THE EFFECT OF PALM OIL SUPPLEMENTATION IN ISOCALORIC AND ISONITROGENOUS DIETS OF BROILERS

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Summary

A study was carried out to investigate the effect of palm oil supplementation on the growth, carcass composition and fatty acid distributions of the broilers fed isonitrogenous and isocaloric diets. This study showed that palm oil supplementation increased feed consumption, weight gain and nitrogen intake. Feed conversion improved at higher fat inclusions, but not significant. Male birds consumed significantly more feed than females resulting in significant increase in energy consumption and weight gain. Increaseing fat content in the ME:P constant diet did not produce significant difference in the fat content of the chicken. Fatty acids content of the diet exert varying effects of the composition and distribution of fatty acids in the muscles of the chicken. The fatty acids found in larger amount in the breast and thigh muscles were palmitic, oleic and linoleic. The fatty acids of the breast and thigh muscles were found to correspond the fatty acids of the diets. There were no differences in the fatty acids distribution patterns between the sexes.

(**Key Words**: Palm Oil, Isonitrogenous, Isocaloric, Chicken Performance, Fatty Acids, Breast, Thigh Muscles)

Introduction

Addition of fat in the diets resulted in improved performance of chicken which is caused by the extra caloric effect of fat (Touchburn and Naber, 1966). When fat is incorporated into the diets, the ME value increased, illustrating the extra caloric effect (Cullen et al., 1962). The ME value of fat is closely related to its absorbability which is influenced by the fatty acid composition (Young 1961) and fats high in unsaturated fatty acids has a higher absorbability values (De Groote et al., 1971). Chicken fed with high fat diet usually have high fat content of the carcass. However, Donaldson et al. (1956) and Summers et al. (1965) reported that fat deposition depended on the energy:protein ratio and increasing energy:protein ratio increased fat deposition (Bartov et al., 1974).

Fatty acids composition among different poultry tissues were found to be similar (Cruickshank, 1934). However, Marion and Woodroof (1966) reported that both the protein levels and types of fat supplement in the diet influenced the fatty acid composition of broiler carcass lipids. Edwards and Hart (1971) showed that fatty acid composition of the carcass lipids reflected the fatty acids composition of the oil fed. Increasing level of fat in the diet resulted in the deposition of fat that resembled the dietary fat composition, the degree of similarity was more at higher level of added fat (Salmon and O'Neil, 1973).

Breast muscle has the largest amount of palmitic, oleic and linoleic acids (George and Essary, 1971) and the fatty acid profile of breast and the thigh muscles changed with the dietary fat composition (De Basilio et al., 1989).

This study was undertaken to investigate the effects of palm oil supplementations in the isocaloric and isonitrogenous diets on growth, carcass composition and fatty acids distribution in the breast and thigh muscles of broilers.

Materials and Methods

One hundred and twenty male and an equal number of female day-old commercial strain broiler chicken were fed commercial diet containing 3,100 ME kcal/kg and 23% crude protein. At three weeks of age the chicken were randomly divided according to sex into groups of six and assigned into raised 40 wire floor pens, 20 each for male and female. Each pen constituted a replication. Five experimental diets containing 0, 2, 4, 6 and 8% palm oil were formulated. The diets were isonitrogenous and

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Received April 22, 1994
Accepted November 18, 1994

isocaloric and the compositions are given in table 1. The determined fatty acid compositions of the diet is shown in table 2.

Body weight and feed consumption were recorded weekly on a group basis. At the end of the experiment, on day 49, two birds from each replicate and each sex were randomly picked and killed by an overdose injection of Nembutal. The carcasses were stored in the freezer (−22℃) for at least 48 hours before analysis.

