), i.e., broilers were divided in 23 groups on 9 different farms during the transition period (Table 1).

Farm Descriptions and Production Planning

Two farmers had 10 to 15 yr experience with organic farming in general, 2 farmers had 2 to 4 yr experience, and the rest had been organic farmers for a short time (0 to 1 yr). Four were full-time farmers, and 5 were part-time farmers. On 4 farms the organic broiler production described here was their first experience, whereas the rest had 1 or 2 yr experience. Most interestingly, no farmers had experience with conventional broiler production beforehand. On 5 farms, broilers were the primary product; however, other products (other livestock, orchards, vegetables, or spruce) were present on all but 1 farm. The mean area of the farms was 13.6 ha (range: 2.5 to 22 ha). All were small farms compared with the mean size of farms in Denmark, 47.7 and 49.7 ha in organic and conventional farms, respectively [17, 18].

Two farmers specialized in production of chickens to be sold at 4 wk of age (starter farms). However, some of the chickens were raised on these farms until slaughter. On 2 farms all chickens were raised from 1 d of age to slaughter (whole farms). The remaining 5 farmers produced broilers from 4 wk of age until slaughter (finishing farms) (Table 1).

All broilers produced were ISA 657 chickens (Scan Labelle) from the same hatchery and broiler breeder operation in Denmark (Scanlayer, Viborg; http://www.scanlayer.dk/Labelle/labelle.htm). Scan Labelle is a cross based on the JA57 female. This type of chicken constitutes more than 25% of the French market. The chickens were not sorted by sex. Except for 3 groups, all broilers were slaughtered at the same abattoir, Fjeldsted Fjerkræslagteri (Funen). Two groups were slaughtered at "Danpo" in Ørbæk (Funen), and the last group was slaughtered at a small, private abattoir.

Housing Facilities and Management Procedures

The housing conditions on the farms varied (Table 2). Heated barns were used in the starting period on 3 of 4 starter farms, whereas the last used old train wagons with heating systems. At the beginning of the starting period SR varied from 11 to 40 broilers/m^2, feeder space was 0.5 to 1.2 cm/broiler, and number of broilers per watering point varied from 146 to 306.

On 5 farms, mobile houses were used for broilers older than 4 wk (eventually supplemented with existing stables), 3 farms used custom-built houses, and the last farmer used existing stables only. The mean indoor SR during transition and finishing was 16 broilers/m^2. In the transition period the mean feeder space per broiler was 1.3 cm, and the mean number of broilers per watering point was 195. The corresponding means for the finishing period were 1.4 cm feeder space and 184 broilers per watering point. The mean length of perches per broiler was approximately 8 cm in the transition and finishing periods. All perches were used during the night, independent of the type of perches (round or square cross section) or the perch circumference (5 to 15 cm). The perches were, to some extent, used during the day as well.

All broilers had access to outdoor areas when older than 4 wk (in the transition and finishing periods). On 4 farms only wide-open areas covered with pasture were available. On 3 farms open areas and areas with planted trees were used, and on 2 farms all outdoor areas were covered by orchards or spruce trees. The mean outdoor SR were 3.1 broilers/m^2 in the transition period and 3.6 broilers/m^2 in the finishing period.

When orchards or spruce trees are used for outdoor areas, the plantings give shelter and shade to the broilers. Tree cover reduces time that hens spend watching for predators and enhances time spent feeding [19]. In general, covering enhances the willingness of hens to be outside the house compared with areas with no covering [20]. During farm visits it was observed that not all broilers were out at the same time, which was independent of the covering. However, it was obvious that nonwoody pastures were more worn in areas where windbreaks or buildings gave shelter. It is clear that if the total outdoor area is to be used, and if the broilers are to feel comfortable, then the outdoor area must have some kind of covering.

TABLE 1. Description of 9 farms with organic broiler production, including number of groups and number of broilers in groups (range given for each farm)

	Farm									
	1	2	3	4	5	6	7	8	9	Total
Farm description										
Full- or part-time farmer	Full	Part	Part	Full	Part	Part	Full	Part	Full	
Broilers primary production	No	No	Yes	Yes	No	Yes	No	Yes	Yes	
Farm type	Whole	Finishing	Finishing	Starter	Finishing	Finishing	Finishing	Starter	Whole	
Groups (n)										
Starting period	4	—	—	8	—	—	—	2	2	16
Transition period	6	1	2	4	3	2	1	2	2	23
Finishing period	6	1	2	2	3	2	1	2	3	22
Broilers per group (n)										
Starting period	816–1,836	—	—	1,020–2,040	—	—	—	5,202–8,058	2,040	35,616
Transition and finishing period	442–1,200	1,962	1,998–2,196	995–2,007	909–1,698	1,657–1,914	1,846	944–2,286	1,000–1,952	34,831

