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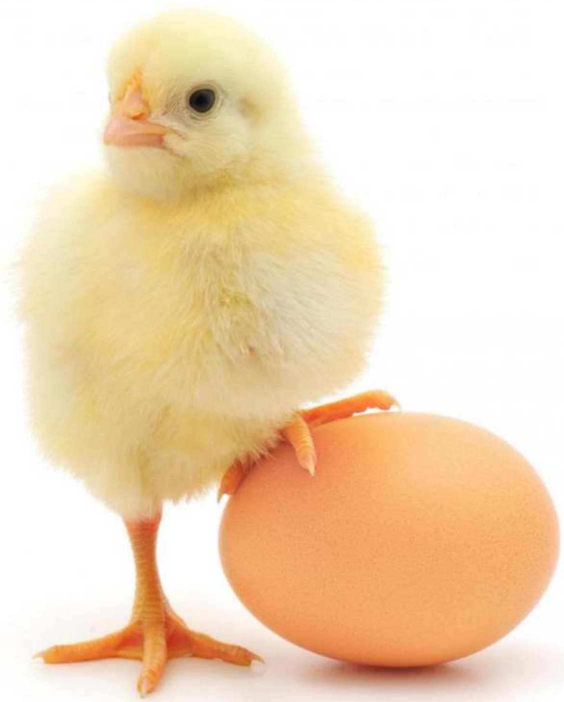

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Comparison of Energy Feeding Programs and Early Feed Restriction on Live Performance and Carcass Quality of Large Male Broilers Grown for Further Processing at 9 to 12 Weeks of Age[1]

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Abstract: Six feeding programs for broilers based on level and time of feeding poultry oil (PO) were compared as well as early feed restriction. All diets were formulated to contain a minimum of 107.5% of NRC (1994) amino acid recommendations, maintained in proportion to dietary energy level. Three different energy levels within each age period were obtained by adding 0, 3, and 6% PO and formulating for optimum nutrient density. Diets within each age period (starter, 0 to 21 days; grower, 21 to 42 days; and finisher, 42 to 84 days) had similar calorie:protein ratios. During the restriction period of 7 to 14 d, the birds were given an amount of their respective diets calculated to provide daily maintenance energy requirements. Before and after the restriction period, the birds were offered feed for *ad libitum* consumption. Body weight, feed consumption, and processing quality were obtained at 63, 70, 77, and 84 d of age. In general, body weight and feed conversion were improved as PO was added to the diet; however, the response was not always significant. Mortality, dressing percentage, abdominal fat, breast, leg, and wing yield did not differ significantly as various levels of PO were fed. In the few instances where there was a significant difference, it did not follow any specific trend among the dietary treatments. There was a significant decrease in the ability to utilize energy by birds grown to 63, 70, 77, or 84 d as the level of PO increased. Feed restriction reduced body weight at 63, 70, and 77 d of age. However, feed conversion was significantly improved and mortality significantly reduced at all ages as compared to birds fed *ad libitum*. Feed restriction had little impact on abdominal fat. No interaction was observed between PO levels and feed restriction.

Key words: Energy levels, feed restriction, large broilers, further processing

Introduction

The increasing consumption of poultry meat has been generated in a large measure by the demand for deboned meat products. The industry has met this demand both by increasing the numbers of birds produced and by increasing their market weight (Brown, 1996). Although increasing the market weight of birds generally increases live cost of production, the fixed costs of processing are reduced. In addition, only a finite number of birds may be processed in a plant in a given time period; thus, increasing the market weight of birds allows for increased plant meat yield without increasing the bird capacity of a processing plant.

Concomitant with the increased body weight of these birds are problems related to mortality or loss of birds from various types of leg disorders, incidence of ascites, and sudden death syndrome. These problems have been attributed in part to the rapid growth of the modern broiler (Bowes *et al.*, 1988; Hulan and Proudfoot, 1981; Arce *et al.*, 1992; Robinson *et al.*, 1992). Various approaches have been made through manipulation of dietary nutrient content, feeding management, and lighting programs to lessen the detrimental effects of these problems while maintaining an economical rate of growth and maximizing the yield of breast meat. Although there is a great deal known about nutritional requirements of broilers, much of this is based upon studies conducted using birds grown to 3 or 4 weeks of age with minimal research on birds grown to older ages. There is limited published research dealing with birds grown to the weights now demanded for deboned meat. Many investigators support the hypothesis that the high incidence of metabolic and skeletal diseases are at least partially related to the rapid growth of the broilers and might be alleviated by reducing early rate of gain (Bowes *et al.*, 1988; Hulan and Proudfoot, 1981; Arce *et al.*, 1992; Robinson *et al.*, 1992; Fontana *et al.*, 1992). Reduction in rate of growth has the concomitant implication of increased time to reach market weight, with its consequent increase in production costs. Therefore, a desirable feeding strategy might include reducing the growth rate in early stages of growth with