TABLE 1. COMPOSITION OF EXPERIMENTAL DIETS

	Level of palm oil (%)				
	0	2	4	6	8
Fish meal	12.00	12.00	12.00	12.00	12.00
Corn meal	70.50	65.00	59.00	53.00	48.00
Soybean meal	15.00	16.10	17.30	18.50	19.50
Palm oil	–	2.00	4.00	6.00	8.00
DL-methionine	–	–	–	0.01	0.01
Dicalcium phosphate	0.05	0.02	0.01	–	–
Limestone	0.25	0.28	0.31	0.34	0.36
Choline chloride	0.35	0.35	0.35	0.35	0.35
Salt	0.50	0.50	0.50	0.50	0.50
Coccidiostat	0.10	0.10	0.10	0.10	0.10
Kaolin clay	1.00	3.40	6.18	8.95	10.93
Vitamin mineral premix	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00
Calculated analysis					
Protein (%)	20.00	20.00	20.00	20.00	20.00
ME (kcal/kg)	3,035.00	3,041.00	3,033.00	3,024.00	3,045.00
Ether extract (%)	3.93	5.73	7.51	9.29	11.11
Calcium (%)	0.90	0.90	0.90	0.90	0.90
Available phosphorus (%)	0.40	0.40	0.40	0.40	0.40
Lysine (%)	1.18	1.20	1.22	1.25	1.26
Methionine + cystine (%)	0.73	0.72	0.72	0.72	0.72
Methionine (%)	0.45	0.45	0.44	0.44	0.44
Determined analysis					
Protein (%)	19.67	19.43	19.69	19.59	19.75
ME (kcal/kg)	3,110.00	3,182.00	3,174.00	3,125.00	3,114.00
Ether extract (%)	4.06	5.93	7.83	9.60	11.35

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

Carcasses separation

Carcasses were sectioned into breast and thigh portion as described by Sahasrabudhe et al. (1985). Two birds were selected at random from all the replicates for slaughter by bleeding.

The carcasses were analysed according to Sibbald and Fortin (1982); ME determination as suggested by Farrel (1978), Vohra et al. (1981) and Brue and Latshaw (1985) and proximate analysis according to AOAC (1980).

Energy and nitrogen balance

Nitrogen and Energy retention were determined by carcass analysis using the formula developed by Simik and Schurch (1967) as follows:

Nitrogen retention = [Nitrogen (g at 49 days) − Nitrogen (g at 21 days)]/28days

Energy retention = [(g retained protein) 5.52 kcal + (g retained fat) 9.46 kcal]/28days

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

Fatty acids*	Levels of palm oil (%)				
	0	2	4	6	8
10 : 0	2.44	2.31	2.16	2.02	1.88
12 : 0	0.37	1.95	3.88	6.07	6.98
14 : 0	405.19	374.85	408.65	401.80	343.22
16 : 0	196.77	457.72	627.85	892.97	968.32
16 : 1	19.39	26.20	23.89	24.63	22.56
18 : 0	43.41	77.41	86.18	114.92	118.44
18 : 1	306.33	538.24	668.72	901.37	967.74
18 : 2	409.43	456.69	489.09	505.55	499.70
18 : 3	21.23	29.78	31.29	39.75	34.76

*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.

Determination of fatty acids

The total lipids of all tissues were extracted according to the method of Folch et al. (1957). Lipid extracts were saponified using methanolic potassium hydroxide followed by trans-esterification with methanoic boron trifluoride according to the method described by Metcalfe et al. (1966). The Fatty Acid Methyl Esters (FAME) were separated by Gas-Liquid Chromatography.

Statistical analysis

The data collected were subjected to both regression analysis and analysis of variance using the Statistic Analysis System (SAS) (1982). The differences between treatments were determined using the protected Least Significant Difference (LSD) method (Steel and Torrie, 1980). Simple correlations were determined for all possible pairs of variables.

Results and Discussion

The results from this study showed that increasing palm oil levels in the diet resulted in concomitant increase in feed intake with the lowest feed intake from the control group (91.07 g/d) (table 3). Feed consumption of chicken reared under tropical condition appeared to be enhanced by the addition of oil in the diet and the relationship between feed intake and dietary palm oil levels appeared to be linearly related ($r = 0.99$). This could possibly be due to the lowering of heat increment of the fat-containing diets which reduces the heat load thus enabling more feed to be consumed (Shannon and Brown, 1969; Fuller and Mora, 1973; Lipstein and Bornstein, 1975; Dale and Fuller, 1979, 1980). There was no evidence of reduced palatability of the diets due to supplemented fat as suggested by Dale and Fuller (1979) and Cherry (1982). On the other hand, added fat could decrease the rate of passage resulting in improved digestion and absorption (Mateos and Sell, 1981; Mateos et al., 1982).

