EFFECTS OF PALM OIL AND SOYBEAN OIL AS FAT SOURCES IN ISONITROGENOUS AND ISOCALORIC DIETS ON THE PERFORMANCE OF BROILERS

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Summary

The effects of palm oil and soybean oil as a high energy source diet on the performance of broilers under the warm humid environment were studied. Palm oil and soybean oil, either singly or mixed, were incorporated in the experimental diets to a total of 6% of the diet. The performance of the chicken improved (though not significant) with increasing unsaturated fatty acid content in the diets, but the responses to treatments were not consistent. The carcass fat content was generally higher in all the treated groups compared to the control but the differences were not statistically significant. The results also failed to show any effect of combining two sources of oils. Fatty acid composition in the body was found to be influenced greatly by dietary fat. When soybean oil was used instead of palm oil, the amount of linoleic and linolenic acids in the carcass were increased proportionately.
(**Key Words** : Palm Oil, Soybean Oil, Isonitrogenous, Isocaloric, Broilers, Growth, Carcass Performances)

Introduction

Palm oil has equal amount of saturated and unsaturated fatty acids and this might influence the performance of the broilers. Unsaturated fatty acids such as linoleic and linolenic acids have been shown to improve the performance of broilers (Brue and Latshaw, 1985). Fat may improve the physical characteristics and palatability of the diet to an extent which promotes increased feed consumption (Dale and Fuller, 1979; Cherry, 1982). The objective of this experiment was to study the effects of combining the soybean oil and palm oil in various combinations at 6% inclusion level in isonitrogenous and isocaloric diets on the growth and carcass performance in broilers.

Materials and Methods

Animals and diets

One hundred and forty four day-old male commercial broiler chicks were raised and fed on commercial diet containing 3,100 ME kcal/kg and 23% crude protein for two weeks.

At three weeks of age the chicks were randomly distributed into 24 raised floor pens in groups of six and were fed on six experimental diets. The diets were isonitrogenous and isocaloric as given in table 1, and the determined fatty acids compositions of the diet are shown in table 2.

Feed and water were provided *ad libitum*. The environmental temperature was not controlled and fluctuated from 22℃ to 32℃.

Body weight and feed consumption were measured once a week, on a group basis. At the termination of the experiment (on day 49), the final weights of chicken were recorded. For carcass analysis, the chicken were fasted for 48 h in order to empty the crop and thus reduced differences in body weight caused by variable gut fill. Two chicken per replicate were selected at random and weighed individually. The chicken were sacrificed without blood loss by an overdose intravenous injection of anesthesia (Nembutal). Each carcass was weighed, placed in individual plastic bags and stored in a freezer (−22℃) for at least 48 hours for later analysis.

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TABLE 1. COMPOSITION OF EXPERIMENTAL DIETS (%)

Diets	A	B	C	D	E	F
Fish meal	12.00	12.00	12.00	12.00	12.00	12.00
Corn meal	70.50	53.00	53.00	53.00	53.00	53.00
Soybean meal	15.00	18.50	18.50	18.50	18.50	18.50
Palm oil : soybean oil	–	6 : 0	4.5 : 1.5	3 : 3	1.5 : 4.5	0 : 6
Limestone	0.25	0.34	0.34	0.34	0.34	0.34
Dicalcium phosphate	0.05	0.01	0.10	0.10	0.10	0.10
Choline chloride	0.35	0.35	0.35	0.35	0.35	0.35
Salt	0.50	0.50	0.50	0.50	0.50	0.50
Vitamin mineral premix	0.25	0.25	0.25	0.25	0.25	0.25
Coccidiostat	0.10	0.10	0.10	0.10	0.10	0.10
Kaolin clay	1.00	8.95	8.95	8.95	8.95	8.95
Total	100.00	100.00	100.00	100.00	100.00	100.00
Calculated analysis						
Protein (%)	20.00	20.00	20.00	20.00	20.00	20.00
ME (kcal/kg)	3,035	3,024	3,024	3,039	3,049	3,054
Ether extract (%)	3.93	9.29	9.29	9.29	9.29	9.29
Calcium (%)	0.90	0.90	0.90	0.90	0.90	0.90
Available phosphorus (%)	0.40	0.40	0.40	0.40	0.40	0.40
Lysine (%)	1.18	1.25	1.25	1.25	1.25	1.25
Methionine + cystine (%)	0.73	0.72	0.72	0.72	0.72	0.72
Methionine (%)	0.45	0.44	0.44	0.44	0.44	0.44
Determined analysis						
Protein (%)	19.46	19.65	19.45	19.70	19.50	19.75
ME (kcal/kg)	3,001	3,048	3,033	3,035	3,100	3,135
Ether extract (%)	3.24	8.71	8.59	8.64	8.55	8.68