TABLE 2. Description of housing facilities, outdoor areas and management procedures including stocking rate (SR), feeder space, watering points, and length of perches in 9 farms with organic broiler production.[A]

Item	Farm 1	2	3	4	5	6	7	8	9	Mean (±SD)	Range
Housing[B]											
Starting/transition and finishing period	T/CB	–/M	–/E	H/M	–/CB	–/M	–/CB	H/M+E	H/M		
Outdoor area[C]											
Transition and finishing period	O	OA	P+OA	OA	S	OA	P+OA	OA	S+OA		
Starting period											
Indoor SR (broilers/m^2)	21–28	—	—	20-40	—	—	—	11–18	20	27 (±8)	11-40
Feeder spacer (cm/broiler)	0.7–0.9	—	—	0.5–0.7	—	—	—	0.8–1.2	0.9–0.9	0.7 (±0.2)	0.5–1.2
Watering points (broilers/watering point)	272-306	—	—	146-291	—	—	—	168-217	204	250 (±59)	146-306
Transition period											
Indoor SR (broilers/m^2)	7–15	19	18-20	17–19	18-20	16-18	21	12–18	14-19	16 (±4)	7-21
Outdoor SR (broilers/m^2)	4.3–7.4	2.4	1.9–2.0	0.9–1.3	2.4–3.0	1.7–2.0	1.1	1.3–4.5	2.8–3.5	3.1 (±2.0)	0.9–7.4
Feeder space (cm/broiler)	1.4–2.2	1.1	0.8–0.9	0.9–1.1	1.2–1.5	1.3–1.4	1.3	1.3–1.5	1.1–1.1	1.3 (±0.4)	0.8–2.2
Watering points (broilers/watering point)	147-200	109	200-222	236-287	—	138-160	231	208-236	100-195	195 (±53)	100-287
Perches (cm/broiler)	5.3–12.7	10.2	10.5–11.6	3.0–12.7	8.6–9.2	8.4–9.7	1.2	7.1–8.6	3.0–8.2	7.7 (±3.1)	1.2–12.7
Finishing period											
Indoor SR (broilers/m^2)	7–15	19	18-20	17–19	17–19	16-18	20	12-18	12-19	16 (±4)	7-20
Outdoor SR (broilers/m^2)	4.4–7.5	2.4	1.9–2.0	1.2–1.3	2.7–3.1	1.8–2.0	1.2	3.2–4.5	2.9–6.8	3.6 (±2.0)	1.2–7.5
Feeder space (cm/broiler)	1.4–2.2	1.4	0.8–1.0	1.0–1.1	1.4–1.6	1.3–1.5	1.3	1.4–1.5	1.1–1.1	1.4 (±0.4)	0.8–2.2
Watering points (broilers/watering point)	147-196	109	197-221	250-252	—	137-157	228	207-236	99-203	184 (±44)	99-252
Perches (cm/broiler)	5.4–12.7	10.2	10.7–11.6	3.0–5.2	8.9–9.5	8.5–9.7	1.2	7.1–8.7	3.0–8.3	8.2 (±3.0)	1.2–12.7

[A]Range indicates minimum and maximum values across all groups.
[B]Housing conditions: H = heated barn, T = train wagons, M = mobile houses, CB = custom-built house, and E = existing stables.
[C]Outdoor area: P = planted area, O = orchards, OA = open area, and S = spruce.

TABLE 3. Composition of concentrate

Feed component (%)	
Wheat + wheat bran	42
Peas	25
Rape seed	9
Barley + triticale	13
Fish meal	5
Alfalfa protein meal	2
Additives[A]	4
Feeding value (per kg of feed)	
ME	12 MJ/kg ~ 2,864 kcal/kg
Protein and amino acids (per kg of feed)	
Crude protein	20%
Methionine	3.21 g/kg
Cystine	3.02 g/kg

[A]Monodicalcium phosphate (1.4%), calcium carbonate (1.0%), blood meal (1.0%), Pantium-NR (0.4%), and feed salt (0.2%).

Feeding, Growth Rates, and Feed Conversion

Feeding. All farms used concentrate from the same feedstuff company in Denmark [21]. Concentrate with the same composition (Table 3) was fed during all production periods. The mean amount of feed offered (concentrate and whole wheat) until d 81 was 6.34 kg/broiler with 0.62, 1.99, and 3.73 kg being consumed in the starting, transition, and finishing periods, respectively (Table 4). However, the feed consumption on farms varied considerably, especially in the finishing period (range: 3.01 to 4.29 kg/broiler).

In the transition and finishing periods, 4 and 13 groups, respectively, were fed wheat as supplementation to the concentrate. In the transition period the mean wheat consumed was 72 g/broiler (range: 31 to 98 g, 2 to 7% of total feed consumption), and in the finishing period it was 410 g/broiler (range: 69 to 853 g, 2 to 23%). The supplement was fed manually indoors. On all farms, roughage was offered on the floor in periods when broilers did not have access to outdoor areas. The amount varied from 8 to 20 kg of clover grass per 2,000 broilers per day. The intake was not assessed but was likely to be low. It was thus not included in the calculation of feed consumption.