Growth rate also increased ($p < 0.05$) with increasing palm oil content in the diets (table 3). The relationship between palm oil levels and weight gain appeared to be linear with the r value of 0.99. The growth rate of chicken (45.09 g/d) on 8% palm oil was significantly ($p < 0.05$) higher than those of the other groups. Weight gain of chicken on 2, 4 and 6% palm oil were not significantly different. Nevertheless, the results demonstrated that supplementation of palm oil has a positive effect on weight gain as a consequence of increased feed intake. Dietary fat enhances growth not only because of its high metabolisable energy content but also because it improves palatability and reduces heat increment. A reduction in heat increment is a major contributing factor to growth since it helps the bird to contain the effect of heat stress. Heat increment is the resultant from nutrient conversion in the body. The conversion of carbohydrates and proteins as compared to fat produced more heat. It is, therefore, not surprising that the efficiency of ME from fats is higher than from glucose (De Groote et al., 1971). Besides, there are also unknown growth factors (UGF) in the fat either singly or in combination which can cause the chicken to grow faster, as suggested by Fuller and Mora (1973), Lipstein and Bornstein (1975) and Dale and Fuller (1979, 1980).

Feed conversion was not improved by palm oil in the

TABLE 3. EFFECTS OF PALM OIL LEVELS ON BROILERS' PERFORMANCE[1]

	Levels of palm oil (%)				
	0	2	4	6	8
Feed intake(g/bird. day)	91.07 ± 2.69[a]	93.66 ± 2.47[ab]	96.30 ± 2.37[b]	97.59 ± 2.25[bc]	101.65 ± 1.15[c]
Weight gain(g/bird. day)	39.29 ± 1.79[a]	40.71 ± 1.57[ab]	42.77 ± 1.39[b]	43.13 ± 1.37[b]	45.09 ± 1.23[c]
Feed : gain	2.33 ± 0.04[a]	2.31 ± 0.04[a]	2.26 ± 0.03[a]	2.27 ± 0.03[a]	2.26 ± 0.03[a]
Nitrogen intake(g/bird. day)	2.52 ± 0.07[a]	2.58 ± 0.07[ac]	2.69 ± 0.07[bc]	2.71 ± 0.06[c]	2.87 ± 0.04[d]
Energy intake(kcal/bird. day)	248.40 ± 7.32[a]	263.07 ± 6.95[b]	270.16 ± 6.64[b]	270.42 ± 6.22[b]	282.36 ± 4.21[c]
Nitrogen retention(g/bird. day)	1.01 ± 0.08[a]	1.10 ± 0.05[a]	1.07 ± 0.03[a]	1.15 ± 0.07[a]	1.09 ± 0.03[a]
Energy retention(kcal/bird. day)	102.45 ± 7.78[a]	116.33 ± 4.67[a]	113.28 ± 3.32[a]	117.88 ± 6.23[a]	122.80 ± 4.44[a]

[1]Mean of four replicate determinations on 6 chicken ± standard error of mean.
Different superscripts in the same row showed significant differences at the 1% level.

diets and similarly, neither nitrogen retention nor energy retention were affected by dietary palm oil levels (table 3).

The sex of chicken had a marked effect on growth performance (table 4). Male birds consumed significantly more feed (100.72 g/d) than the females (91.39 g/d) resulting in a significant increase in energy consumption as well as average daily gain. Feed conversion of the male chicken (2.22) was also better than the females (2.36). There are a number of possible reasons which could account for the observed differences in growth rate between the sexes. The males had been found to have a higher level of growth hormone than the females (Harvey et al., 1979). Besides the metabolic rate of the males is considerably higher than the females (Edward and Denman, 1975; Dale and Fuller, 1980; Mabray and Waldroup, 1981). Similar result was found in this study when male chicken consumed more energy (279.82 kcal/d) than the females (253.94 kcal/d) (table 4).

There was only a marginal increase in the fat content of chicken when palm oil was added to the diets, but the differences between treatments were not significant (table 5). According to Edwards et al. (1973), the slight change in fat content may be due to the increase in the availability of net energy from high fat diets, causing a widening of the energy to protein ratio. The results from the present study, in general, showed that carcass composition was not affected by the addition of dietary fat if the calorie to protein ratio was maintained. It is also evident from the results that dietary oil per se did not induce fat deposition in the body as similarly reported by Young and Artman (1961), Bartov et al. (1974), Deaton et al. (1981), and Alao and Balnave (1985).