Ethoxyquin was added at 125 mg/kg feed as antioxidant and antifungus.

Oil and blending

The crude palm oil was obtained from a local feed mill while soybean oil was purchased from a local grocery store. The oils were blended in large glass jars by stirring for 15 min with a magnetic stirrer (Crick et al., 1988) at ratio of 6:0, 4.5:1.5, 3:3, 1.5:4.5 and 0:6 (w/w) respectively.

Carcass analysis and metabolisable energy determination

Carcasses were sectioned into breast and thigh portion as described by Saharabudhe et al. (1985). The carcass were prepared according to Sibbald and Fortin (1982) and the proximate analysis were done according to AOAC (1980). Metabolisable energy of the feed were determined following the methods suggested by Farrel (1978), Vohra et al. (1981) and Brue and Latshaw (1985). Nitrogen and energy retention were determined by carcass analysis and calculated as suggested by Sirnik and Schurch (1967). Fatty acids were extracted by the method of Folch et al. (1957) and were determined after following the method of Metcalfe et al. (1966). The fatty acid methyl esters (FAME) were separated by gas liquid chromatography.

Statistical analysis

Data were analyzed statistically by analysis of variance using the Statistical Analysis System (SAS) (1982). The differences between treatments were determined using the protected Least Significant Difference (LSD) method (Steel and Torrie, 1980).

Results and Discussion

The results of palm oil and soybean oil supplementation in isocaloric and isonitrogenous diets of chicken showed that feed intake was generally higher in the oil supplemented groups (diets B-F) compared to the control, but the differences were not significant (table 3).

TABLE 2. FATTY ACID COMPOSITION (mg /100 g FEED) OF THE PRACTICAL DIETS AS DETERMINED

Fatty acids*	Palm oil : soybean oil (w/w)					
	Basal (A)	6:0 (B)	4.5:1.5 (C)	3:3 (D)	1.5:4.5 (E)	0:6 (F)
10 : 0	2.56	15.67	11.47	9.07	6.06	2.90
12 : 0	1.15	174.48	147.86	104.80	72.85	4.48
14 : 0	444.03	481.01	435.81	417.53	379.54	352.74
16 : 0	194.24	883.68	743.57	601.59	452.43	338.79
16 : 1	12.12	15.81	12.37	13.52	11.60	11.57
18 : 0	41.08	114.72	109.43	101.48	95.32	87.76
18 : 1	281.17	896.49	834.29	754.93	668.16	599.44
18 : 2	590.75	618.97	754.82	900.36	1,086.76	1,281.46
18 : 3	27.05	35.88	57.19	81.07	108.35	138.96
Unsaturated : saturated ratio						
	1.33 : 1	0.94 : 1	1.15 : 1	1.42 : 1	1.86 : 1	2.58 : 1

* 10 : 0, capric acid; 12 : 0, lauric acid; 14 : 0, myristic acid; 16 : 0, palmitic acid; 16 : 1, palmitoleic acid; 18 : 0, stearic acid; 18 : 1, oleic acid; 18 : 2, linoleic acid; 18 : 3, linolenic acid.