In the starting period, feed consumption was significantly affected by indoor SR ($P < 0.001$). For example, groups at high SR consumed less feed than groups at lower SR (Figure 1A). The effect of the number of broilers per watering point changed with time. In the starting period, feed consumption increased with the number of broilers per watering point ($P < 0.001$), but in the transition period it decreased ($P < 0.05$). The effect of farm on feed consumption was significant ($P < 0.01$) and almost eliminated other effects in the transition and finishing periods (Table 5). No effect of feeder space on feed consumption was found in any of the periods ($P > 0.5$).

Growth. Mean live weight gains within the 3 production periods based on live weights corrected to d 24, 50, and 81 were 297, 716, and 1,119 g, respectively. Mean total weight gain from hatching to 81 d was 2,132 g (Table 4). When adding live weight at hatching (~35 g), the mean live weight at d 81 was 2,167 g. The differences between group weight gains increased with increasing age of broilers. At 24 d of age the difference between the lowest and highest weight gain was 100 g, at 50 d it was 196 g, and at 81 d the difference was 347 g (Table 4).

Weight gain was significantly affected by feed consumption in the starting ($P < 0.01$) and transition ($P < 0.001$) periods. Weight gain increased with increasing feed consumption (Figure 2, A and B). In the same periods weight gain decreased with increasing indoor SR ($P < 0.05$) (Figure 1B) and increasing number of broilers per watering point ($P < 0.05$). These effects were intensified by the negative influence on feed consumption. Additionally, more feeder space increased weight gain in the transition period ($P < 0.05$). In the finishing period no effect of feed consumption was observed ($P > 0.5$) because the differences among groups ($P < 0.05$) overshadowed other effects (Table 5).

TABLE 4. Mean amount of feed consumption (concentrate and wheat, kg), mean live weight gain (g), and mean feed conversion per broiler in each period given as range within each farm and total mean (±SD).[A,B]

Item		Farm 1	2	3	4	5	6	7	8	9	Mean (±SD)	Range
Feed consumption (kg)												
Starting period	(1–24 d)	0.68–0.73	—	—	0.50–0.62	—	—	—	0.63–0.66	0.58–0.67	0.62 (±0.07)	0.50–0.73
Transition period	(25–33 d)	0.57–0.58	—	—	0.33–0.64	—	—	—	—	0.47–0.61	0.54 (±0.09)	0.33–0.64
Transition period	(34–50 d)	1.32–1.65	1.53	1.39–1.40	1.19–1.31	1.51–1.59	1.41–1.50	1.66	1.60–1.60	1.18–1.35	1.45 (±0.15)	1.19–1.66
Finishing period	(51–81 d)	3.48–1.26	3.79	3.43–3.44	3.01–3.08	3.97–4.13	3.52–4.03	4.04	3.92–4.29	3.42–3.60	3.73 (±0.34)	3.01–4.29
Total											6.34	
Live weight gain (g)												
Starting period	(1–24 d)	287-315	—	—	234-307	—	—	—	325-334	330	297 (±28)	234-334
Transition period	(25–33 d)	204-241	198	124-189	195-225	182-188	193-199	216	203-225	186-201	201 (±23)	124-241
Transition period	(34–50 d)	456-588	537	503-504	429-548	463-480	477-496	576	586-625	496	515 (±51)	429-625
Finishing period	(51–81 d)	1,073–1,140	1,148	941–1,030	1,087–1,168	1,031–1,141	1,113–1,288	1,199	1,081–1,096	1,169–1,216	1,119 (±71)	941–1,288
Total											2,132	
Feed conversion (kg feed/kg weight gain)												
Starting period		2.2–2.5	—	—	1.8–2.2	—	—	—	1.9–2.0	1.8	2.1 (±0.2)	1.8–2.5
Transition period		2.7–3.3	2.8	2.8–2.8	2.4–2.8	3.2–3.3	2.9–3.0	2.9	2.6–2.7	2.7	2.8 (±0.3)	2.4–3.3
Finishing period		3.1–3.9	3.3	3.3–3.7	2.6–2.8	3.5–4.0	3.1–3.2	3.4	3.6–3.9	2.8–3.1	3.3 (±0.4)	2.6–4.0
Total										2.9		

[A]Range indicates minimum and maximum values across all groups.

[B]Due to practical circumstances, feed consumption and live weights could not be measured on all farms on day 25–33. The transition period is, therefore, separated into two minor periods.