TABLE 4. PERFORMANCE OF MALE AND FEMALE BROILERS[1]

	Male	Female
Feed intake (g/bird. day)	100.72 ± 1.17[a]	91.39 ± 1.39[b]
Weight gain (g/bird. day)	45.48 ± 0.64[a]	38.91 ± 0.82[b]
Feed : gain	2.22 ± 0.01[a]	2.36 ± 0.02[b]
Nitrogen intake (g/bird. day)	2.80 ± 0.04[a]	2.54 ± 0.04[b]
Energy intake (kcal/bird. day)	279.82 ± 3.39[a]	253.94 ± 4.07[b]
Nitrogen retention (g/bird. day)	1.18 ± 0.03[a]	1.00 ± 0.03[b]
Energy retention (kcal/bird. day)	120.00 ± 3.72[a]	109.10 ± 3.48[a]

[1]See table 3.
Different superscripts in the same row showed significant differences at the 1% level.

TABLE 5. EFFECTS OF PALM OIL LEVELS ON THE BODY COMPOSITION OF BROILERS[1]

	Levels of palm oil (%)				
	0	2	4	6	8
Moisture (%)	62.03 ± 0.53[a]	62.14 ± 0.76[a]	62.19 ± 0.70[a]	61.94 ± 0.90[a]	61.61 ± 0.81[a]
Ash (%)	7.35 ± 0.15[a]	7.55 ± 0.26[a]	7.41 ± 0.25[a]	7.20 ± 0.21[a]	7.25 ± 0.17[a]
Protein:					
In dry matter (%)	44.22 ± 0.81[a]	42.20 ± 0.90[a]	43.37 ± 1.11[a]	44.37 ± 1.20[a]	41.00 ± 1.05[a]
Total amount (g)	274.35 ± 18.03[a]	295.06 ± 14.08[a]	289.58 ± 7.46[a]	301.95 ± 16.31[a]	288.38 ± 8.21[a]
Fat:					
In dry matter (%)	45.93 ± 0.73[a]	46.02 ± 1.34[a]	46.68 ± 1.11[a]	46.53 ± 1.16[a]	48.16 ± 1.05[a]
Total amount (g)	285.25 ± 19.36[a]	321.67 ± 15.46[a]	310.29 ± 10.50[a]	315.65 ± 14.42[a]	341.36 ± 17.60[a]

[1]Mean of four replicate determinations on 2 chicken ± standard error of mean.
Different superscripts in the same row showed significant different at the 5% level.

The carcass composition differed significantly between the sexes. The male broilers had significantly higher moisture and protein content than the females (table 6). On the other hand, the females tended to have a higher fat content (47.72%) than the males (45.61%) (table 6). This could be due to the higher estrogen in the female as suggested by Griminger (1976).

TABLE 6. EFFECT OF SEX ON THE BODY COMPOSITION OF BROILERS[1]

	Male	Female
Moisture (%)	62.80 ± 0.05[a]	61.17 ± 0.37[b]
Ash (%)	7.54 ± 0.13[a]	7.17 ± 0.21[b]
Protein:		
In dry matter (%)	44.11 ± 0.75[a]	41.95 ± 0.56[b]
Total amount (g)	316.08 ± 7.09[a]	263.64 ± 5.97[b]
Fat:		
In dry matter (%)	45.61 ± 0.72[a]	47.72 ± 0.63[a]
Total amount (g)	328.88 ± 10.72[a]	300.81 ± 9.84[a]

[1]See table 5.
Figures with different superscripts in the same row differ significantly at the 5% level.

Poultry farmers are apprehensive about the use of high levels of fat in poultry ration especially under warm environment. The present study indicated the beneficial effects of including fat in the diets. Under high temperature the presence of dietary fat, to some extent, modifies the lipid metabolism by reducing the heat load (Edward, 1969). Any reduction in body heat production will to some extent alleviates the stress effect of high ambient temperature, thus enabling the birds to improve performance as shown from this study.