TABLE 3. EFFECTS OF PALM OIL AND SOYBEAN OIL COMBINATION ON PERFORMANCE OF BROILERS[1]

	Palm oil : soybean oil (w/w)					
	Basal (A)	6 : 0 (B)	4.5 : 1.5 (C)	3 : 3 (D)	1.5 : 4.5 (E)	0 : 6 (F)
Feed intake (g/bird. day)	112.05	120.27	119.50	119.20	117.95	116.70
	±3.69	±1.76	±4.25	±2.44	±2.42	±4.78
Weight gain (g/bird. day)	47.66	51.79	52.14	52.50	53.57	51.79
	±0.91	±0.68	±2.08	±1.04	±1.11	±1.92
Feed : gain	2.34	2.32	2.30	2.27	2.20	2.26
	±0.03	±0.02	±0.05	±0.03	±0.01	±0.03
Nitrogen intake (g/bird. day)	3.49	3.78	3.72	3.76	3.68	3.69
	±0.12	±0.06	±0.13	±0.08	±0.08	±0.15
Energy intake (kcal/bird. day)	335.57	366.58	362.60	361.77	365.64	365.85
	±10.50	±5.35	±12.88	±7.41	±7.50	±14.98
Nitrogen retention (g/bird. day)	1.16	1.16	1.18	1.20	1.35	1.13
	±0.03	±0.04	±0.01	±0.05	±0.03	±0.04
Energy retention (kcal/bird. day)	95.81	102.72	119.60	126.12	126.98	115.01
	±2.73	±2.63	±3.65	±2.81	±4.99	±4.47

[1] Mean of four replicate determination on 6 chicks ± standard error of mean.
No treatment effect ($p > 0.05$).

Among the treated groups, feed consumption tended to decrease with increasing soybean oil content (increasing unsaturated fatty acids). The different effects of soybean oil and palm oil on feed consumption may be due to the fatty acid compositions which are not similar in the two oils. The latter consists of higher amount of long chain fatty acids such as palmitic and stearic. According to Atteh and Leeson (1983), chicken consumed significantly more feed when they were fed palmitic or stearic acid than when they were fed linoleic or oleic acid. The increasing level of unsaturated fatty acids in the diets of higher inclusion of soybean oil decrease the feed intake. This could be due to the high energy yield capability of soybean. The saturated fatty acids in palm oil have low digestibility than the unsaturated fatty acids in the soyabean oil.

It is therefore, chicken in groups E and F fed higher level of soybean oil compared to groups C and D reduced their feed consumption. The reduction in voluntary feed intake in diets could also be due to varying effects of soybean oil in the diets. It is not clear to what extent ME value is affected by combining the two sources of oils in the present study. The finding of Lewis and Payne (1966), Leeson and Summers (1976), Sibbald (1978) and Bartov (1987) all showed that the combined ME value of two types of oil exceeded the sum of the individual value. It is suspected that the combining effect is more in the case of groups E and F with a higher soybean oil content.

Body weight gain improved slightly with increasing soybean oil content in the diets (table 3), but the response to treatments was not significant. Chicken fed diets C, D and E were heavier and had better feed conversion compared to birds fed diets B and F (table 3). These results showed that a combination of palm and soybean oil might be more efficiently utilized than when either is fed alone. Soybean oil is rich in linoleic acid (18:2) while palm oil is high in oleic (18:1) and palmitic (16:0) acid and combining the two sources of oil could result in a more balanced distribution of fatty acids and might well influence growth. There is also a possibility of synergistic effects when two or more fatty acids are combined as suggested by Garret and Young (1975) and Sibbald and Kramer (1978).

Nitrogen and energy retention in chicken fed with diets D and E were higher though not significantly different compared to the other groups. However, feed conversion seemed to improve although the nitrogen and energy intake were not increased. The slight improvement in feed conversion could be the results of synergetic effects of fatty acids as observed earlier. The result are in agreement with the findings of Renner and Hill (1960) who demonstrated that the addition of unsaturated fatty acids caused an increase in the overall absorbability of fat as well as the ME value of the diets thus explaining the overall improvement in performance.

The carcass fat content was generally higher in all the treated groups compared to the control (table 4). The observed differences in the carcass fat content in percentage or absolute amount were not statistically significant. The results also failed to show any effect of combining the two sources of oils since the fat contents in the treated groups were almost similar. On the other hand, the percentage of carcass protein was lower in all treated groups though not significantly different. When the carcass protein was expressed in absolute term, the amount appeared to be consistent between all groups.

