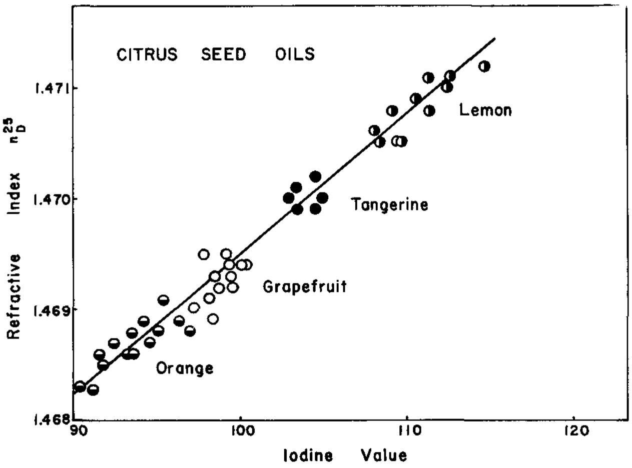

FIG. 1. Relation between iodine value and refractive index for seed oils from various *Citrus* species.

curred on January 16, and it is suggested that physiological maturity of this *Citrus* variety has probably been indicated. Maturity is understandably an intangible value, and is legally more conveniently defined and determined for regulatory purposes in the citrus industry by measurement of total soluble solids/acid ratio of extracted citrus juices.

The GLC analyses of this study are presented in Table II. Average values have been shown that represent in each case a minimum of seven samples. The fatty acid composition of orange varieties were quite similar and were not discernibly changed by maturity. This similarity within a species shows, as has been suggested (11), the tendency of certain plant species to characterize their oil by virtue of the quantity of specific unsaturated acids being present. Data for seed oils made from King orange, Dancy tangerine, and the Ponderosa and Avon lemon are included in

TABLE II

Average fatty acid composition of seed oils from four important Florida orange varieties and some other *Citrus* species.

Variety	Fatty Acid Composition %				
	Palmitic	Stearic	Oleic	Lino-leic	Lino-lenic
Hamlin	31.7	4.1	24.4	36.6	3.1
Parson Brown	30.9	4.1	24.9	36.6	3.4
Pineapple	30.0	4.6	25.0	36.8	3.7
Valencia	31.8	3.2	26.4	35.9	2.6
King Orange	31.7	3.0	18.2	43.9	3.0
Dancy Tangerine	31.6	3.3	20.5	40.0	4.6
Ponderosa Lemon	23.8	3.7	50.1	18.7	3.7
Avon Lemon	24.9	3.0	29.8	30.3	12.0

Table II for comparison. Fatty acid composition of King orange was noted as being more similar to Dancy tangerine than to the four orange varieties shown; the relationship is suggested by taste also. Likewise, the seed oil of Ponderosa lemon was quite different from other lemon seed oils which are represented by the Avon lemon.

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Growth Stimulating Effects of High Levels of Vegetable Oils

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Abstract

Diets containing up to 30% of vegetable oils resulted in increased growth and feed efficiency in the chick. At 40 and 46% levels, the liquid nature of the mixture, and not a deleterious effect of the fat as such, reduced the availability of the solid constituents and resulted in high levels of mortality.

No beneficial effects on growth or feed efficiency resulted after increases in the levels of vitamin and/or mineral mixtures with increase in energy. The growth response to added vegetable oils does not appear to be caused by an unidentified factor, such as may be found in distillers dried solubles, antibiotic fermentation residue, whey product, fish meal, or condensed fish solubles.

Introduction

HIGH ENERGY rations for the production of broilers, introduced by Scott et al. (1) has resulted in the general use of fat as an energy source in animal feed. Other reported benefits from adding fat include improvement in appearance of the feed, increased feed efficiency, and sometimes improved growth. Yacowitz and Chamberlin (2) observed a slight improvement in growth and improved feed efficiency from feeding 1.5–3.0% soybean oil and animal tallow. Other workers (3,4) have also observed increases in the growth of chicks associated with the presence of fat in the diet.

The ability of the chick to utilize high levels of dietary fat has not been investigated extensively. Henderson and Irwin (5) reported that feeding soybean oil in excess of 10% of the diet resulted in a negative growth response. More recently Donaldson et al. (6,7) found that feeding corn oil or animal fat at levels up to 30% of practical or purified diets resulted in slight improvements in growth and feed efficiency.