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little negative effects on the final broiler performance. There are many reports which state that broiler chickens are able to compensate for the loss of weight resulting from a short period of feed restriction at an early age (Jones and Farrell, 1992; Leeson *et al.*, 1991; Plavnik *et al.*, 1986; Plavnik and Hurwitz, 1985, 1988, 1989, 1991). However, other researchers have not been able to demonstrate the broilers' ability to completely compensate for a growth reduction induced during a period of feed restriction (Robinson *et al.*, 1992; Fontana *et al.*, 1992; Attia *et al.*, 1991; Beane *et al.*, 1979; Cabel and Waldroup, 1990; Washburn, 1990). It has been reported that timing, severity and duration of the feed restriction period may affect the subsequent ability of the bird to recover from a growth deficit (Robinson *et al.*, 1992; Leeson *et al.*, 1991; Plavnik *et al.*, 1986; Plavnik and Hurwitz, 1988, 1991; Jones and Farrell, 1992; Marks, 1979).

Many investigators have observed more efficient feed conversion in feed-restricted broilers compared with full-fed cohorts (Beane *et al.*, 1979; Kasim and Leeson, 1992; Pinchasov and Jensen, 1989). Furthermore, feed-restricted birds have been shown to have less carcass fat content at market age than birds fed *ad libitum* (Plavnik and Hurwitz, 1985; Cabel and Waldroup, 1990; Simon *et al.*, 1978). These reports are in conflict with other researchers (Robinson *et al.*, 1992; Leeson *et al.*, 1991; Summers *et al.*, 1990) who observed that even though feed restricted birds had lower fat content, they showed feed efficiency similar to those fed *ad libitum*. Fontana *et al.* (1993) and Scheideler and Baughman (1993) observed no effect of feed restriction regimens on carcass fat content.

Because of the limited amount of information related to nutrient requirements of birds grown to heavier market weights, an experiment was conducted to evaluate feeding programs and nutrient needs for male broilers grown to heavy weights. In this study we investigated the effect of different energy feeding programs and early feed restriction on performance of large broiler males grown to 12 weeks of age.

Materials and Methods

Diet formulation: Diets were formulated by linear programming to provide a minimum of 107.5% of NRC (1994) amino acid recommendations, maintained in proportion to dietary energy level. A minimum crude protein (CP) level was imposed on all diets and maintained in proportion to dietary energy. Within each age period (0 to 21 days, 21 to 42 days, 42 to 84 days) diets were formulated to optimum nutrient density (energy and associated nutrients) commensurate with 0, 3, or 6% added poultry oil (PO). In a previous study (Saleh *et al.*, 2003) it was observed that 6% supplemental poultry oil provided maximum performance with a reduction in performance at higher levels of supplementation. Although no specific ratio of protein and energy was specified, diets within each age period had similar ratios. All diets contained 5% of a low-ash pet food grade poultry byproduct meal. Diets were fortified with vitamin and trace mineral premixes obtained from commercial integrators. Composition of the diets is shown in Table 1. All diets were pelleted with steam; starter diets were crumbled.

Birds and housing: Male chicks of a commercial broiler strain[2] were obtained from a local hatchery where they had been vaccinated in ovo for Marek's virus and had received vaccinations for Newcastle Disease and Infectious Bronchitis post hatch via a coarse spray. Fifty birds were randomly placed in each of 48 pens (5.2 m^2) in a commercial type steel-truss poultry house with concrete floors. Previously used softwood shavings served as litter with a top-dressing of new shavings. Temperature and ventilation were maintained with thermostatically controlled brooder stoves, fans, and automatic sidewall curtains. Each pen was equipped with two tube feeders and an automatic water font. Incandescent lights supplemented natural daylight to provide 23 hr light daily.