TABLE 4. EFFECTS OF PALM OIL AND SOYBEAN OIL COMBINATION ON THE BODY COMPOSITION OF BROILERS[1]

	Palm oil : soybean oil (w/w)					
	Basal (A)	6 : 0 (B)	4.5 : 1.5 (C)	3 : 3 (D)	1.5 : 4.5 (E)	0 : 6 (F)
Moisture (%)	67.21	67.15	64.97	63.67	65.77	64.77
	± 1.02	± 0.19	± 1.01	± 0.75	± 0.82	± 0.69
Ash (%)	8.49	8.42	7.47	7.47	7.86	7.82
	± 0.25	± 0.12	± 0.21	± 0.39	± 0.32	± 0.30
Protein, in dry matter (%)	50.08	47.37	45.80	43.68	48.38	44.82
	± 2.59	± 1.34	± 1.90	± 0.91	± 1.56	± 0.89
total amount (g)	298.14	297.83	301.25	306.62	332.67	293.27
	±12.12	±12.99	±10.80	±15.82	±11.31	±12.33
Fat, in dry matter (%)	35.48	39.98	42.35	42.61	41.08	41.53
	± 1.52	± 0.98	± 2.16	± 1.04	± 2.24	± 1.50
total amount (g)	213.38	232.67	281.94	298.18	285.43	273.07
	±15.53	±10.98	±22.53	± 9.85	±25.87	±19.92

[1] Mean of four replicate determinations on 6 chicks ± standard error of mean.
No treatment effect ($p > 0.05$).

The fatty acid composition in the muscle is shown in tables 5 and 6. In the breast muscles, myristic (14:0), palmitic (16:0), oleic (18:1) and linoleic (18:2) acids were dominant (table 5). The level of fatty acids in breast muscles of chicken fed with only palm oil supplement (diet B) was relatively higher than the control (diet A). Of the fatty acids determined in the breast muscles only capric, lauric, palmitic, oleic and linoleic acids were significantly higher. The result also showed the levels of linoleic and linolenic acid in all the treated groups were higher compared to the control. The increase in linoleic and linolenic acid appeared to be related to soybean oil content in the diet.

As in the case of the thigh muscle, there were four major fatty acids (myristic, palmitic, oleic and linoleic) present (table 6). The inclusion of 6% palm oil in diet B did not change markedly the pattern of most fatty acids when compared to the control. The exceptions were capric, lauric and myristic acids which increased significantly. It could be inferred that the increase in linoleic and linolenic acids in the thigh muscles was also related to soybean oil supplementation (table 6). These results clearly showed that appreciable quantities of most of the major fatty acids in the diet were deposited as carcass fat. The increasing level of linoleic and linolenic acid is more pronounced because these acids are readily absorbed and deposited within the bird's fat depots (Reiser, 1950). Soybean oil not only caused large increases in the levels of linoleic and linolenic acids in the carcass lipids, but also reduced the quantity of saturated fatty acids. It is also clear from the result that the fatty acids composition in the breast and thigh muscles were, to a large extent, influenced by dietary fat as reported by salmon (1969), Salmon and O'Neil (1971) and Yau et al. (1989).

TABLE 5. EFFECTS OF PALM OIL AND SOYBEAN OIL COMBINATION ON FATTY ACID CONTENT (mg /100 g TISSUE) OF BREAST MUSCLES[1]