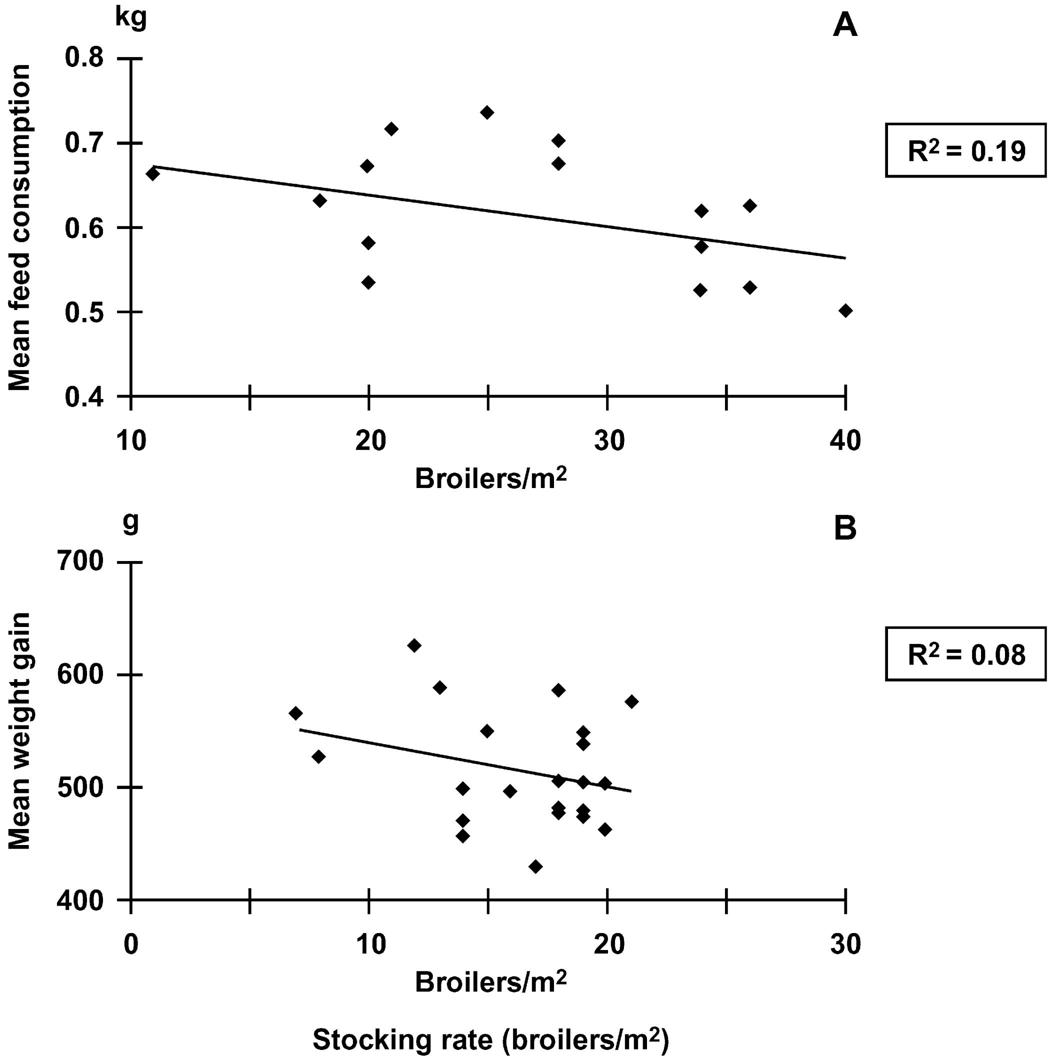

FIGURE 1. Effect of indoor stocking rate (broilers/m^2) on A) mean feed consumption (kg) in starting period and on B) mean live weight gain (g) in the transition period.

Mean live weight of broilers per group and the corresponding Gompertz function is shown in Figure 3. The estimated formula was $y = 3{,}840 \times e\ (-4.7080 \times e\ (-0.02592 \cdot t))$.

With this function, the expected live weights of organic broilers at 24, 50, and 81 d of age are 307, 1,059, and 2,157 g, respectively. When using the derived y', maximum daily weight gain can be expected to be 37 g at d 60. The mean daily weight gain from d 1 to 81 is 27 g.

There was a significant effect of sex on final body weight ($P < 0.001$). Mean live weights of female and male broilers were 1,974 and 2,468 g, respectively, in 16 groups at the end of the finishing period.

Feed Conversion

Feed conversion (kg feed/kg of weight gain) increased when age of broilers increased. The mean feed conversion within periods was 2.1, 2.8, and 3.3, respectively (Table 4). Overall feed conversion for the entire life cycle (d 1 to 81) was 2.91, or 2.86 when corrected for live weight at hatching (~35 g).