Feeding program: Six feeding programs were compared based on diets containing the three different levels of poultry oil. The six feeding programs were: 1) Constant low PO (0%); 2) Constant medium PO (3%); 3) Constant high PO (6%); 4) Low to 21 d, medium to 84 d; 5) Low to 21 d, high to 84 d; 6) Medium to 21 d, high to 84 d. Each of these feeding programs was assigned to eight replicate pens of birds.

For the first seven days post-hatch all birds were offered the test diets for *ad libitum* consumption. From 7 to 14 d, four of the eight replicate pens of each dietary treatment were given their respective diets on a restricted basis. At 7 d the birds were weighed and the pen mean body weight determined. From 7 to 14 d they were given a restricted amount of feed calculated to provide the following amount of energy:

$$\text{ME Kcal/day} = 1.5 \times BW^{0.666}$$

where BW = mean body weight (g) at 7 d, as suggested by Plavnik and Hurwitz (1990). After 14 d the birds were again offered their respective test diets for *ad libitum* consumption.

Measurements: Body weight by pen was taken at 63, 70, 77, and 84 d. Feed consumption was determined at the

[2]Ross Breeders, Huntsville AL.

Table 1: Composition (g/kg) and calculated nutrient content of diets with different levels of poultry oil

Ingredient	Starter (0-21 d)			Grower (21-42 d)			Finisher (42-63 d)		
	A	B	C	A	B	C	A	B	C
Yellow corn	657.60	600.68	543.75	694.14	639.11	584.11	729.87	676.35	620.80
Dehulled soybean meal	264.13	289.25	314.05	232.90	256.53	280.14	200.67	222.99	247.31
Poultry byproduct meal	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
Poultry oil	0.00	30.00	60.00	0.00	30.00	60.00	0.00	30.00	60.00
Iodized salt	3.70	3.95	4.12	3.78	3.98	4.20	3.85	4.05	4.26
Ground limestone	10.28	10.69	10.98	10.85	11.23	11.60	10.01	10.35	10.70
Dicalcium phosphate	8.22	9.15	9.98	3.65	4.32	4.98	1.51	2.10	2.70
DL Methionine (98%)	2.07	2.28	2.48	0.68	0.83	0.97	0.09	0.16	0.23
L-Lysine HCl (98%)	0.00	0.00	0.64	0.00	0.00	0.00	0.00	0.00	0.00
Constant ingredients[1]	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Total	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00
ME kcal/kg	2973	3094	3213	3014	3135	3256	3052	3175	3297
Crude protein, %	21.50	22.27	23.09	20.19	20.90	21.62	18.87	19.53	20.18
ME kcal/% CP	138	139	139	149	150	151	162	163	163
Met, %	0.56	0.58	0.61	0.40	0.42	0.45	0.33	0.34	0.35
Lys, %	1.14	1.20	1.31	1.05	1.11	1.17	0.97	1.02	1.07
TSAA, %	0.90	0.94	0.97	0.73	0.76	0.79	0.64	0.66	0.68

[1]Includes trace mineral mix to supply per kg of diet: Mn 100 mg; Zn 100 mg; Fe 50 mg; Cu 10 mg; I , 1 mg; vitamin premix to provide per kg of diet: vitamin A 7714 IU; cholecalciferol 2204 IU; vitamin E 16.53 IU; vitamin B_{12} 0.013 mg; riboflavin 6.6 mg; niacin 39 mg; pantothenic acid 10 mg; menadione 1.5 mg; folic acid 0.9 mg; choline 1040 mg; thiamin 1.54 mg; pyridoxine 2.76 mg; d-biotin 0.066 mg; ethoxyquin 125 mg; Se 0.1 mg; BMD-50 (Alpharma, Inc., Ft. Lee, NJ 07024) to provide 50 g/ton bacitracin activity; Coban 60 (Elanco Animal Health division of Eli Lilly & Co., Indianapolis, IN 46825) to provide 90 g/ton monensin.