Fatty acids*	Palm oil : soybean oil (w/w)					
	Basal (A)	6:0 (B)	4.5:1.5 (C)	3:3 (D)	1.5:4.5 (E)	0:6 (F)
10 : 0	0.21 ± 0.02^{a}	0.40 ± 0.03^{c}	0.49 ± 0.03^{c}	0.40 ± 0.05^{bc}	0.29 ± 0.06^{ab}	0.30 ± 0.05^{ab}
12 : 0	0.23 ± 0.15^{a}	4.58 ± 0.56^{b}	4.36 ± 1.34^{b}	1.56 ± 0.20^{a}	0.68 ± 0.10^{a}	0.30 ± 0.04^{a}
14 : 0	160.59 ±14.91^{a}	179.23 ± 6.17^{a}	159.37 ±10.82^{a}	191.91 ±28.50^{a}	179.85 ± 2.87^{a}	155.23 ± 8.10^{a}
16 : 0	124.09 ± 6.20^{ac}	170.48 ±17.36^{b}	137.06 ±17.67^{ab}	138.92 ±12.84^{ab}	89.41 ± 8.37^{c}	119.03 ±10.61^{ac}
16 : 1	31.32 ± 3.78^{a}	32.46 ± 5.90^{a}	24.75 ± 4.57^{a}	24.74 ± 1.96^{a}	12.13 ± 1.96^{a}	20.15 ± 3.82^{a}
18 : 0	38.39 ± 1.36^{a}	44.01 ± 2.78^{a}	38.50 ± 2.96^{a}	41.04 ± 2.52^{a}	36.47 ± 1.08^{a}	42.47 ± 2.63^{a}
18 : 1	168.16 ±11.12^{a}	245.70 ±24.45^{c}	197.08 ±31.37^{ac}	196.77 ±20.67^{ac}	113.26 ±10.91^{b}	157.79 ±18.11^{a}
18 : 2	87.75 ± 3.39^{a}	113.68 ± 8.91^{b}	122.75 ±16.22^{b}	150.18 ±12.33^{bc}	115.35 ±11.85^{b}	178.96 ±16.64^{c}
18 : 3	1.87 ± 0.26^{a}	3.12 ± 0.34^{a}	5.52 ± 1.10^{ab}	8.28 ± 0.75^{b}	6.49 ± 0.98^{b}	12.86 ± 1.25^{c}

* Table 2.
[1] See table 4.
Figures with different superscripts in the same row differ significantly ($p < 0.05$).

TABLE 6. EFFECTS OF PALM OIL AND SOYBEAN OIL COMBINATION ON FATTY ACID CONTENT (mg /100 g TISSUE) OF THIGH MUSCLES[1]

Fatty acids*	Palm oil : soybean oil (w /w)					
	Basal (A)	6:0 (B)	4.5:1.5 (C)	3:3 (D)	1.5:4.5 (E)	0:6 (F)
10 : 0	0.74	1.72	1.62	1.06	0.84	0.54
	± 0.10[a]	± 0.23[c]	± 0.12[bc]	± 0.30[ab]	± 0.13[a]	± 0.04[a]
12 : 0	1.95	31.50	18.47	11.38	8.03	2.17
	± 0.27[a]	± 4.25[d]	± 1.18[c]	± 1.45[b]	± 0.30[ab]	± 0.11[a]
14 : 0	368.80	573.70	350.77	366.73	523.62	426.51
	± 15.56[a]	± 21.59[b]	± 24.38[a]	± 26.15[a]	± 21.90[b]	± 27.79[a]
16 : 0	989.80	1,097.54	883.33	928.60	891.31	786.48
	± 126.47[a]	± 101.88[a]	± 44.63[a]	± 121.48[a]	± 101.73[a]	± 29.81[a]
16 : 1	321.98	253.01	202.98	232.53	200.52	175.41
	± 43.93[a]	± 33.87[a]	± 14.47[a]	± 38.79[a]	± 20.33[a]	± 13.14[a]
18 : 0	213.86	204.26	178.18	188.68	203.19	212.53
	± 26.84[a]	± 17.36[a]	± 6.66[a]	± 23.94[a]	± 22.66[a]	± 11.08[a]
18 : 1	1,486.96	1,694.09	1,382.70	1,472.61	1,424.94	1,231.99
	± 203.09[a]	± 131.63[a]	± 82.81[a]	± 186.95[a]	± 174.01[a]	± 50.24[a]
18 : 2	675.85	704.51	796.20	1,005.17	1,306.78	1,306.55
	± 78.21[a]	± 46.75[a]	± 41.66[ac]	± 122.69[ac]	± 151.42[bc]	± 47.31[b]
18 : 3	22.07	25.43	41.76	65.47	87.00	98.43
	± 3.16[a]	± 2.41[a]	± 2.72[a]	± 8.46[b]	± 9.66[c]	± 6.19[c]

* Table 2.

[1] See table 4.

Figures with different superscripts in the same row differ significantly ($p < 0.05$).

Literature Cited

Association of Official Analytical Chemists. 1980. Official Methods of Analysis. 13th ed. Washington, DC.