Feed conversion was affected, in the same way as feed consumption and live weight gain,

TABLE 5. Results of general linear models analyses on feed consumption, weight gain, feed conversion, and mortality for each production period including R^2 and *P*-values.[A,B]

Item	R^2	*P*-value					
		Feeder space	SR_{indoor}	$SR_{outdoor}$	Broilers per watering point (n)	Farm	Feed consumption
Feed consumption							
Starting period	0.71	0.98	0.0001	—	0.0003	0.50	—
Transition period	0.86	0.83	0.39	0.23	0.02	0.002	—
Finishing period	0.76	0.48	0.44	0.42	0.34	0.004	—
Weight gain							
Starting period	0.85	0.54	0.03	—	0.02	0.03	0.007
Transition period	0.77	0.03	0.02	0.67	0.01	0.89	0.0001
Finishing period	0.69	0.95	0.98	0.85	0.41	0.02	0.50
Feed conversion							
Starting period	0.86	0.42	0.007	—	0.005	0.01	0.73
Transition period	0.53	0.02	0.02	0.50	0.01	0.90	0.64
Finishing period	0.90	0.96	0.96	0.76	0.48	0.02	0.002
Mortality							
Starting period	0.45	0.04	0.02	—	0.14	0.92	0.78
Transition period	0.59	0.45	0.66	0.80	0.86	0.11	0.86
Finishing period	0.50	0.94	0.20	0.47	0.54	0.20	0.15

[A]Variables underlined were included in the model after stepwise elimination. SR = stocking rate.
[B]Analyses made on the transition period included d 34 to 50 only.

by management variables in the starting and transition periods: indoor SR ($P < 0.05$), feeder space ($P < 0.05$), and number of broilers per watering point ($P < 0.01$). In the finishing period, feed conversion mainly depended on feed consumption ($P < 0.01$). Feed conversion increased with increasing feed consumed (Figure 2C) and with farm ($P < 0.05$).

The results described in the last 3 sections are concordant with the Label Rouge production in France [7, 10] and other investigations of slow-growing broilers [11, 12]. Mean live weight 81 d of age was 2,167 g, just under the live weights reported in the investigations mentioned (2,200 to 2,400 g in mixed production, 2,713 to 2,785 g in male-only production). Feed consumption in the present investigation (mean: 6.3 kg/broiler) is in accordance with [8] but less than found in [7] and [10], which were 7.4 and 8.3 kg, respectively. The latter results are from production of males only, which results in higher feed consumption and corresponding higher live weights compared with mixed production.

On the basis of the literature [7, 8, 10], feed requirement in organic production is suggested to be 2.5 to 3.0 kg feed/kg of weight gain. In the present investigation, the overall feed conversion was 2.9 kg feed/kg of weight gain. Analysis within periods showed that the feed conversion rate was especially high in the finishing period when broilers were 50 to 81 d old (mean: 3.3).

Management had a marked influence on the results in the starting and transition period. In summary, feed consumption and weight gains were higher and feed conversion was improved when broilers had more space available on the floor (lower indoor SR), in front of watering points (lower number of broilers) and in front of feeders (higher length of trough per broiler).

Most of our observations were confirmed by the existing literature: feed consumption [22, 23] and live weight [23, 24] increase when feeder space is increased, but the same studies show that feed conversion is unchanged [23] or even decreased [24]. Also, free access to water is important to not cause reductions in weight gain [25]. Increased indoor SR reduces feed consumption [7, 26] and live weight [22, 26, 27, 28], but the effect on feed conversion is equivocal. Feed conversion was better in 2 studies [26, 29], poorer in 2 studies [22, 27], and unchanged in 1 study [29]. The effect of outdoor SR on

