Free-choice feeding of free-range meat chickens[1]

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Primary Audience: Small- and Medium-Scale Poultry Producers, Organic and Sustainable Agricultural Practitioners, Researchers, International, Policy Makers

SUMMARY

Interest in small- and medium-scale free-range poultry production for local and regional markets is growing, and alternative feeding methods should be considered. Free-choice feeding is a method that offers birds separate feedstuffs, such as grains, protein concentrates, and natural vitamin and mineral sources, from which they can self-select a diet suited to their changing needs. Free-choice feeding may prove useful in production systems with outdoor access because nutrient needs change widely due to temperature fluctuations and bird activity. Many small producers do not have access to the nutritional services that large producers do and may have specific goals in regard to nutrition, such as using farm-raised feed ingredients and pasture forage to provide nutrients. In addition, most organic programs do not permit the use of synthetic amino acids in feed. Free-choice methods have been used historically and can be useful for alternative producers, making use of farm-raised feeds to improve savings and increase nutrient cycling. In the current study, a fully formulated diet and free-choice diet were compared in a free-range system using slow-growing meat chickens. The formulated diet was a commercial product (20% CP), whereas the free-choice diet chosen by birds was much lower in CP (13%). Final live weights did not differ between treatments; however, ready-to-cook yield and breast yields were higher in the birds from the formulated treatment, most likely due to amino acid supplements in the formulated feed. The diet chosen by free-choice birds was less expensive than the formulated diet.

Key words: free range, organic, poultry, feeding, dietary self-selection, free choice

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DESCRIPTION OF PROBLEM

Interest in specialty poultry production is growing in the United States, including free range or access to the outdoors, organic, and small flocks for local food production. Whereas the most common method of feeding in commercial poultry production is a fully formulated diet (usually in phases such as starter, grower, and finisher), free-choice feeding may offer advantages.

[1]Mention of a trade name, proprietary product, or specific equipment does not constitute a guarantee or warranty by the USDA and does not imply its approval to the exclusion of other products that are suitable.

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Free choice is an alternative feeding method in which feed ingredients are provided in separate feeders and birds self-select energy, protein, mineral, and vitamin feedstuffs as needed; it is also called cafeteria feeding. Free-choice feeding is based on the principle that poultry can adjust intake as a function of nutrient requirements. Feed selection can be specific for energy, protein, minerals, or other nutrients [1]. Birds can adjust intake daily to meet nutrient needs, which may vary widely in free-range production, particularly where housing is open to provide outdoor access and not climate-controlled.

This feeding method was used in the past in the United States [2], but may hold renewed potential for alternative poultry production. It can also be useful in developing parts of the world where vitamin, mineral, and amino acid supplements may not be available. In addition, in organic livestock production, synthetic amino acids are largely banned. Methionine is the only synthetic amino acid still permitted under the USDA National Organic Program (**NOP**) but only with restrictions [3].

Free-choice feeding lends itself to using feed ingredients that have been raised on the farm, which can reduce costs and increase nutrient cycling in an agroecosystem, an important concept in sustainability. Specifically, when crops are grown on the farm or region to feed animals and the animal manure is then applied to the crop fields as fertilizer, nutrients are cycled in the system instead of requiring external inputs. Organic programs are generally based on ecological principles [4].

Free-choice feeding is well-suited to production systems with outdoor access because poultry can obtain additional nutrients on pasture from forage. Also, when feed ingredients are offered free choice, the need for transportation, grinding, formulation, and mixing can be reduced, which can reduce energy usage. In the current study, a trial was conducted with the objective of determining the effect of free-choice feeding on performance of free-range chickens.

MATERIALS AND METHODS

Two hundred slow-growing hybrid chicks [5] were purchased at 1 d old; a naked neck type was used. The straight-run chicks were vaccinated against Marek's disease and coccidia. Chickens were managed according to protocols approved by the University of Arkansas Institutional Animal Care and Use Committee.