Atteh, J. O. and S. Leeson. 1983. Effects of dietary fatty acids and calcium levels on performance and metabolism of broiler chickens. Poult. Sci. 62:2412-2419.

Bartov, I. 1987. Combined effect of age and ambient temperature on the comparative growth of broiler chicks fed tallow and soybean oil. Poult. Sci. 66:273-279.

Brue, R. N. and J. D. Latshaw. 1985. Energy utilization by the broiler chicken as affected by various fats and fat levels. Poult. Sci. 64:2119-2130.

Cherry, J. A. 1982. Noncaloric effects of dietary fat and cellulose on voluntary feed consumption of white leghorn chickens. Poult. Sci. 61:345-359.

Crick, D. C., E. N. Nwokolo and J. S. Sim. 1988. Effect of blending dietary oils on growth performance, total and individual fatty acid absorption by growing chick. Nutr. Res. 8:643-651.

Dale, H. M. and H. L. Fuller. 1979. Effects of diet composition on feed intake and growth of chicks under heat stress. I. Dietary fat levels. Poult. Sci. 58:1529-1534.

Farrell, D. J. 1978. Rapid determination of metabolizable energy of food using cockerels. Brit. Poult. Sci. 19:303-308.

Folch, J., M. Lees and G. H. Sloane-Stanley. 1957. A simple method for the isolation and purification of total lipids from animal tissues. J. Biol. Chem. 226:497-509.

Garret, R. L. and R. J. Young. 1975. Effect of micelle formation on the absorption of natural fat and fatty acids by the chicken. J. Nutr. 105.827-838.

Leeson, S. and J. Summers. 1976. Fat ME Values: The effect of fatty acid saturation., Feedstuffs. 48:26-27.

Lewis, D. and C. G. Payne. 1966. Fat and amino acids in broiler rations. 6. Synergistic relationship in fatty acid utilisation. Brit. Poult. Sci. 7:209-218.

Metcalfe, L. D., A. A. Schmitz and J. R. Pelka. 1966.

Rapid preparation of fatty acid esters from lipids for gas chromatographic analysis. Anal. Chem. 38:514-515.

Reiser, R. 1950. The metabolisable of polyunsaturated fatty acids in growing chicks. J. Nutr. 42:325-328.

Renner, R. and F. W. Hill. 1960. The utilization of corn oil, lard and tallow by chicks of various ages. Poult. Sci. 39:849-854.

Sahasrabudhe, M. R., F. D. Nicole and D. F. Wood. 1985. Neutral and polar lipids in chicken parts and their fatty acid composition. Poult. Sci. 64:910-916.

Salmon, R. E. 1969. Soybean versus rapeseed oil in turkey starter diets. Poult. Sci. 48:87-93.

Salmon, R. E. and J. B. O'Neil. 1971. The effect of the level and source of dietary fat on the growth, feed efficiency, grade and carcass composition of turkeys. Poult. Sci. 50:1456-1467.

Sibbald, I. R. 1978. The true metabolisable energy values of mixtures of tallow with either soybean oil or lard. Poult. Sci. 57:473-477.

Sibbald, I. R. and A. Fortin. 1982. Preparation of dry homogenates from whole and eviscerated chickens. Poult. Sci. 61:589-590.

Sibbald, I. R. and J. K. G. Kramer. 1978. The effect of the basal diet on the true metabolisable energy value of fat. Poult. Sci. 57:685-691.

Simik, V. and A. Schurch. 1967. Comparison of the balance-trail and carcass-analysis methods for measuring deposition of body substances and energy retention. In: Energy Metabolism of Farm Animals. pp. 411-414.

Statistical Analysis System. 1982. In: SAS User's Guide: Statistic. SAS Inst. Inc. Cary, N.C.

Steel, R. G. D. and J. H. Torrie. 1980. In: Principles and Procedures of Statistics. A Biometrical Approach 2nd ed. McGraw-Hill Book Company, New York.

Vohra, P., D. B. Chami and E. O. Oyawoye. 1981. Determination of metabolisable energy by fast method. Poult. Sci. 61:766-769.

Yau, J. C., A. R. Sams, J. H. Denton and C. A. Bailey. 1989. Enrichment of selected fatty acid in broiler tissues. Poult. Sci. (Abstr.) 68:162.