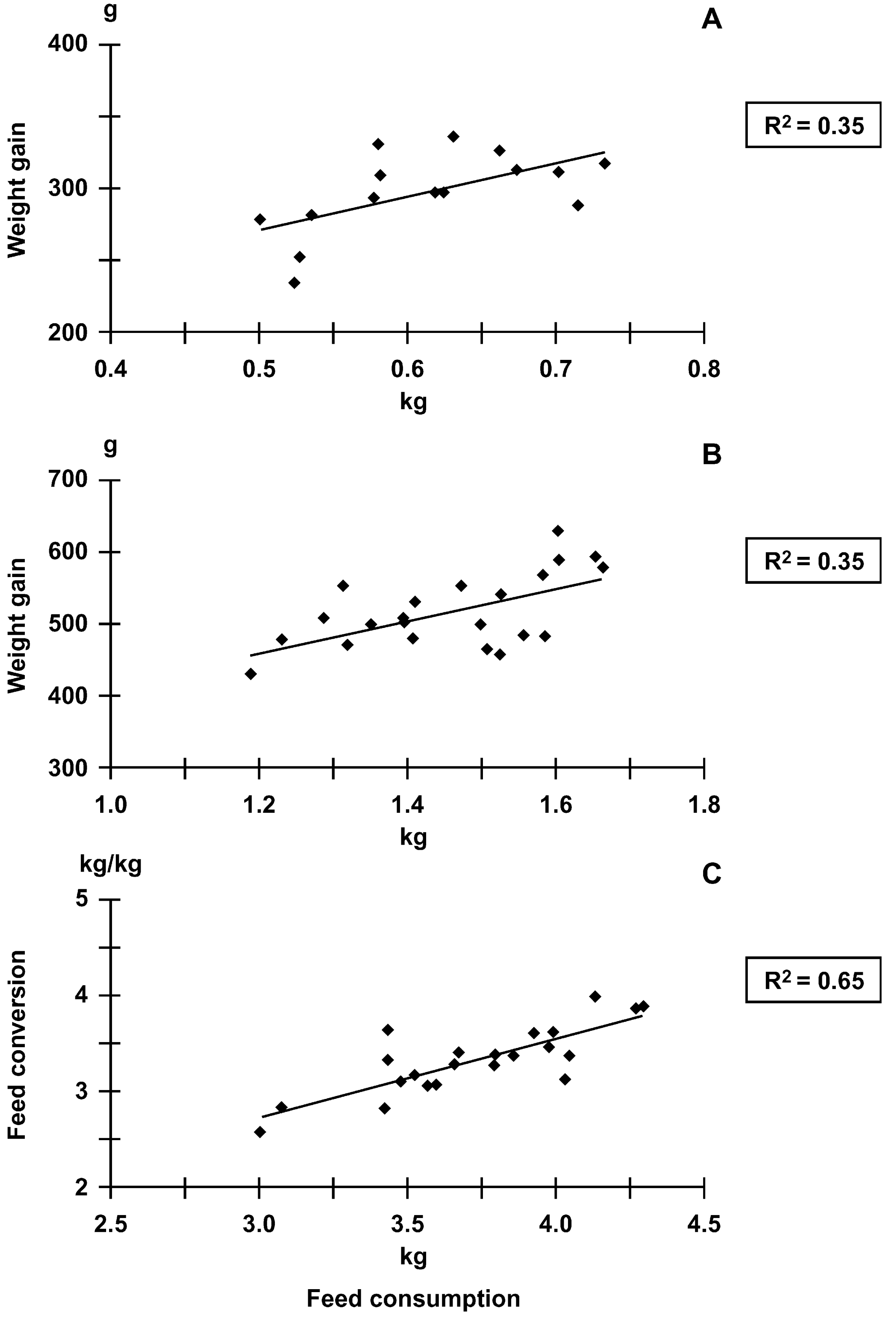

FIGURE 2. Effect of feed consumption (kg) on mean live weight gain (g) in the A) starting and B) transition periods, and on C) mean feed conversion (kg/kg) in the finishing period.

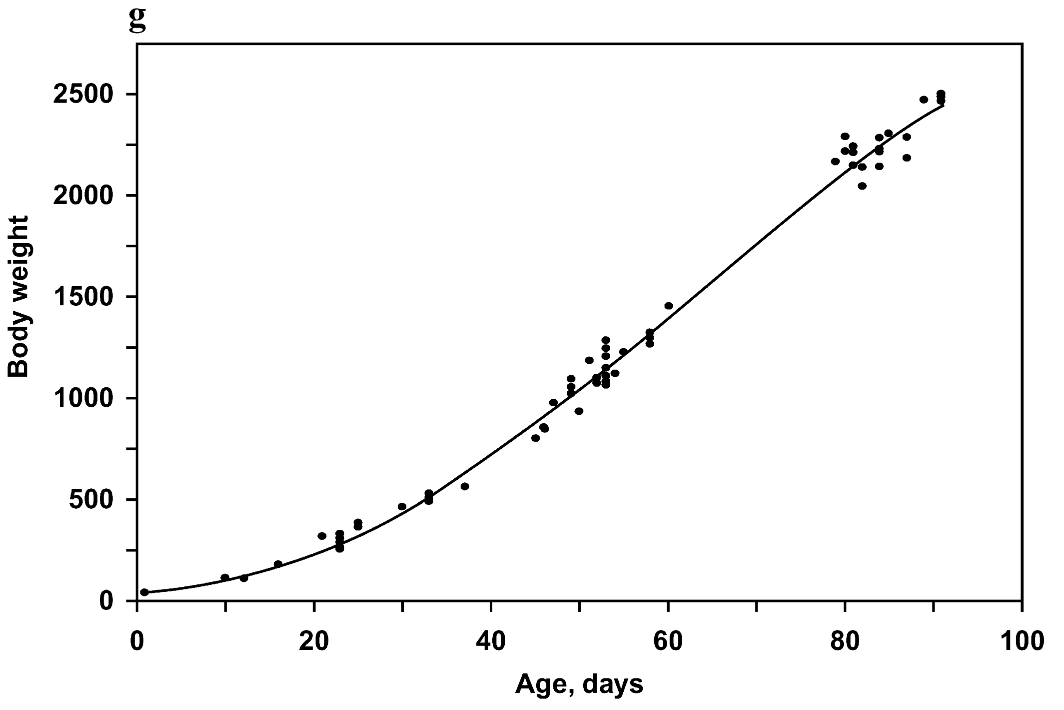

FIGURE 3. Mean live weight (g) of broilers per group and curve modeled by the Gompertz function [16].

production results has not been investigated previously. In this investigation outdoor SR showed no effect.