Chicks were randomly assigned to pens of 20 birds on 1 of 2 treatments, a fully formulated diet (**FF**; control) or free-choice (**FC**) diet, with 5 replications of each treatment. Chicks were raised in floor pens in a naturally ventilated house with outdoor access. The pens (3.1 × 3.1 m) were covered with litter. Chicks were brooded at 32.2°C with a reduction in temperature each week for 4 wk [6]; birds were allowed to go outside every day after 5 wk. Bird doorways provided access to paddocks during the day. Each paddock (3.1 × 30.5 m) was completely covered with vegetation, and the trial was conducted in the fall when cool-season forages were predominant, in this case, tall fescue (*Festuca arundinacea*). The poultry house had glass windows and natural light was used. A propane heater [7] provided supplemental heat when needed to keep the temperature above 10°C in the house.

Free-choice feedstuffs were cracked corn, whole wheat, soybean meal, fishmeal, crushed oyster shell, kelp meal, bone meal, and trace mineral salt. All ingredients were provided in separate feeders. In contrast, the formulated diet was a commercial, nonmedicated product, a starter and grower diet that is readily available to small-scale producers and intended to be used the entire life of the broiler [8] (Table 1). Because the FC treatment used multiple feeders, the FF treatment also used the same number of feeders for homogeneity.

During the brooding period (0–27 d), formulated feed was provided to both treatments. During the grower period (28–49 d), the FC treatments also received formulated feed along with the free-choice ingredients for training purposes so the birds could learn to self-select. During the finisher period (49–83 d), however, FC received only free-choice ingredients (Table 1). Insoluble grit was provided to all birds to help grind whole grains or forage [9]. Feed and water were provided both indoors and outdoors.

Live weight of birds was measured weekly on a pen basis. Feed intake was also measured weekly on a pen basis; accordingly, feed ingredients consumed in the FC treatment were mea-

Table 1. Design of dietary treatments comparing fully formulated feed and free-choice feed for free-range meat chickens

Item	Starter[1]	Grower[2]	Finisher
Week	0–3	4–6	7–11
Formulated treatment	Formulated[1]	Formulated[1]	Formulated[1]
Free-choice treatment	Formulated[1]	Formulated[2] plus free-choice ingredients	Free-choice ingredients

[1]Formulated feed was Powell's Poultry Starter/Grower [8], which is a 20% CP product designed for use throughout a broiler's entire life.

[2]During the grower period, formulated feed was also provided to young chicks to allow for adjustment to self-selection.

sured individually. Feed intake was adjusted for mortality.

Feed samples were analyzed for nutrients. Free-choice diet composition was calculated for each week during the grower and finisher periods based on the feed ingredients selected by the birds. The nutrient composition was analyzed for wk 7 (49–56 d) and 11 (77–83 d), representing the beginning and end of the finisher period. These small sample diets were based entirely on bird selection and compounded solely for the purpose of analysis.

During the last week of the trial, forage remaining in the pens was measured. The forage in the paddocks was predominantly bermudagrass (*Cynodon dactylon*) and tall fescue (*Festuca arundinacea*). Because the birds had outdoor access in early autumn, the cool-season forage tall fescue was the predominant forage. Square frames (0.5 × 0.5 m) were positioned in 2 random places in each paddock and forage within the frame was cut to ground level. The forage was dried in a 105°C oven [10] for 48 h and the 2 amounts were averaged for each paddock. No attempt was made in this study to analyze nutrients in the forage.

Indoor temperatures were recorded daily during the trial. Birds were raised for 83 d and then transported to a small processing plant where they were commercially processed. Carcass yield and parts yield were determined [11]. Skin color was determined by a broiler color fan [12], with a scale of 102 to 106 in which a higher category was more yellow.

This one-factor experiment had a completely randomized design with the experimental unit as the pen. The *t*-test was used to analyze the weight gain, feed conversion, and forage amount data. The Chi-squared test was conducted to compare the frequency of distribution among color categories of FF and FC; SAS 9.2 [13] was used. Repeated measures ANOVA with compound symmetry variance-covariance structure of R-side random effects (repeated measures) was used to compare average weekly gain by pen. Analysis was performed using the GLIMMIX procedure of SAS [14]. Significance implies $P < 0.05$.