Palm oil levels in the diet exert varying effects on the composition and distribution of fatty acids in the muscles of chicken. The three acids present in large amounts in both breast and thigh muscles were palmitic, oleic, and linoleic (tables 7, 8 and 9). The breast muscle from the control group had the highest level of oleic acid, although the diet of the control feed contained the largest amount of linoleic acid. The results clearly demonstrated that the amount of a particular fatty acid in the ration may not necessarily be deposited in the same proportion in the chicken and the deposition site also varied. It thus indicates that the fatty acid deposition in tissues is not always dependent on or correlated to the lipid content of the ration which is in agreement with the findings of George and Essary (1971).

On the other hand, the fatty acid compositions in the breast and thigh muscles from chicken in all treated groups were found to correspond to the initial proportion in the feeds (tables 7 and 8). When the levels of fatty acids for each diet were compared in both tissues, it was observed that the levels of fatty acids were higher in the thigh muscles. This could be due to greater free lipid content in the muscle (Sahasrabudhe et al., 1985; Phetteplace and Watkins, 1989; Yau et al., 1989).

The majority of fatty acids in the breast meat did not change significantly in concentration, except lauric, palmitic, oleic, and linoleic acids in the 8% palm oil group. In the thigh meat, changes in fatty acid concentration were observed only in lauric and palmitoleic acids (tables 7 and 8). It is possible that higher levels of palm oil only induced a small change in fatty acid compositions in the chicken muscles, in agreement with

TABLE 7. EFFECTS OF PALM OIL LEVELS ON FATTY ACID CONTENT (mg / 100 g TISSUE) OF BREAST MUSCLES[1]

Fatty acids*	Levels of palm oil (%)				
	0	2	4	6	8
10 : 0	0.56 ± 0.22^{a}	1.02 ± 0.43^{a}	0.69 ± 0.25^{a}	4.50 ± 1.03^{b}	1.57 ± 0.80^{a}
12 : 0	0.44 ± 0.12^{a}	0.38 ± 0.07^{a}	0.55 ± 0.08^{ab}	0.81 ± 0.13^{b}	1.47 ± 0.10^{c}
14 : 0	157.65 ± 31.46^{a}	155.12 ± 31.50^{a}	166.82 ± 12.71^{a}	122.27 ± 10.51^{a}	218.80 ± 42.91^{a}
16 : 0	206.06 ± 31.20^{a}	186.43 ± 17.11^{a}	179.66 ± 23.83^{a}	187.04 ± 18.52^{a}	328.31 ± 28.74^{b}
16 : 1	64.88 ± 13.04^{a}	51.12 ± 6.17^{a}	41.68 ± 6.60^{a}	42.29 ± 7.03^{a}	69.71 ± 8.23^{a}
18 : 0	45.81 ± 4.27^{ab}	38.76 ± 2.07^{b}	37.16 ± 3.43^{b}	35.84 ± 1.96^{b}	54.45 ± 2.73^{a}
18 : 1	308.67 ± 46.95^{a}	277.16 ± 28.96^{a}	261.28 ± 39.01^{a}	277.42 ± 33.11^{a}	514.54 ± 42.83^{b}
18 : 2	115.91 ± 16.73^{a}	105.58 ± 9.91^{a}	101.16 ± 13.91^{a}	111.83 ± 11.63^{a}	188.69 ± 12.71^{b}
18 : 3	4.53 ± 0.45^{a}	3.85 ± 0.36^{a}	3.70 ± 0.52^{a}	4.13 ± 0.82^{a}	5.43 ± 0.74^{a}

* See table 2. [1]See table 5.

Figures with different superscripts in the same row differ significantly at the 5% level.

