ISSN 1682-8356
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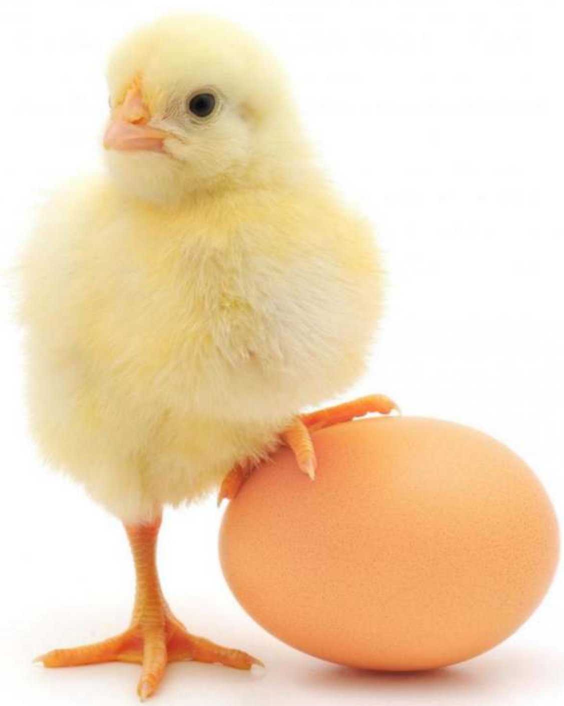

INTERNATIONAL JOURNAL OF POULTRY SCIENCE

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International Journal of Poultry Science 3 (1): 11-16, 2004

Consideration for Dietary Nutrient Density and Energy Feeding Programs for Growing Large Male Broiler Chickens for Further Processing[1]

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Abstract: Three trials with identical experimental design were conducted to examine the effects of dietary nutrient density and energy feeding programs on male broiler chickens grown to heavy weights for further processing. Diets were formulated to provide a minimum of 107.5% of NRC (1994) amino acid requirements, maintained in proportion to dietary energy levels. Diets with different nutrient density were obtained by adding 0, 3, and 6% poultry oil (PO) while maintaining essential nutrients in a constant balance with energy. Diets within each age period (0 to 21 days, 21 to 42 days, and 42 to 63 days) had similar ratios of metabolizable energy to crude protein. Six feeding programs were obtained by either feeding these three levels of PO continuously to 63 d or by increasing the amount of PO in the diet at 21 d. Live performance was examined at 14, 21, 42, and 63 d and carcass composition was examined at 63 d. Dietary energy levels or feeding programs had no significant effect on body weight except at 42 d, which improved as PO was added to the diet. Feed intake was not significantly affected by feeding various levels of poultry oil or by utilizing different feeding programs. However, feed conversion at all ages showed a significant improvement as the level of supplemental PO increased. Calorie conversion was not affected at 14, 21, and 42 d. At 63 d, calorie conversion was significantly reduced when birds received diets with increased supplemental PO. Neither supplemental PO or feeding program affected the dressing percentage or yield of economically important carcass components at 63 d when examined on an absolute basis or as percentage of carcass weight. Abdominal fat content was not significantly influenced by level of supplemental poultry oil.

Key words: Broilers, energy levels, feeding programs, performance

Introduction

An increasing number of broilers are being grown to heavy weights to meet consumer demands for deboned poultry meat. As birds grow to older ages, the efficiency of utilizing feed declines, making it more important to minimize feed costs. Approximately 70% of the total cost of poultry diets is related to meeting energy needs (Skinner *et al*., 1992). Thus, choosing the proper level of energy that will optimize growth, carcass quality and feed efficiency, while still allowing for profitable production is a major concern to any integrator. It has been consistently demonstrated that if essential nutrients are maintained in relationship to dietary energy, an increased growth rate and improved feed efficiency is observed as a result of increasing the level of dietary energy (Farrell *et al*., 1976; Waldroup, 1981; Jackson *et al*., 1982; Bartov, 1992; Leeson *et al*., 1996).

It has been demonstrated that savings can result if selection can be made among diets which can support different rates of growth rather than formulated to a single predetermined set of nutrient specifications (Waldroup *et al*., 1976). In order to utilize this type of formulation, there must be more data available to characterize the response of chicks to changes in nutrient levels. Waldroup (1981) argued that although higher energy levels may allow for more rapid gains or for a greater quantity of meat to be produced in a given time in order to minimize capital costs of housing, equipment and labor, the ingredient and production costs of higher energy diets in contrast to diets of lower energy density may negate the benefits of improved performance. According to Brown and McCartney (1982), the major differences in the cost of all diets are due to the price of corn, soybean meal, and poultry fat. The relative advantage or disadvantage of using any of these diets has to be determined by the price of these ingredients at the time of use.