RESULTS AND DISCUSSION

The trial was conducted during early autumn and ambient temperatures varied from an average low of 10.5°C at night to an average high of 20.5°C during the day. The FF diet used in the trial was a conventional starter and grower diet readily available to small growers and contained 63.5% corn, 30.5% soybean meal, and 2.5% fishmeal. In contrast, based on selection data, the feeds chosen by FC birds at the end of the finisher period included a higher level of grain and fishmeal and a lower level of soybean meal (89% grain, 7% soybean meal, and 1.2% fishmeal; Table 2). Therefore, the FC diet was much lower in protein compared with the FF diet, 13.2 compared with 20.75% by the end of the trial (Table 3). Weekly weight gain was significantly different between treatments at 6 ($P < 0.001$), 8 ($P < 0.001$), and 10 wk ($P < 0.05$) of age. Weight gain peaked at 7 wk for FF but peaked later for FC, at 8 wk; the delay was perhaps a result of birds learning to self-select (Figure 1; Table 4). Mortality was less than 2% in both treatments.

Final live weights did not differ between treatments ($P > 0.05$); however, carcass yield and breast yields were higher in the birds from the FF treatment ($P < 0.05$; Table 5). The higher breast meat yield (7%) was most likely due to the higher protein level and amino acid supplements in the formulated feed. Specifically, the FF diet contained a synthetic DL-methionine

Table 2. Ingredients of formulated feed and self-selected diets for free-range meat chickens

Ingredient (%)	Starter/grower; formulated[1]	Free-choice diet; self-selected from 49 to 56 d[2]	Free-choice diet; self-selected from 77 to 83 d[2]
Corn	63.47	74.00	51.91
Whole wheat	NA[3]	13.95	37.04
Soybean meal, 47.5%	30.46	2.62	1.25
Fishmeal	2.50	6.39	6.93
Dicalcium phosphate	1.51	NA	NA
Bone meal	NA	0.76	0.41
Limestone	1.05	NA	NA
Oystershell, crushed	NA	0.47	0.81
Kelp	NA	0.36	0.29
Salt	0.50	0.09	Negligible
Poultry vitamin/trace mineral premix	0.38	NA	NA
DL-Met	0.14	NA	NA
Grit[4]	1.30	1.36	1.36

[1]Powell's Poultry Starter/Grower [8], average of 2 lots.

[2]Self-selected diets were composed of average of intake from 5 pens.

[3]Not applicable (either not part of the diet or not offered).

[4]Grit was provided in separate feeders and also offered free choice to the formulated treatment.

supplement and had an analyzed TSAA content of 1.04%, whereas the FC ingredients contain no synthetic DL-methionine and the diet selected by birds at 77 to 83 d had a TSAA content of only 0.70%.

Because the NRC recommends 18% protein for 6- to 8-wk-old broilers [15], the FC birds consumed a much lower protein level in the diets than is recommended. However, it is possible for free-range birds to obtain additional protein

Table 3. Analyzed nutrient composition of formulated feed and 2 diets self-selected by free-range meat chickens

Ingredient (%, unless otherwise noted)	Starter/grower; formulated[1]	Free-choice diet; self-selected from 49 to 56 d[2]	Free-choice diet; self-selected from 77 to 83 d[2]
DM	89.90	88.60	88.80
Protein	20.75	15.20	13.20
Ash	6.73	4.56	4.16
Fat	2.27	3.18	2.83
Amino acids			
Cys	0.46	0.33	0.30
Met	0.58	0.41	0.40
Lys	1.24	0.78	0.72
Minerals			
Ca	1.02	0.69	0.85
P	0.67	0.51	0.48
K	1.06	0.66	0.42
Na	0.22	0.11	0.06
Minerals (ppm)			
Mg	2,056	1,635	1,341
S	2,208	1,517	1,356
Fe	135	82	61
Mn	123	38	15
Zn	156	71	26
Cu	18	9	2
Al	54	23	22

[1]Formulated feed was Powell's Poultry Starter/Grower [8], average of 2 lots.

[2]Self-selected diets were composed of average of intake from 5 pens.

Table 4. Effect of feeding method on growth performance of free-range meat chickens[1]

Item	Treatment		Pooled SEM	P-value
	Formulated	Free choice		
Grower period (28–48 d)				
Weight gain (g/bird)	743.8	704.4	23.4	0.13
Feed intake (g/bird)	2,269.4	2,196.0	101.0	0.50
FCR	3.1	3.2	0.2	0.63
Finisher period (49–83 d)				
Weight gain (g/bird)	1,146.4[b]	1,225.1[a]	33.2	0.05
Feed intake (g/bird)	6,338.9[a]	4,596.7[b]	108.2	<0.01
FCR	5.6[a]	3.8[b]	0.2	<0.01
Combined grower/finisher period (28–83 d)				
Weight gain (g/bird)	1,929.8	1,917.0	75	0.87
Feed intake (g/bird)	8,542.9[a]	6,872.4[b]	206.2	<0.01
FCR	3.3	3.1	1.3	0.89
Overall (0–83 d)				
Weight gain (g/bird)	2,386.8	2,394.2	51.2	0.89

[a,b]Means within a row with different superscripts differ ($P < 0.05$).