In the present investigation the feed consumption per kilogram of live weight gain increased during the finishing period, i.e., feed conversion was reduced. This result is explained by decreasing growth rate and increasing energy requirements for maintenance [13], which reduced use of feed.

The present investigation showed a marked difference in live weight (~500 g) of female and male broilers 81 d of age, which was also expected, based on earlier investigations [7, 8, 10, 11, 12]. The reason for this finding is that the growth rate curve declines earlier for female broilers than for male broilers [30]. The same authors point out that female broilers will deposit fat earlier than male broilers, which means that live weight and body composition at slaughter are most likely dependent on sex.

Animal Health and Mortality

During the starting period, mortality ranged between 0.9 and 15% per group (Table 6). In 3 groups on 2 farms, mortality was high (8, 12.5, and 15%), whereas it was markedly lower in the rest of the groups (0.9 to 2.5%). In one group (farm 4) the high mortality (15%) was supposedly caused by mistakes made at the hatchery, probably incubation failure with suboptimal humidity or temperature leading to weak 1-d-old chickens. The hatchery accepted responsibility for the problem. The 2 remaining cases of high mortality (farm 1 and 4) could not be explained and were not correlated with the diseases found at necropsy. Mean mortality in the starting period was 3.5%. When corrected for the 15% group at farm 4, it was 2.7%.

In the transition period, mean mortality was 1.4%. Except for one group at farm 5 that had a mortality rate of 10% due to coccidia problems, mortality ranged from 0 to 2.8%. In the finishing period mean mortality was 0.8%. Overall mortality was 6.2% (or 5.5% when corrected for the group with 15% mortality at farm 4).

Except for the starting period when decreasing feeder space per broiler ($P < 0.05$) and increasing SR ($P < 0.05$) increased mortality, the described management procedures did not affect

TABLE 6. The mortality (%) in organically produced broilers, shown as a range for each farm (exceptionally high mortality rates for groups are noted separately) and carcass quality of organic broilers, described as mean proportion of broilers with A and B classification (%) and rejected broilers (%) in each period and overall means (±SD)[A]

	Farm									Mean of farm means
Item	1	2	3	4	5	6	7	8	9	(±SD)
Mortality (%)										
Starting period	0.9–2.1[B]	—	—	1.0–2.5[C]	—	—	—	1.0–2.1	0.9–1.8	3.5 (±4.4)
Transition period	0.0–1.8	0.5	0.3–1.3	0.2–1.3	2.5–2.8[D]	0.6–1.3	1.4	0.2–0.3	1.0–1.1	1.4 (±2.0)
Finishing period	0.7–1.8	0.5	1.0–1.6	0.4–1.0	0.7–1.5	0.2–0.3	0.6	0.8–1.1	0.4–1.0	0.8 (±0.4)
Carcass quality										
Groups (n)	3	1	2	2	3	2	1	2	3	
Broilers (n)	2,555	1,940	3,963	1,990	3,285	3,479	1,776	2,992	3,831	
A classification (%)	72	83	85	74	85	71	89	81	77	79 (±6)
B classification (%)	23	14	10	19	9	25	8	15	18	16 (±7)
Rejected (%)	5	3	5	7	7	4	3	4	5	5 (±2)
Breast blisters (%)	5/5/5	7	3/6	–/5	–/–/–	–/10	1	–/5	5/17/17	6 (±4)

[A]The proportion of broilers with breast blisters at slaughter in each group (%) is listed below. A dash indicates data not available.
[B]One group 8%.
[C]One group 12.5%, one group 15.0%.
[D]One group 10.0%.

mortality (Table 5). When groups with exceptionally high mortality rates were excluded from the starting period analysis, no effect of management procedures was found ($P > 0.20$).

Relatively few birds were submitted for postmortem examination. On farm 4, four chickens died between d 2 and 21 due to yolk sac infections. Postmortem examination of 3 broilers from this farm could not be performed. On farm 8 coccidiosis was diagnosed in 3 chickens that died between 24 and 26 d of age. On farm 9, ten chickens died between d 29 and 34 from necrotic enteritis, and 3 chickens on the same farm died from kidney failure between d 42 and 67. A single chicken from farm 1 could not be examined due to decomposition.

Mortalities of 0.9, 2.1, and 4.6% have been found in the production of slow-growing chickens [7, 8, 10]. In Denmark, mean mortality in fast-growing breeds in the conventional production system is 3.8% [3]. Therefore, mortality of 6% (or 5.5%) in the present investigation is unacceptably high, and efforts should be made to minimize this problem. However, due to the low number of dead chickens investigated, the present study can only indicate which diseases might be of importance in organic production systems.