Table 2: Effects of diets containing different levels of supplemental poultry oil and given *ad libitum* or restricted from 7 to 14 d on body weight (g) of male broilers grown for further processing

% Poultry oil[1]	63 d	70 d	77 d	84 d
0 - 0	3858^{b}	4253	4579	4886
3 - 3	3968^{ab}	4332	4621	4789
6 - 6	4048^{a}	4438	4744	4887
0 - 3	3950^{ab}	4372	4647	4812
0 - 6	3958^{ab}	4421	4742	4914
3 - 6	3900^{b}	4372	4679	4883
Probability > F	0.07	0.23	0.40	0.75
SEM	42	54	64	67
Ad libitum	4052^{x}	4432^{x}	4723^{x}	4853
Restricted[2]	3842^{y}	4298^{y}	4614^{y}	4871
Probability > F	0.0001	0.006	0.04	0.74
SEM	24	32	37	39

[1]Percent poultry oil in diets 0 - 21 d; percent in diets 21 to 84 d. [2]Fed from 7 to 14 d in amounts calculated to provide the following energy: ME kcal/day = 1.5 x $BW^{0.666}$ where BW = mean 7 d BW (Plavnik and Hurwitz, 1990). [ab, xy]Means in column with common superscript do not differ significantly ($P < 0.05$).

same time intervals. Mortality was checked twice daily and the weight of dead birds recorded and used to adjust feed conversion ratio. At 63, 70, 77, and 84 d five birds from each pen were selected at random from among birds within one-half standard deviation of the mean pen weight. After feed was withheld for 12 hr the selected birds were transported 1 km to the University pilot processing plant and processed to determine dressing percentage and parts yield as described by Izat *et al*. (1990).

Data were subjected to the analysis of variance using the General Linear Models (GLM) procedure of the SAS Institute (1988). When significant differences among or between treatments were found, means were separated by repeated t-tests using probabilities generated by the LSMEANS option of the GLM procedure of SAS software. Pen means were the experimental unit; main effects of dietary treatment and restricted feeding and the interaction of dietary treatment and feed restriction were examined. Mortality data were transformed to $\sqrt{n+1}$ prior to analysis. Percentage data for processing effects were converted to arc sine before analysis. Data are presented as natural numbers.

Table 3: Effects of diets containing different levels of supplemental poultry oil and given *ad libitum* or restricted from 7 to 14 d on mortality-adjusted feed conversion by male broilers grown for further processing

% Poultry oil[1]	0-63 d	0-70 d	0-77 d	0-84 d
0 - 0	2.164	2.307[a]	2.459	2.578
3 - 3	2.121	2.274[ab]	2.428	2.584
6 - 6	1.114	2.267[ab]	2.416	2.557
0 - 3	2.120	2.238[b]	2.395	2.502
0 - 6	2.102	2.234[b]	2.391	2.527
3 - 6	2.141	2.261[ab]	2.426	2.553
Probability > F	0.11	0.05	0.10	0.08
SEM	0.016	0.017	0.019	0.017
Ad libitum	2.141[x]	2.287[x]	2.435[x]	2.578[x]
Restricted[2]	2.110[y]	2.240[b]	2.404[y]	2.529[y]
Probability > F	0.03	0.002	0.04	0.001
SEM	0.009	0.009	0.011	0.010

[1]Percent poultry oil in diets 0 - 21 d; percent in diets 21 to 84 d. [2]Fed from 7 to 14 d in amounts calculated to provide the following energy: ME kcal/day = 1.5 x $BW^{0.666}$ where BW = mean 7 d BW (Plavnik and Hurwitz, 1990). [ab, xy]Means in column with common superscript do not differ significantly (P < 0.05).

Table 4: Effects of diets containing different levels of supplemental poultry oil and given *ad libitum* or restricted from 7 to 14 d on mortality-adjusted calorie conversion (ME kcal/kg gain) by male broilers grown for further processing

% Poultry oil[1]	0-63 d	0-70 d	0-77 d	0-84 d
0 - 0	6542[c]	6980[d]	7206[d]	7810[c]
3 - 3	6669[bc]	7158[bc]	7646[bc]	8140[b]
6 - 6	6900[a]	7406[a]	7897[a]	8365[a]
0 - 3	6608[c]	7021[cd]	7521[c]	7919[c]
0 - 6	6816[ab]	7259[ab]	7778[ab]	8229[ab]
3 - 6	6967[a]	7366[a]	7916[a]	8335[a]
Probability > F	0.001	0.001	0.001	0.0001
SEM	52	54	63	55
Ad libitum	6793[x]	7269[x]	7683	8207[x]
Restricted[2]	6707[y]	7128[b]	7638	8059[y]
Probability > F	0.05	0.004	0.39	0.003
SEM	30	31	36	32

[1]Percent poultry oil in diets 0 - 21 d; percent in diets 21 to 84 d. [2]Fed from 7 to 14 d in amounts calculated to provide the following energy: ME kcal/day = 1.5 x $BW^{0.666}$ where BW = mean 7 d BW (Plavnik and Hurwitz, 1990). [abcd, xy]Means in column with common superscript do not differ significantly (P < 0.05).