The objectives of the present study were to investigate the response of chicks to high dietary levels of unsaturated fats, to test for the need of increased vitamins and minerals with very high levels of dietary fat, and to test the possibility that the growth re-

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sponse to unsaturated fat may be due to an unidentified nutrient in the fat.

Experimental

Sexed, day-old broiler strain chicks were wing-banded, vaccinated for Newcastle disease, and randomly distributed into thermostatically controlled, heated pens with raised wire floors. Individual body weights and feed efficiency were determined when four weeks old. The chicks were fed semi-purified diets in all experiments. Basal diets are presented in Table I.

In order to determine the effect of graded levels of soybean oil on the chick, 10,20,30, and 40% of the oil was substituted for cerelose in diets containing a calorie to protein ratio (C/P) of 42:1, and 10,20,30, and 46% was substituted for cerelose at a C/P of 50:1. Each group contained 10 male and 10 female chicks.

TABLE I
Basal Diets

Ingredient	Experiments 1–3 C/P Ratio		Experiment 4 C/P Ratio 41:1
	42:1	50:1	
Isolated Soybean Protein	30.5	26.0	23.22
Glucose Monohydrate	58.4	62.9	50.95
Wood Pulp	3.0	3.0	2.64
Mineral Mixture [a]	6.84	6.84	6.84
Vitamin Mixture [b]	1.35	1.35	1.35
Unidentified Growth Factors [c]	....	....	15.00

[a] Mineral Mixture: (% of diet) $CaCO_3$, 1.0; $CaHPO_4 \cdot 2H_2O$, 3.89, NaCl 0.6; $MnSO_4 \cdot H_2O$, .037; $MgSO_4 \cdot 7H_2O$, .527; $FeSO_4 \cdot 7H_2O$, .015; $CuSO_4$ (anhyd.), .0011; $ZnCl_2$, .10104; $CoCl_2 \cdot 6H_2O$, .00016; KCl, .763; $Na_2MoO_4 \cdot 2H_2O$, .000076; KI, .0007.

[b] Vitamin Mixture (mg/kg diet): Thiamin.HCl, 10 mg; Riboflavin, 10 mg; D-Calcium pantothenate, 20 mg; pyridoxine, 6 mg; para-amino benzoic acid, 20 mg; inositol, 500 mg; biotin, 0.2 mg; vitamin A, 10,000 I.U.; vitamin D_3, 4000 I.C.U.; methionine, 7500 mg; glycine, 3500 mg; niacin, 75 mg; folic acid, 4 mg; aureomycin HCl, 10 mg; BHT, 5000 mg; d-alpha-tocopheryl acetate, 20 mg; choline chloride, 1.5 mg; menadione, .5 mg; vitamin B_{12}, 20 mcg.

[c] Composed of 6% distillers dried solubles, 0.5% antibiotic fermentation residue, 0.5% whey product, 5% fish meal and 3% condensed fish solubles.

As an additional test of the influence of dietary fat on growth and feed efficiency, corn oil and rice bran oil were compared to soybean oil at 10,20, and 30% of the diet at the 42:1 C/P.

Because of the demonstrated need for an increase in the percentage level of dietary protein and riboflavin with increase in dietary fat (8), it was thought there might also be a similar increased requirement for minerals and vitamins. To test this possibility, vitamin and mineral mixtures were added to the diets containing 10,20, and 30% of soybean oil at such levels that the calorie-to-vitamin and calorie-to-mineral ratios were constant. As before, 10 male and 10 female chicks were in each group. C/P ratio was 42:1.

It has been said that the chick requires factors present in unsaturated fats, particularly vegetable oils, for maximum growth (3,4). For this reason it was of interest to know whether or not the growth response to oils could be obtained by feeding a semi-purified diet (Table I) which contained 15% of the commonly known unidentified growth factor sources. The unidentified factor mixture was composed of 6% dried distillers solubles; 0.5% antibiotic fermentation residue; 0.5% whey product (6% lactose); 5% fish meal and 3% condensed fish solubles.

In this experiment 16 male and 16 female chicks were in each group. Soybean oil was added at levels of 0,10, and 20%. The vitamin and mineral mixtures were the same as those of the previous experiments, and a constant C/P of 41:1 was maintained by adjusting the protein and glucose levels.