[1]Values are means of 5 pens of 20 straight-run chickens.

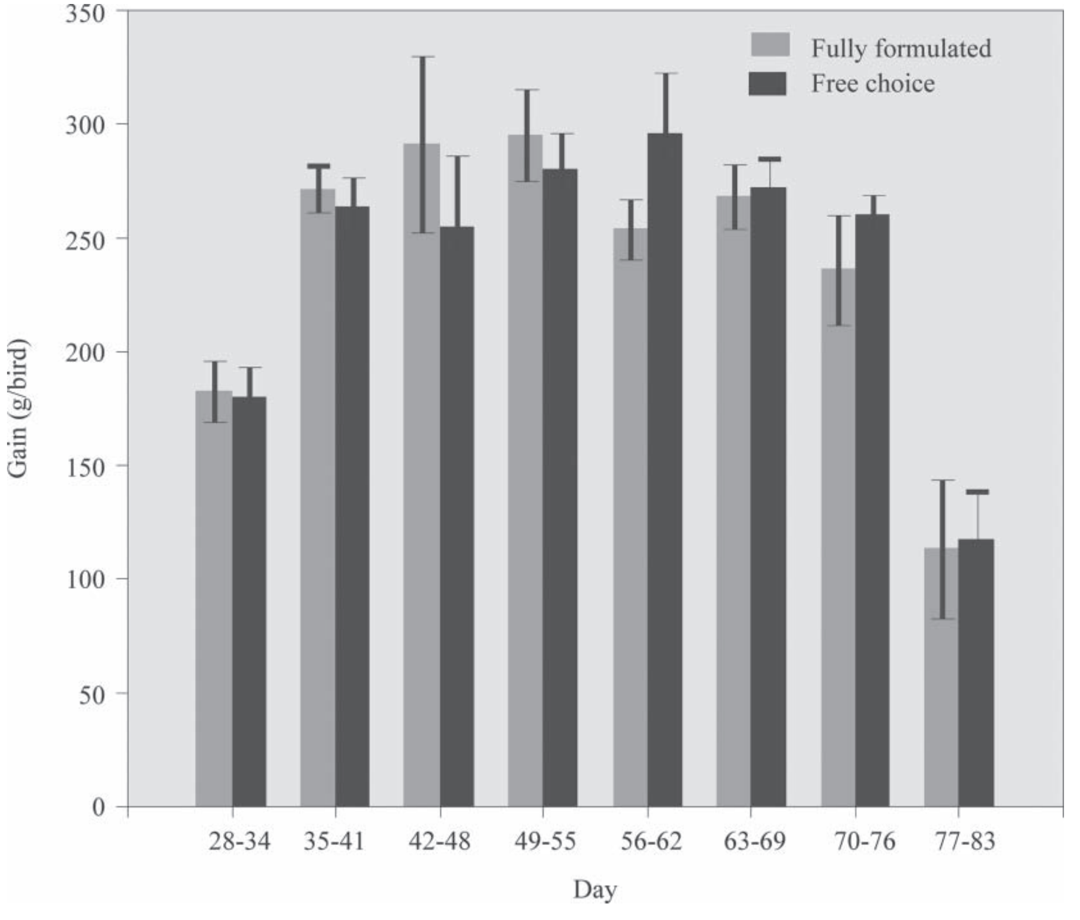

Figure 1. Effect of feeding method on average weekly gain of free-range meat chickens. Values are means of 5 pens of 20 straight-run chickens. Each error bar is constructed using a 95% CI of the mean.