Controversy exists regarding the influence of dietary energy levels on carcass composition and quality. As the modern broiler industry increasingly targets further processed or cut-up parts, any change in composition or quantity of economically important parts is a concern. Carcass fatness is also a concern especially when dietary energy levels are concerned. In general, carcass

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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.

fatness will not change as long as the ratio of energy and protein are kept constant; otherwise, carcass fatness increases as dietary energy level increases (Fraps, 1943; Donaldson *et al.*, 1956; Bartov *et al.*, 1974; Griffiths *et al.*, 1977; Mabray and Waldroup, 1981; Skinner *et al.*, 1992). Therefore, it is important to maintain a balance between energy and crude protein in formulating poultry diets.

Virtually all studies related to the response of broilers to dietary energy were conducted using broilers fed to much younger ages than currently practiced in the broiler industry. Therefore, these experiments were designed to evaluate the effects dietary energy on birds grown to older ages. Diets with different energy levels were obtained by supplementing PO at 0, 3, and 6% of the diet while maintaining optimum nutrient density commensurate with the different energy levels of male broilers. Different feeding programs resulting from changing the level of PO at 21 d were also evaluated.

Materials and Methods

Diet formulation: Diets were formulated 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. Within each age period (0 to 21 days, 21 to 42 days, 42 to 63 days), diets were formulated to be optimum in nutrient density (energy and associated nutrients) commensurate with 0, 3, or 6% added PO. In a previous study (Saleh *et al.*, 2003) we observed that 6% supplemental poultry oil provided the maximum response in growth rate related to dietary energy level in broilers. Although no specific ratio of energy to protein 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 adequate vitamins and trace minerals. 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 (Ross 308[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 (5.20 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 lamps supplemented natural daylight to provide 23 hr light daily.

[2]Ross Breeders, Huntsville AL 35805

Table 2: Effects of diets containing different levels of supplemental poultry oil on body weight of male broilers (mean of three trials each with eight pens of 50 male broilers per treatment)

Poultry oil[1](%)	14 d BW(g)	21 d BW(g)	42 d BW(g)	63 d BW(g)
0-0	275	574	2119[c]	3509
3-3	281	596	2190[bc]	3633
6-6	286	622	2222[ab]	3631
0-3			2216[ab]	3614
0-6			2234[ab]	3602
3-6			2281[a]	3673
Probability > F	0.85	0.18	0.001	0.67
SEM	11	16	26	68

[1]Percent supplemental poultry oil in diets 0-21 d followed by level fed 21 to 63 d. [abc]Means in column with common superscript do not differ significantly (P < 0.01).

Table 3: Effects of diets containing different levels of supplemental poultry oil on feed intake by male broilers (mean of three trials each with eight pens of 50 male broilers per treatment)

Poultry oil[1] (%)	0-14 d feed per bird (g)	0-21 d feed per bird (g)	0-42 d feed per bird (g)	0-63 d feed per bird (g)
0-0	388	857	3794	7740
3-3	376	847	3747	7725
6-6	375	843	3733	7704
0-3			3787	7727
0-6			3749	7734
3-6			3819	7867
Probability > F	0.81	0.91	0.89	0.95
SEM	16	25	56	125

[1]Percent supplemental poultry oil in diets 0-21 d followed by level fed 21 to 63 d.

Table 4: Effects of diets containing different levels of supplemental poultry oil on feed conversion (adjusted for mortality) by male broilers (mean of three trials each with eight pens of 50 male broilers per treatment)

Poultry oil[1](%)	0-14 d feed:gainratio	0-21 d feed:gainratio	0-42 d feed:gainratio	0-63 d feed:gainratio
0-0	1.425[a]	1.495[a]	1.789[a]	2.211[a]
3-3	1.360[b]	1.421[b]	1.710[b]	2.131[b]
6-6	1.323[b]	1.350[b]	1.678[c]	2.124[b]
0-3			1.707[b]	2.167[ab]
0-6			1.676[c]	2.153[b]
3-6			1.673[c]	2.146[b]
Probability > F	0.002	0.001	0.0001	0.01
SEM	0.020	0.012	0.01	0.018

[1]Percent supplemental poultry oil in diets 0-21 d followed by level fed 21 to 63 d. [abc] Means in column with common superscript do not differ significantly (P < 0.01).