It has been previously shown that chicks may be reared on diets containing 30% fat (7) with slight increases in growth, and improved feed efficiency, but none of the reported responses were of the magnitude presented in the data of this experiment. Table II shows growth responses to levels of 10,20, and 30% soybean oil at both 42:1 and 50:1 protein:calorie ratios with corresponding improvement in feed efficiency. Mortality was increased with the higher levels of fat. All chicks which received 40 or 46% soybean oil were dead at age 10 days, probably because the high levels of oil resulted in unhomogenous mixtures with the oil floating on top. It should be noted: although there was a pronounced increase in growth rate with increase in dietary soybean oil to 10% it did not continue to increase at the 30% level at 42:1 C/P but did at 50:1. The feed efficiency, on the contrary, increased up to the 30% level at C/P 42:1, but only up to 20% when it was 50:1. It is questionable, therefore, whether there is any significant advantage of the 30% at either of the C/P ratios.

TABLE II
The Effect of Graded Levels of Soybean Oil at Two Calorie: Protein Ratios on Growth and Feed Efficiency of Chicks

Group no.	Treatment	4 wk body wt	Response over basal	Efficiency	Improvement in feed eff. over basal	Mortality
		g	%	g feed/g body wt	%	%
1	Basal [a]	407.4 ± 20.17*	......	1.64	......	0
2	10% Soybean oil	483.5 ± 23.27	18.7	1.28	22.1	0
3	20% Soybean oil	388.8 ± 32.94	44.5	1.16	29.2	5
4	30% Soybean oil	583.8 ± 38.50	43.3	1.10	32.7	5
5	40% Soybean oil	....	......	......	......	100
6	Basal [b]	396.8 ± 21.90	......	1.68	......	0
7	10% Soybean oil	546.6 ± 33.00	37.8	1.32	21.7	15
8	20% Soybean oil	560.2 ± 36.17	41.2	1.16	30.9	0
9	30% Soybean oil	583.8 ± 54.35	47.1	1.29	23.2	35
10	46% Soybean oil	....	......	......	......	100

[a] C/P ratio 42:1.
[b] C/P ratio 50:1.
* Mean ± confidence interval, 95%.

As shown in Table III the increase in mineral and vitamin levels in the diet did not improve growth or feed efficiency in the presence of increased fat. This failure indicates that the levels of the vitamins and

TABLE III
The Influence of Calorie to Mineral and Calorie to Vitamin Ratios on the Growth Response of Chicks to Graded Levels of Soybean Oil

Treatment	4 wk body wt	Response over basal	Feed efficiency	Improvement in feed eff. over basal	Mortality
	g	%	g feed/g body wt	%	%
Basal	396.6 ± 27.53[c]	......	1.44	......	5
10% Soybean oil	459.6 ± 30.39	15.9	1.45	−1.2	20
20% Soybean oil	504.2 ± 32.99	27.1	1.20	16.3	5
30% Soybean oil	518.4 ± 30.92	30.7	1.14	20.3	5
Basal [a]	395.9 ± 22.50	......	1.46	......	0
10% Soybean oil C/V	487.9 ± 17.10	23.2	1.13	20.8	0
20% Soybean oil C/V	513.2 ± 35.22	29.6	1.12	21.9	5
30% Soybean oil C/V	503.2 ± 46.13	27.1	1.10	22.8	0
Basal [b]	411.0 ± 25.94	......	1.39	......	0
10% Soybean oil C/M	495.3 ± 35.85	20.5	1.19	16.7	10
20% Soybean oil C/M	486.0 ± 25.64	18.3	1.23	13.8	0
30% Soybean oil C/M	494.8 ± 30.36	20.4	1.14	20.6	0
Basal	393.1 ± 36.05	......	1.44	......	0
10% Soybean oil C/V C/M	475.5 ± 24.45	20.8	1.40	2.4	20
20% Soybean oil C/V C/M	513.2 ± 24.81	30.4	1.12	21.6	5
30% Soybean oil C/V C/M	512.8 ± 40.35	30.3	1.12	21.6	5

[a] Calories/vitamin mixture ratio held constant.
[b] Calories/mineral mixture ratio held constant.
[c] Mean ± 95% confidence interval.

minerals used in the basal diet were ample even when the total feed intake was reduced by increasing the energy level. The responses to the increases in dietary fat in this experiment are in general agreement with those of Experiment 1. It was noted that poor feathering did occur at the 30% level with soybean oil. Previously it had been reported by Donaldson et al. (6) that poor feathering in birds occurred on diets containing over 4% fat.