Table 5. Effect of feeding method on meat yield of free-range meat chickens[1]

Item	Treatment		Pooled SEM	*P*-value
	Formulated	Free choice		
Carcass (kg)	1,718.3	1,699.0	43.3	0.66
Carcass yield[2] (%)	71.8[a]	70.5[b]	0.4	<0.01
Breast weight[3] (g)	356.2[a]	330.3[b]	8.7	<0.01
Breast yield[4] (%)	20.9[a]	19.6[b]	0.2	<0.01
Wing yield[4] (%)	12.2	12.0	0.1	0.18
Leg yield[4] (%)	33.7	33.9	0.2	0.23
Frame yield[4,5] (%)	32.6[b]	33.5[a]	0.3	<0.01

[a,b]Means within a row with different superscripts differ ($P < 0.05$).

[1]Values are means of 5 pens of 20 straight-run birds raised for 83 d.

[2]Carcass yield represents the chilled, ready-to-cook carcass weight as a percentage of live BW.

[3]Pectoralis major and pectoralis minor (boneless, skinless).

[4]Calculated as a percentage of chilled carcass weight.

[5]Frame is the carcass including skin but with breast, wings, and legs removed.

from forage plants, depending on forage quality, as well as live protein, such as insects and annelids. In addition, the nutrient requirements of slow-growing meat chickens are not as well-known as they are for fast-growing broilers.

Siegel et al. [16] offered 2 diets to meat chickens and suggested that chickens do not chose diets to maximize growth and economic efficiency; rather, the bird self-formulates to enhance its well-being in its environment and for long-term survival benefits. According to Felton et al. [17], common theories of vertebrate diet self-selection include energy or protein maximization, or avoidance of plant secondary metabolites; however, those authors found that free-roaming primates maintained a stable daily protein intake and allowed total energy intake to vary as food items were available.

The USDA NOP has included plans to phase out the use of synthetic methionine in organic poultry production since the program's establishment in 2002 [18]. In October 2012, the NOP limited the amount of synthetic methionine to 0.1% of the diet for broilers. It is the only synthetic amino acid permitted in organic livestock production and only in poultry production due to the limiting amount of methionine in poultry diets. In the current study, the level added to the FF diet was 0.14%. With the new NOP limit, breast yield is likely to be reduced. In other studies, it was indicated that a yield loss results when synthetic methionine is not used [19, 20]. Currently, no natural methionine supplement is available commercially that is permitted in organic production.

In the current study, the mineral levels self-selected by the FC birds in the diet were not at the levels recommended by the NRC [15]. However, the birds could get additional minerals from forage plants and soil. The calcium level selected was at the NRC level from 77 to 83 d, but not from 49 to 56 d. The calcium-to-phosphorus level was not consistently at the recommended ratio of 2 to 1, and the magnesium levels selected by the FC treatment were high (Table 3). However, no nutritional diseases were noted due to excess or deficiency.

Birds in the FF treatment had higher feed intake and inferior FE in the finisher period ($P < 0.05$), apparently due to wastage. The FF diet was only available in crumble form and, whereas crumbles are designed to improve feed intake and efficiency, in this case, birds seemed to select large particles while flicking small particles to the ground. Small-scale growers generally have little control over the particle size of purchased feeds.

Because of the wastage, it is not known the full extent to which FE could be improved by free-choice feeding. Whereas formulated feeds are typically provided in the starter, grower, and finisher phases, small growers often do not have the opportunity to feed formulated diets in multiple phases, and only 1 diet may be fed throughout the entire growing period. In addition, the nutrient needs of birds change more frequently than these phases [21]. Free-choice feeding can allow birds to adjust nutrient intake on a daily basis via self-selection.

Forages can provide a source of farm-raised nutrients for poultry, particularly protein and vitamins for poultry [22]. Historically, Ladino clover (*Trifolium repens*) and alfalfa (*Medicago sativa*) were preferred high-protein forages for poultry. Horsted et al. [23] found chicory (*Cichorium intybus*) to be a good source of nutrients. Moritz et al. [24] found that forage can contribute to meeting methionine requirements. They found that forage (tall fescue, orchard grass, red clover, and white clover) had higher methionine levels in the summer than in the fall (0.31 vs. 0.17%, respectively). In subsequent studies, it was found that the methionine in forage had a digestibility of 88% [25].