Feeding programs: Six feeding programs were derived from the diets with three different levels of supplemental poultry oil. The six feeding programs were as follows: 1) Constant low PO (0%); 2) constant medium PO (3%); 3) constant high PO (6%); 4) low to 21 d, medium to 63 d; 5) low to 21 d, high to 63 d; 6). medium to 21 d, high to 63 d. Each of these feeding programs was assigned to eight replicate pens of birds in each of the three trials. Measurements Body weight by pen was taken at 14, 21, 42, and 63 d. Feed consumption was determined at the same time intervals. Mortality was checked twice daily and the weight of dead or culled birds used to adjust feed conversion ratio. At 63 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). Since no experiment by treatment interaction was observed, data from all three experiments were pooled and analyzed to simplify the discussion.

Statistical analysis: Data were subjected to one-way

Table 5: Effects of diets containing different levels of supplemental poultry oil on calorie conversion by male broilers (mean of three trials each with eight pens of 50 male broilers per treatment)

Poultry oil[1](%)	0-14 d ME kcal per kg gain	0-21 d ME kcal per kg gain	0-42 d ME kcal per kg gain	0-63 d ME kcal per kg gain
0-0	4230	4439	5372	6686[c]
3-3	4199	4386	5296	6676[c]
6-6	4242	4323	5352	6885[ab]
0-3			5332	6818[bc]
0-6			5395	7006[a]
3-6			5426	7015[a]
Probability > F	0.89	0.14	0.08	0.0001
SEM	61	37	33	58

[1]Percent supplemental poultry oil in diets 0-21 d followed by level fed 21 to 63 d. [abc]Means in column with common superscript do not differ significantly ($P < 0.01$).

Table 6: Effects of diets containing different levels of supplemental poultry oil on mortality by male broilers (mean of three trials each with eight pens of 50 male broilers per treatment)

Poultry oil[1](%)	14 d BW(g)	21 d BW(g)	42 d BW(g)	63 d BW(g)
0-0	1.66	2.00	5.93	19.52[a]
3-3	1.99	2.29	5.92	15.52[ab]
6-6	1.42	2.01	7.08	13.67[b]
0-3			6.43	16.37[a]
0-6			4.75	12.31[a]
3-6			5.84	14.11[b]
Probability > F	0.55	0.79	0.61	0.01
SEM	0.32	0.34	0.91	1.45

[1]Percent supplemental poultry oil in diets 0-21 d followed by level fed 21 to 63 d. [abc]Means in column with common superscript do not differ significantly ($P < 0.01$).

Table 7: Effects of diets containing different levels of supplemental poultry oil on carcass components of male broilers (mean of three trials each with eight pens of 5 broilers per treatment)

Poultry Oil[1]	Percent of carcass (%)					Actual weight (g)			
	Dressing	Breast	Leg Quarters	Wing	Abdominal fat	Breast	Leg quarter	Wing	Abdominal Fat
0-0	71.76	23.88	35.55	11.19	3.28	604	891	280	81.6
3-3	70.85	23.81	35.32	11.15	3.48	560	885	278	86.7
6-6	71.68	24.44	35.43	11.04	3.47	635	915	284	89.2
0-3	71.97	23.26	35.31	11.08	3.54	634	915	287	91.3
0-6	71.37	23.95	35.60	11.06	3.37	622	920	286	86.5
3-6	70.82	24.16	34.78	11.31	3.34	624	896	289	84.5
Probability > F	0.22	0.78	0.63	0.30	0.80	0.77	0.75	0.80	0.53
SEM	0.41	0.35	0.36	0.09	0.15	21.4	20.6	6.1	3.7

[1]Percent supplemental poultry oil in diets 0-21 d followed by level fed 21 to 63 d.

analysis of variance using the General Linear Models (GLM) procedure of the SAS Institute (1991). When significant differences among 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 poultry oil feeding programs were examined. Mortality data were transformed to $\sqrt{n+1}$ prior to analysis. Dressing percentage and yield of breast, leg quarter, wing, and abdominal fat were converted to arc sine before analysis. Data are presented as natural numbers.

Results and Discussion

Body weight: Effects of the different PO feeding programs on body weight are presented in Table 2. When various levels of PO were fed on a continuous basis, body weight at 14 d and 21 d improved as PO increased but was not statistically significant. Body weight at 42d and 63 d improved as PO level increased or as the birds were shifted from a diet with no supplemental PO to a diet supplemented with either 3 or 6% PO; however, it was significant only at 42 d. In general, as PO was supplemented, body weight was numerically improved at all ages.