TABLE 8. EFFECTS OF PALM OIL LEVELS ON FATTY ACID CONTENT (mg / 100 g TISSUE) OF THIGH MUSCLES[1]

Fatty acids*	Levels of palm oil (%)				
	0	2	4	6	8
10 : 0	0.68 ± 0.06^{a}	0.74 ± 0.13^{a}	0.80 ± 0.08^{a}	2.90 ± 1.04^{b}	0.69 ± 0.89^{a}
12 : 0	2.06 ± 0.21^{a}	3.52 ± 0.22^{b}	4.42 ± 0.37^{bc}	5.39 ± 0.33^{cd}	6.99 ± 0.61^{d}
14 : 0	211.91 ± 23.33^{a}	185.41 ± 11.07^{a}	230.85 ± 14.14^{a}	204.45 ± 43.01^{a}	234.61 ± 32.94^{a}
16 : 0	1,082.18 ± 83.33^{a}	1,070.69 ± 45.99^{a}	1,219.76 ± 100.08^{a}	1,042.01 ± 64.70^{a}	1,205.17 ± 95.24^{a}
16 : 1	416.84 ± 30.52^{a}	370.27 ± 19.42^{a}	370.89 ± 37.66^{a}	288.25 ± 17.53^{b}	287.42 ± 22.45^{b}
18 : 0	194.52 ± 12.28^{a}	179.66 ± 12.02^{a}	179.44 ± 10.69^{a}	153.71 ± 10.63^{a}	172.44 ± 9.96^{a}
18 : 1	1,810.18 ± 88.73^{a}	1,767.14 ± 68.49^{a}	1,916.68 ± 140.54^{a}	1,734.90 ± 140.03^{a}	1,961.80 ± 137.23^{a}
18 : 2	643.51 ± 36.22^{a}	625.47 ± 23.29^{a}	681.75 ± 48.80^{a}	633.87 ± 40.12^{a}	724.94 ± 58.48^{a}
18 : 3	24.91 ± 1.90^{a}	25.62 ± 1.86^{a}	24.62 ± 1.97^{a}	23.28 ± 2.05^{a}	25.51 ± 2.49^{a}

* See table 2.
[1]See table 5.
Figures with different superscripts in the same row differ significantly at the 5% level.

TABLE 9. EFFECT OF SEX ON FATTY ACID CONTENT (mg / 100 g TISSUE) OF BREAST MUSCLES[1]

Fatty acids*	Male	Female
10 : 0	2.18 ± 0.53^{a}	1.94 ± 0.49^{a}
12 : 0	0.93 ± 0.09^{a}	0.68 ± 0.07^{a}
14 : 0	155.18 ± 8.20^{a}	162.31 ± 13.29^{a}
16 : 0	232.80 ± 14.61^{a}	202.20 ± 9.76^{a}
16 : 1	59.10 ± 4.41^{a}	48.78 ± 2.89^{a}
18 : 0	43.82 ± 1.69^{a}	40.99 ± 1.39^{a}
18 : 1	346.05 ± 22.72^{a}	309.57 ± 17.55^{a}
18 : 2	130.61 ± 7.45^{a}	118.66 ± 6.38^{a}
18 : 3	4.96 ± 0.40^{a}	4.06 ± 0.29^{a}

* See table 2.
[1]See table 5.
Figures with different superscripts in the same row differ significantly at the 5% level.

TABLE 10. EFFECT OF SEX ON FATTY ACID CONTENT (mg / 100 g TISSUE) OF THIGH MUSCLES[1]

Fatty acids*	Male	Female
10 : 0	1.26 ± 0.29^{a}	1.20 ± 0.40^{a}
12 : 0	4.51 ± 0.28^{a}	4.44 ± 0.28^{a}
14 : 0	200.75 ± 7.66^{a}	226.15 ± 13.83^{a}
16 : 0	1,134.33 ± 32.88^{a}	1,113.60 ± 34.64^{a}
16 : 1	352.89 ± 14.06^{a}	340.57 ± 11.45^{a}
18 : 0	174.60 ± 5.66^{a}	177.29 ± 3.84^{a}
18 : 1	1,806.56 ± 46.05^{a}	1,869.72 ± 45.92^{a}
18 : 2	653.05 ± 18.60^{a}	670.80 ± 17.27^{a}
18 : 3	25.28 ± 0.92^{a}	24.29 ± 0.74^{a}

* See table 2.
[1]See table 5.
Figures with different superscripts in the same row differ significantly at the 5% level.

De Basilio et al. (1989).

The fatty acid distribution patterns revealed no differences between the sexes (tables 9 and 10). The result is in line with the findings of Marion and Woodroof (1965) and Friston and Weihrauch (1976) who reported that breed and sex had only minor effect on fatty acid distribution patterns in the body.

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