Results and Discussion

Body weight: Effects of the various dietary treatments on body weight are shown in Table 2. At 63 d, birds with no supplemental PO did not differ significantly in body weight from those fed 3% PO on a continuous basis but were significantly lighter than birds fed 6% PO on a continuous basis. At 70 days of age and at subsequent ages, no differences in body weight were noted among the birds fed the various levels of PO. When birds fed 3% PO were changed to diets with 6% PO at 21 days of age, their body weights were not generally improved compared to those which continued to receive 3% PO and were somewhat lighter in body weight than those who received 6% PO on a continuous basis, with the difference being statistically significant at 63 days of age. Feed restriction from 7 to 14 d reduced body weight significantly at 63, 70, and 77 days of age, with no interaction between feeding programs and feed restriction. Therefore, birds were not able to totally compensate for the weight lost during the restriction program even after extended feeding.

Feed conversion: Effects of the dietary treatments on feed conversion are shown in Table3. When the various levels of the PO were fed on a continuous basis, feed conversion at 63, 70, 77, and 84 day tended to improve as PO was added to the diet but the differences were not statistically significant. When birds grown on diets with no supplemental PO were changed to diets with 3 or 6% PO at 21 days of age or birds fed 3% PO were changed to 6% PO at 21 days, feed conversion at 63, 70, 77, and

Table 5: Effects of diets containing different levels of supplemental poultry oil and given *ad libitum* or restricted from 7 to 14 d on mortality (%) of male broilers grown for further processing

% Poultry oil[1]	0-63 d	0-70 d	0-77 d	0-84 d
0 - 0	13.31	15.05	17.56	19.82
3 - 3	10.28	10.78	12.29	14.79
6 - 6	12.59	15.85	18.87	20.89
0 - 3	14.80	15.80	16.80	18.30
0 - 6	12.47	14.23	17.99	19.23
3 - 6	9.39	11.11	13.29	15.27
Probability > F	0.38	0.09	0.14	0.33
SEM	1.88	1.55	1.99	2.25
Ad libitum	13.90[x]	15.15[x]	17.91[x]	20.58[x]
Restricted[2]	10.38[y]	12.46[y]	14.36[y]	15.51[y]
Probability > F	0.03	0.04	0.03	0.01
SEM	1.08	0.89	1.14	1.31

[1]Percent poultry oil in diets 0 - 21 d; percent in diets 21 to 84 d. [2]Fed from 7 to 14 d in amounts calculated to provide the following energy: ME kcal/day = 1.5 x $BW^{0.666}$ where BW = mean 7 d BW (Plavnik and Hurwitz, 1990). [xy]Means in column with common superscript do not differ significantly (P < 0.05).

Table 6: Effects of diets containing different levels of supplemental poultry oil and given *ad libitum* or restricted from 7 to 14 d on dressing percentage (%) of male broilers grown for further processing

% Poultry oil[1]	63 d	70 d	77 d	84 d
0 - 0	68.77[a]	71.15	73.23	71.37
3 - 3	67.34[b]	72.51	73.53	71.21
6 - 6	69.15[a]	70.73	73.57	71.64
0 - 3	68.30[ab]	71.17	73.64	71.71
0 - 6	68.07[a]	70.96	73.49	72.06
3 - 6	68.39[ab]	71.36	73.61	71.61
Probability > F	0.04	0.07	0.97	0.66
SEM	0.38	0.42	0.35	0.36
Ad libitum	68.71[x]	71.60	73.61	71.83
Restricted[2]	67.97[y]	71.03	73.42	71.36
Probability > F	0.02	0.10	0.55	0.12
SEM	0.22	0.24	0.20	0.21

[1]Percent poultry oil in diets 0 - 21 d; percent in diets 21 to 84 d. [2]Fed from 7 to 14 d in amounts calculated to provide the following energy: ME kcal/day = 1.5 x $BW^{0.666}$ where BW = mean 7 d BW (Plavnik and Hurwitz, 1990). [ab, xy]Means in column with common superscript do not differ significantly (P < 0.05).