Coccidiosis is likely to pose a threat on organic farms if the houses or areas are used repeatedly over time and are not properly cleaned and rotated. Increased mortality was observed in 2 flocks without any specific causative factors that could be identified. However, necrotic enteritis was diagnosed in 2 other flocks. This disease has previously been predicted to cause increasing problems in production systems that eliminate the regular use of antimicrobial compounds in feed [31, 32]. Apart from that, other mortality was mainly due to management factors (e.g., kidney failure, which is often related to deprivation of water) or common opportunistic pathogens (e.g., *Escherichia coli*) that are encountered in any production system.

Carcass Quality

Classification of broilers at slaughter included 25,811 broilers from 19 groups. The incidence of breast blisters at slaughter was recorded for 18,492 broilers from 13 groups. An average of 79% of the broilers produced on each farm were "A" broilers, 16% were classified as "B" broilers, and 5% were rejected (Table 6). More than 70% of the rejected broilers were rejected due to conditions listed in Table 7. Emaciation, abnormal smell, and discoloring were the main reasons followed by damaged areas of skin. The remaining rejections (30%) were due to death during transport, insufficient bleeding, damages from machinery, and fractures or bleeding, but the relative frequencies were not recorded. An average of 6% of the broilers had breast blisters, ranging from 1 to 17% within groups (Table 6).

TABLE 7. Relative frequency of pathological causes of rejection at slaughter of organically produced broilers, based on examination of 25,811 broilers and a level of rejection for pathological reasons of 3.5%.

Cause	%
1. Emaciation, abnormal smell, or discoloring	66.9
2. Ascites	0.5
3. Joints or bones	3.1
4. Skin	24.1
5. Heart	0.1
6. Lungs	0.0
7. Liver	2.9
8. Kidneys	0.0
9. Peritoneum or oviduct	0.5
10. Other illness	1.8
Total	100.0

In the conventional production in Denmark 1.3% of broilers (calculated as kg) are rejected [3], and the most frequent reasons for rejection are emaciation (approximately 31% of rejections in 2000 to 2001), skin disorders (23%), ascites (10%), and problems with liver (14%), joints (9%), and heart (3%) [3, 33]. As considerably more organic broilers are rejected, it seems that the carcass quality of organic broilers is poorer when compared with those from the conventional system. However, the pathological reasons for rejection were the same as observed in the conventional production system, although emaciation clearly is more frequent in organic systems and ascites and liver disorders less frequent. It is unknown whether the number of broilers rejected for other causes was disproportionately high in the present investigation.

Breast blisters are the most common cause of rejection in the Label Rouge production [34]. Poor litter quality or acute litter deterioration appear to be the major responsible cause of increased frequency of breast blister [35], but factors such as sex, age (~length of exposure), and lighting program also may play roles [36]. Interactions of these factors with breed are poorly understood. Breast blisters are almost absent from the conventional broiler production, e.g., 0.3% incidence in a survey of 12.6 millions birds [35].

CONCLUSIONS AND APPLICATIONS

1. Facilities for organic broiler production varied from the use of available old stables with access to wide open pastures to custom-built houses in combination with orchard or spruce plantings.
2. Production was by farmers with little prior experience with broiler production.
3. The mean feed consumption from 1 to 81 d was 6.3 kg/broiler (concentrate and whole wheat). Until approximately 24 d of age, chicks were fed forage in house; thereafter they had access to outdoor areas.
4. The mean live weight gain from 1 to 81 d was 2,167 g, and growth within periods (1 to 24 d, 25 to 50 d, and 51 to 81 d) was 297, 716, and 1,119 g, respectively. Overall feed conversion was 2.9 kg feed/kg broiler live weight.
5. The management practices for stocking rate, feeding troughs, and watering points affected the results of the production, e.g., broilers in groups with more space available on the floor (lower indoor stocking rate), in front of watering points (lower number of broilers), and in front of feeders (higher length of trough per broiler) had higher feed consumption, higher weight gains, and improved feed conversion compared with groups of broilers with less space. However, this was only the case until broilers were approximately 50 d old. Thereafter differences between farms could not be attributed to these practices.
6. The overall mortality on farms was 6% and thus higher than in conventional flocks. No general tendency with regard to the cause of mortality could be described on basis of the necropsies performed, but coccidiosis and necrotic enteritis were prevalent in some groups. These diseases may constitute a particular threat to organic production systems.
7. At slaughter, 79% of the broilers were classified as A broilers, and 16% were classified as B broilers. The remaining 5% were rejected, primarily because of emaciation, abnormal smell, or discoloring. Breast blisters seemed to be specific to this type of production and possibly related to slow-growing broilers.

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