Less forage was left in the paddocks of the FC birds; therefore, it is assumed they consumed more forage than the FF birds (18.3 vs. 34.1 g; $P < 0.05$). A visible color difference was observed in the paddock areas as the trial progressed; the FC birds stripped the green growth from the pasture. It is possible that the chickens sought additional vitamins or trace minerals from the forage, as there were no vitamin or trace mineral supplements offered free choice. In contrast, the FF diet included these supplements. By the end of the trial, the FC bird paddocks appeared brown compared with the green of the more lightly used paddocks of the FF birds. In addition, the skin color of the FC birds was more yellow compared with the FF birds ($P < 0.05$; Table 6), suggesting more ingestion of forages and their pigments.

Free-choice feeding methods vary greatly. In the current study, cracked corn and whole wheat provided energy, although other cereal grains can also be used. In the past, it was recommended to offer at least 2 different grains [26]. Soybeans provide plant protein in poultry diets, but to use them a grower must have access to a roaster or other method to destroy antinutritive factors such as trypsin inhibitors. Animal protein is useful in poultry feeding due to its high quality and nutrient density; likewise, it plays an important role if synthetic methionine is not used. Fishmeal, in particular, is often used in organic production because animal slaughter by-products are not permitted. Novel proteins, such as worm meal or insect meal, also hold potential. Macro minerals often come from off-farm sources. In the current study, calcium carbonate was provided by oyster shell and sodium chloride by trace mineral salt. Small-scale farmers sometimes provide kelp for trace minerals; however, the birds did not eat it in the current study. Phosphorus was provided by bone meal in the current study. In certified organic production, a nonslaughter by-product, such as whey, could be used. When animal manures are incorporated to increase nutrient cycling, off-farm minerals can be reduced.

In the current study, an adjustment period was used. However, because young chicks are precocious, they may be able to self-select ingredients adequately from 1 d old without an adjustment period. Visual clues such as color, particle size, or feeder position are important because chickens depend on their sight in feed-seeking [27, 28].

Feed is a major cost in raising poultry. The diet chosen by FC birds at the end of the finisher period was less expensive than the formulated diet ($0.07 vs. $0.08/kg). In this study, all feed ingredients were purchased. Cost of the FF diet was determined by cost of the bag (22.7 kg), because many small farmers purchase by the bag instead of in bulk. The cost of the FC diet was based on the cost per kilogram of each feed ingredient and the amount consumed. However, the use of farm-raised feed ingredients may further reduce costs.

Whole grains are often used in free-choice feeding because the feed may not be processed.

Table 6. Effect of feeding method on distribution of skin color scores on free-range meat chickens[1]

Item	Formulated	Free choice
Color score[2] (%)		
101	2.2	2.3
102	26.7	10.2
103	52.2	9.1
104	17.8	43.2
105	1.1	28.4
106	0	6.8
P-value	<0.01	

[1]Values represent distribution of 100 birds per treatment.

[2]DSM Nutritional Products. Broiler Color Fan [12]; high score is more yellow.

Although grinding, formulating, mixing, and pelleting may have advantages for feed intake or FE, many small producers are interested in whole grain feeding to reduce the energy used in feed processing and also for gastrointestinal health.

Whole grain feeding enhances the development of the gastrointestinal tract so it is better able to absorb dietary nutrients, optimizing gut performance [29]. According to Bjerrum et al. [30], the gizzard functions as a barrier organ to help prevent pathogenic bacteria from entering the digestive tract. In the current study, some whole grains were used in the FC treatment, but, in the FF, the commercial feed was completely ground.

CONCLUSIONS AND APPLICATIONS

1. In conclusion, free-choice feeding of free-range chickens resulted in similar weight gain and lower breast yield compared with formulated feeding.
2. Free-choice feeding cost less than the fully formulated diet in this study.
3. Free-choice feeding may be more suited to small- or medium-scale production rather than large-scale production, because the number of feeders needed makes automation difficult. It is also useful for poultry production in developing countries where formulated feeds and premixes may be limited.

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9. Gran-I-Grit, Developer-Layer, North Carolina Granite Corporation, Mt. Airy, NC.

10. Precision Scientific Inc., Model #645, Chicago IL.

11. Carcass weight was chilled, ready-to-cook weight. Carcasses were deboned on a cone and parts were breast fillet and tenders (pectoralis major and pectoralis minor, boneless, skinless), bone-in wing, bone-in leg, and frame.

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