Comparison of corn oil and rice oil with soybean oil (Table IV) showed that all the oils produced comparable increases in growth and food efficiency except that 30% rice oil produced a drop in feed efficiency as compared to 10 or 20%. It also produced the highest mortality.

Data in Table V show that the increase in growth rate which occurred with the increase in fat in the diet cannot be attributed to any unknown factor which may also be present in the above named sources of unidentified factors. Despite the presence of excess quantities of each of these factors, the response to increasing levels of soybean oil was still obtained.

Apparently the chick is capable of utilizing high levels of energy in the form of fat provided that the protein level of the diet is adjusted accordingly, and the physical condition of the feed is such that all nutrients in the diet are available. When the fat is in the form of a liquid oil, as in the present diet, it is impossible to test the effects of over 30% fat because of the physical nature of the mixture. The oil floats on top of the solid parts of the feed, making the latter unavailable to the chick.

TABLE IV
Comparison of Nutritive Values of Soybean, Corn and Rice Bran Oils

Group no.	Treatment	4 wk body wt	Response over basal	Feed efficiency	Improvement in feed eff. over basal	Mortality
		g	%	g feed/g body wt	%	%
1	Basal	408.5 ± 15.55	......	1.46	......	0
2	10% Soybean oil	462.5 ± 17.41	9.4	1.30	11.9	0
3	20% Soybean oil	540.8 ± 25.86	27.9	1.08	26.8	5
4	30% Soybean oil	537.0 ± 27.67	29.0	1.06	28.2	5
5	Basal	421.7 ± 27.46	......	1.48	......	5
6	10% Corn oil	496.3 ± 24.79	17.4	1.19	19.5	0
7	20% Corn oil	541.0 ± 19.92	28.0	1.08	27.0	0
8	30% Corn oil	521.0 ± 24.82	23.2	1.08	27.2	10
9	Basal	438.3 ± 50.28	......	1.49	......	10
10	10% Rice oil	487.9 ± 25.23	16.2	1.27	14.2	5
11	20% Rice oil	498.9 ± 26.56	18.0	1.19	19.1	5
12	30% Rice oil	540.8 ± 38.59	27.9	1.36	7.6	40

[a] 95% confidence interval.

TABLE V
Influence of Unidentified Nutrient Factors on the Nutritive Value of Soybean Oil

Group no.	Supplement to basal diet	4 wk body wt	Response over basal	Feed efficiency	Improvement in feed eff. over basal	Mortality
		g	%	g feed/g body wt	%	%
1	None	508.8 ± 21.10[a]	......	1.55	......	0
2	10% Soybean oil	585.9 ± 23.18	15.2	1.27	18.1	..
3	20% Soybean oil	592.7 ± 31.11	16.5	1.17	24.5	0

[a] Contains 6% distillers dried solubles, 0.5% antibiotic fermentation residue, 0.5% whey product, 5% fish meal, 3% fish solubles.

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• *Letter to the Editor*

The Relationship Between Optical Activity and Structure of Natural Triglycerides

THERE HAS BEEN considerable recent discussion in the literature concerning the analysis of natural fat triglycerides to determine which fatty acids are esterified to which hydroxy groups of the glycerol molecule. Partial hydrolysis by pancreatic lipase can be used to determine which fatty acids are esterified at the 2-position of natural triglycerides (1). Comparison of these results with the fatty acid composition of the total fat allows calculation of which fatty acids are esterified at the combined 1- and 3-positions (the terminal positions). VanderWal (2) and Gunstone (3) have referred to the absence of suitable techniques for determining whether or not the fatty acids esterified at the 1- and 3-positions of natural triglycerides are equivalent. Apparently, the relationship between the optical activity of triglycerides and the equivalence or non-equivalence of their terminal positions has not been considered. We wish to point out that optical activity determinations can be used to establish whether natural triglycerides have equivalent or non-equivalent fatty acids esterified at the 1- and 3-positions of the glycerol.

The term "equivalence or non-equivalence of the 1- and 3-positions in natural triglycerides" refers to whether nature has differentiated between these two positions during the biosynthesis of triglycerides. Symmetrical mono- and diacid triglycerides (such as trilaurin and 2-oleodipalmitin) will, of course, have equivalent terminal positions since both are esterified to the same fatty acid. The 1- and 3-positions of a single triglyceride molecule can be esterified to different fatty acids, however, and the total fat containing