84 d were generally equivalent to that of birds that had been continuously fed diets with 6% PO. Feed conversion was significantly improved at all ages by restricting feed intake during the 7 to 14 day period as compared to their *ad libitum*-fed counterparts.

Calorie conversion: The effects of the different dietary treatments on calorie conversion ratio (CCR) expressed as ME kcal/kg gain, are shown in Table 4. This measurement may be a more economically important estimate of the ability of the chick to utilize diets with different levels of supplemental PO than is feed conversion, since the various dietary treatments differed markedly in energy content. When PO was fed on a continuous basis, CCR was significantly increased as the level of PO increased. This indicates that by keeping the birds to later ages, the apparent utilization of energy in diets with higher levels of PO was reduced in comparison to diets with no supplemental PO. When birds grown on diets with no supplementary PO were changed to diets with 3 or 6% PO at 21 days of age or birds fed 3% PO were changed to 6% PO at 21 days, CCR at 63, 70, 77, and 84 d were generally equivalent to that of birds that had been fed the same levels of PO on a continuous basis. Calorie conversion was significantly improved by restricting feed intake during the 7 to 14 d period as compared to their *ad libitum*-fed counterparts, in concert with the improvement in feed efficiency. This significant improvement in CCR was maintained throughout the duration of the trial with the exception of 77 d, which improved numerically.

Mortality: Percentage mortality at Day 63, 70, 77, and 84 are shown in Table 5. Excessively cold weather during the period of 42 to 63 d resulted in considerable mortality from ascites among all treatments. The level of

Table 7: Effects of diets containing different levels of supplemental poultry oil and given *ad libitum* or restricted from 7 to 14 d breast meat yield of male broilers grown for further processing

Treatment	As percentage of dressed carcass weight				Weight in grams			
% Poultry oil[1]	63 d	70 d	77 d	84 d	63 d	70 d	77 d	84 d
0 - 0	24.45	23.68	24.93	24.85	719	837	959	1016
3 - 3	24.15	25.11	25.14	24.92	702	889	967	1012
6 - 6	24.61	24.34	25.29	24.95	738	853	999	1029
0 - 3	24.89	24.71	25.46	25.02	737	874	978	1033
0 - 6	24.33	24.05	24.64	25.27	721	817	933	1068
3 - 6	23.98	24.26	24.31	24.65	725	847	954	995
Probability > F	0.36	0.08	0.28	0.88	0.83	0.12	0.50	0.60
SEM	0.54	0.34	0.37	0.35	21	19	24	29
Ad libitum	24.49	24.69^{x}	25.18	25.11	746^{x}	883^{x}	998^{x}	1048^{x}
Restricted[2]	24.31	24.02^{y}	24.74	24.78	701^{y}	822^{y}	932^{y}	1002^{y}
Probability > F	0.53	0.02	0.15	0.12	0.01	0.0004	0.002	0.05
SEM	0.21	0.19	0.21	0.21	12	11	14	17

[1]Percent poultry oil in diets 0 - 21 d; percent in diets 21 to 84 d. [2]Fed from 7 to 14 d in amounts calculated to provide the following energy: ME kcal/day = 1.5 x $BW^{0.666}$ where BW = mean 7 d BW (Plavnik and Hurwitz, 1990). ^{xy}Means in column with common superscript do not differ significantly ($P < 0.05$).