Feed intake: The effects of dietary treatments on feed intake are shown in Table 3. There was no significant effect on feed intake at all ages when various levels of PO were fed on continuous basis or when the diets were changed to 3 or 6% supplemental PO at 21 d. These results show that the birds are primarily eating to maximum fill rather than to satisfy their energy need, in agreement with Saleh *et al.* (2003).

Feed efficiency: Effects of the various dietary treatments on feed conversion are presented in Table 4. When the various levels of PO were fed on a continuous basis, feed conversion at 14, 21, 42, and 63 days of age was significantly improved when the birds received 3 or 6% PO compared to that of birds fed no supplemental PO. At 42 and 63 d, feed efficiency was also improved as the diet was changed at 21 d from 0 to either 3 or 6% PO, or from 3 to 6% PO. These results are in agreement with numerous previous reports (Farrell *et al.*, 1976; Waldroup, 1981; Jackson *et al.*, 1982; Bartov, 1992; Leeson *et al.*, 1996; Saleh *et al.*, 2003).

Calorie conversion: In order to properly compare the utilization of diets differing in energy it is necessary to compare the efficiency of using dietary calories. This is usually done by determining the calorie conversion ratio (CCR), expressed as ME kcal/kg gain. Results of dietary effects on CCR are shown in Table 5. There were no significant differences in CCR at 14, 21, and 42 days of age, indicating that the birds utilized consumed calories with equal efficiency regardless of the level of supplemental poultry oil. However, at 63 d, there was a significant increase in CCR as the level of PO increased. This supports findings by Saleh *et al.* (2003) that at later ages the apparent utilization of energy in diets with high levels of PO was reduced in comparison to diets with no supplemental PO. This finding is interesting in light of research that suggests that the ability to use supplemental fats improves as birds grow older (Renner and Hill, 1960; Young, 1961; Carew *et al.*, 1972; Sell *et al.*, 1986). However in most of these cited studies the primary effect of age was upon utilization of highly saturated fats such as tallow with minimal effect on utilization of highly unsaturated fats such as corn oil or animal-vegetable fat blends. Poultry oil is highly unsaturated (Waldroup and England, 1995) and thus should not be as sensitive to age-associated changes in absorption, but little research is available on absorption of poultry oil at various ages. It is possible that an insufficient amount of some nutrient(s) limits the utilization of energy at these older ages, since most of the nutrient requirements are based upon research on younger birds (NRC, 1994).

Mortality: The effects of the various dietary treatments on mortality are shown in Table 6. Due to excessively cold weather in the first of the three experiments, mortality from ascites in the period of 42 to 63 d was considerably high among all treatments. At 14, 21, and 42 days of age, dietary treatments had no significant effect on mortality. However, at 63 d, mortality was significantly affected. In general, the addition of PO to the diets tended to decrease mortality, in agreement with the report of Saleh *et al.* (2003). Hopkins and Nesheim (1967) reported that increasing levels of linoleic acid reduced the incidence of respiratory-related mortality in broilers. As poultry oil is a good source of linoleic acid (Waldroup and England, 1995) this might be a partial explanation of this reduction in mortality.

Processing quality: The effects of the dietary treatments on processing quality at 63 day of age are shown in Table 7. Dressing percentage was not significantly affected by the various dietary treatments. Breast yield, expressed as percentage of carcass weight or as absolute value, was not significantly affected by the dietary treatments. Similarly, yield of leg quarters and wings as well as abdominal fat, both on absolute or percentage basis, was not significantly affected by dietary treatments. This may be attributed to the fact that the ratio between energy and crude protein was maintained relatively constant within each age period, in agreement with the reports of Fraps, 1943, Donaldson *et al.*, 1956; Bartov *et al.*, 1974; Griffiths *et al.*, 1977 and Mabray and Waldroup, 1981.

Conclusions: In general increasing dietary energy level improved body weight of male broilers up to 63 d of age, however the improvements were not always significant. Feed efficiency improved significantly as dietary energy increased. Feed intake was not affected by the various dietary treatments, suggesting that the birds are eating to maximum fill rather than to meet a specific caloric need. At early ages the apparent utilization of energy in diets with higher levels of PO was not reduced; however, at 63 d birds on higher energy diets demonstrated reduced energy utilization. Dressing percentage and yield of economically important carcass components was not significantly affected by the various dietary treatments. Abdominal fat content was similar among dietary treatments, due primarily to maintenance of a consisted ratio of protein to energy.

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