Table 8: Effects of diets containing different levels of supplemental poultry oil and given *ad libitum* or restricted from 7 to 14 d leg quarter yield of male broilers grown for further processing

Treatment	As percentage of dressed carcass weight				Weight in grams			
% Poultry oil[1]	63 d	70 d	77 d	84 d	63 d	70 d	77 d	84 d
0 - 0	33.59	34.35	35.14	33.94	985	1208	1351	1385
3 - 3	33.29	33.29	34.67	33.73	966	1179	1333	1366
6 - 6	33.95	33.63	34.04	34.22	1016	1174	1344	1408
0 - 3	33.33	33.94	34.10	33.91	983	1199	1304	1392
0 - 6	34.04	33.71	34.83	34.13	1009	1145	1314	1436
3 - 6	34.18	33.69	34.69	33.77	1030	1173	1357	1358
Probability > F	0.08	0.18	0.06	0.91	0.37	0.39	0.53	0.49
SEM	0.26	0.27	0.27	0.35	23	21	23	30
Ad libitum	33.58	33.68	34.45	33.73	1020^{x}	1201^{x}	1363^{x}	1404
Restricted[2]	33.87	33.85	34.72	34.17	977^{y}	1157^{y}	1304^{y}	1378
Probability > F	0.17	0.46	0.26	0.15	0.02	0.01	0.003	0.30
SEM	0.15	0.16	0.16	0.21	13	13	13	17

[1]Percent poultry oil in diets 0 - 21 d; percent in diets 21 to 84 d. [2]Fed from 7 to 14 d in amounts calculated to provide the following energy: ME kcal/day = 1.5 x $BW^{0.666}$ where BW = mean 7 d BW (Plavnik and Hurwitz, 1990). ^{xy}Means in column with common superscript do not differ significantly ($P < 0.05$).

PO in the diet had no significant effect on the mortality at any age whether fed on a continuous basis or changed at Day 21 of age. However, feed restriction resulted in a significant reduction in mortality at all ages.

Dressing percentage: The effects of the dietary treatments on carcass dressing percentage at different ages are shown in Table 6. Although significant differences in dressing percentage were observed among birds fed the various levels of PO at 63 d, these did not follow any consistent pattern related to level of PO fed on a continuous or cyclic basis. No significant differences in dressing percentage were observed at subsequent ages. Feed restriction significantly reduced dressing percentage at 63 d as compared to birds that were fed the same diets on an *ad libitum* basis. At subsequent ages, no significant differences in dressing percentage were noted as a result of feed restriction.

Breast meat yield: Breast meat yield, expressed as both percent of the chilled carcass and as quantitative yield, is shown in Table 7. No significant effects of level of supplemental PO or time of feeding PO were observed on breast meat yield at any age examined. Birds that were subjected to a restricted feed intake program from 7 to 14 d had significantly lighter breast weight at every age examined than birds that received the same diets on an *ad libitum* basis. However, when expressed as a

Table 9: Effects of diets containing different levels of supplemental poultry oil and given *ad libitum* or restricted from 7 to 14 d on abdominal fat content of male broilers grown for further processing

Treatment	As percentage of dressed carcass weight				Weight in grams			
% Poultry oil[1]	63 d	70 d	77 d	84 d	63 d	70 d	77 d	84 d
0 - 0	3.11	3.38	2.85^{c}	3.19	92.1	117.9	110.8^{c}	132.0
3 - 3	3.57	3.28	3.45^{ab}	3.44	104.5	116.0	132.9^{ab}	139.8
6 - 6	3.24	3.33	3.18^{abc}	3.11	98.0	116.6	125.4^{abc}	129.1
0 - 3	3.49	2.91	3.10^{abc}	3.22	103.1	103.3	117.7^{bc}	133.3
0 - 6	3.01	3.22	3.00^{bc}	3.06	889.3	109.7	112.9^{c}	129.5
3 - 6	3.18	3.23	3.57^{a}	3.49	96.3	112.9	140.3^{a}	142.0
Probability > F	0.13	0.33	0.04	0.44	0.32	0.43	0.02	0.84
SEM	0.16	0.15	0.16	0.17	5.4	5.5	6.5	8.6
Ad libitum	3.27	2.98^{y}	3.11	3.13	99.9	106.9^{y}	123.3	131.2
Restricted[2]	3.28	3.47^{x}	3.28	3.37	94.5	118.5^{x}	123.4	137.5
Probability > F	0.97	0.0004	0.22	0.11	0.23	0.01	0.99	0.40
SEM	0.09	0.08	0.09	0.10	3.10	3.2	3.8	5.0

[1]Percent poultry oil in diets 0 - 21 d; percent in diets 21 to 84 d. [2]Fed from 7 to 14 d in amounts calculated to provide the following energy: ME kcal/day = 1.5 x $BW^{0.666}$ where BW = mean 7 d BW (Plavnik and Hurwitz, 1990). $^{abc,\,xy}$Means in column with common superscript do not differ significantly (P < 0.05).

Table 10: Effects of diets containing different levels of supplemental poultry oil and given diets full-fed or restricted from 7 to 14 d on wing yield of male broilers

Treatment	As percentage of dressed carcass weight				Weight in grams			
% Poultry oil[1]	64 d	70 d	77 d	84 d	63 d	70 d	77 d	84 d
0 - 0	10.74	10.25	10.48	10.22	315	360	402	416
3 - 3	10.77	9.98	10.40	10.14	310	353	400	410
6 - 6	10.59	10.30	10.54	10.08	317	359	415	413
0 - 3	10.81	10.28	10.61	10.12	321	362	405	415
0 - 6	10.72	10.49	10.69	10.12	317	354	403	425
3 - 6	10.58	10.21	10.23	10.19	319	355	400	410
Probability > F	0.90	0.20	0.21	0.98	0.85	0.80	0.64	0.46
SEM	0.17	0.13	0.13	0.14	5.8	5.5	6.9	5.6
Ad libitum	10.74	10.27	10.44	10.20	326^{x}	366^{x}	412^{x}	4.24^{x}
Restricted[2]	10.67	10.24	10.53	10.09	307^{y}	349^{y}	395^{y}	406^{b}
Probability > F	0.60	0.82	0.43	0.33	0.0003	0.001	0.005	0.005
SEM	0.10	0.07	0.07	0.08	3.4	3.2	4.1	3.2

[1]Percent poultry oil in diets 0 - 21 d; percent in diets 21 to 84 d. [2]Fed from 7 to 14 d in amounts calculated to provide the following energy: ME kcal/day = 1.5 x $BW^{0.666}$ where BW = mean 7 d BW (Plavnik and Hurwitz, 1990). ^{xy} Means in column with common superscript do not differ significantly (P < 0.05).

percentage of the carcass, these birds differed significantly only at 70 d. Because breast meat is considered one of the highest value portions of the carcass, this finding negates much of the potential value of early feed restriction to improve mortality or feed conversion.

Leg quarter yield: Leg quarter yield, expressed as both percentage of the chilled carcass and as quantitative yield, is shown in Table 8. No significant effects of level of supplemental PO or time of feeding PO were observed on leg quarter yield at any age examined. Birds that were subjected to feed restriction had significantly lighter leg quarters at 63, 70, and 77 d than birds fed *ad libitum*. However, when expressed as a percentage of the carcass, no significant differences were observed on leg quarter yield.

Abdominal fat content: Abdominal fat content, expressed as both percent of the chilled carcass and as quantitative yield, is shown in Table 9. The level of PO fed on continuous basis or changed at 21 d had no significant impact on abdominal fat content at 63, 70, or 84 d. However, at 77 d significant differences in abdominal fat content (percent of carcass or quantitative weight) were observed among birds fed the various dietary treatments, but no particular trend in relation to level of PO in the diet was observed. Feed restriction had little impact on abdominal fat content. At 70 d, birds that were subjected to feed restriction had significantly higher abdominal fat content (percent or quantitative) than those fed comparable diets on an *ad libitum* basis. At other ages, however, feed restriction had no significant effect on abdominal fat content.

Wing yield: The results for wing yield are shown in Table 10. No significant effects of level of supplemental PO or time of feeding PO were observed on wing yield at any age examined. Birds that were subjected to a restricted intake program had significantly lighter wings than birds on *ad libitum* feed intake. When expressed as a percentage of carcass, no differences were observed at any age as a result of early feed restriction.

In general, dietary energy levels obtained by varying level of poultry oil had little or no effect on the live performance (body weight and feed conversion) of male broilers grown for further processing to ages beyond the usual industry standard. At older ages, the apparent utilization of energy in diets with higher levels of poultry oil was reduced in comparison to diets with no supplemental poultry oil. Therefore, economics might favor formulation of diets with minimal supplemental fats and oils.

Birds subjected to early feed restriction from 7 to 14 d had reduced body weight, which did not totally recover even by 77 days of age. Quantitative weight of the economically important breast meat was also significantly reduced by early feed restriction. However, feed conversion was significantly improved and mortality significantly reduced by feed restriction. The economic tradeoffs of these effects must be considered in making a decision to utilize early feed restriction as a management tool.

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