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RESPONSE OF LAYING HENS TO SUPPLEMENTATION WITH VARIOUS FATTY ACIDS WHEN FED DIETS INADEQUATE IN PROTEIN AND SULPHUR AMINO ACIDS

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ABSTRACT

The response of Brown laying hens to palmitic, stearic, oleic and linoleic acids was investigated. Five experimental diets were obtained by supplying the above fatty acids up to 30 g kg^{-1} each to an inadequate protein and sulphur amino acid (SAA) diet. Each diet was fed to 24 individual hens from 39 to 50 weeks of age. Only supplemental palmitic acid increased egg production and egg output significantly. Egg weight was increased by added linoleic acid significantly. Supplemental palmitic acid improved the efficiency of protein, SAA and energy utilization.

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اثرات افزایش اسیدهای چرب مختلف به جیره‌های غذایی حاوی مقادیرکافی پروتئین وآمینواسیدهای گوگرددار برمرغهای تخمگذار

جوادپوررضا

دانشجوی دوره دکترا دردانشکده غربی اسکاتلند واکنون استادیار پرورش طیور گروه دامپروری دانشگاه صنعتی اصفهان .

چکیده

واکنش مرغهای تخمگذار رقهوه‌ای به اسیدهای چرب پالمتیک ،استئاریک ، اولئیک ولینولئیک بررسی رشدپنج جیره غذایی با اضافه‌کردن اسیدهای چرب فوق به‌میزان ۳۰ گرم‌درهرکیلوگرم به‌یک جیره‌پایه‌ای که‌ازنظرپروتئین وآمینواسیدهای گوگرددار رفقیربود ،تهیه‌شد .هرجیره‌غذایی به ۲۴ مرغ‌تخمگذار ازبین ۳۹ هفتگی تا ۵۰ هفتگی تغذیه‌گردید .تولیدتخم‌مرغ‌تنها با اضافه‌کردن اسیدپالمتیک افزایش یافت .اسیدلینولئیک باعث افزایش وزن تخم‌مرغ گردیدواسیدپالمتیک راندمان استفاده‌ازپروتئین ،آمینواسیدهای گوگرددار وانرژی رابهبودبخشید .

INTRODUCTION

The composition and to some extent the configuration of dietary fat have a significant effect on digestion and absorption processes. Short chain and unsaturated fatty acids are digested and absorbed better than long chain and saturated fatty acids (16). Increased unsaturated fatty acids in the diet raised the absorption of saturated fatty acids which indicated synergistic relationships in fatty acid utilization (5). Highly saturated fats are resistant to hydrolysis in the chicken digestive tract and therefore, are less digestible (6). Increased egg weight is mainly attributed to increases in the linoleic acid content of the diet (12), but some reports indicated a rise in egg size due to increases in the oleic acid content of the diet (11). Data indicating the effect of saturated fatty acids in increasing egg weight are contradictory with many points needing clarification in this respect.

The purpose of the present experiment was to determine: 1) The effect of different fatty acids and fatty acid mixtures with constant unsaturated to saturated ratios on the performance of laying hens with equal feed, protein, sulphur amino acids (SAA) and energy intakes. 2) The importance of unsaturated to saturated ratios on the response of egg production to added fatty acids.

MATERIALS AND METHODS

One hundred and twenty Ross Brown layers at 38 wk of age were used in this experiment. Daily egg production was recorded for 4 wk before starting the experiment. The birds were randomly divided among 120 individual cages (24.5 cm wide and 47.0 cm high). Each experimental diet was fed to 24 birds (8 birds per tier) along the bank of cages from 39 to 50 wk of age. The house temperature control system was set to maintain a daily minimum of 21°C at the middle tier level.

The five experimental diets were prepared by mixing appropriate portions of the summit and dilution diets and the addition of different fats and fatty acids. Fats and fatty acids were substituted *in lieu* of glucose and cellulose which were used as inert compounds. The composition of the summit and dilution diets is presented in Table 1.

Table 1. Composition of summit and dilution diets.

Ingredients g kg^{-1}	Unit	Summit	Dilution†
Wheat		488.0	-
Maize		100.0	-
Full fat soya		48.0	-
Soybean meal, 44% protein		198.0	-
Fish meal, 65% protein		36.2	-
Corn oil		4.4	28.0
Oat hulls		-	188.2
Maize starch		-	490.0
Glucose		-	193.0
Ground limestone		103.0	103.0
Dicalcium phosphate		13.2	13.2
Salt		3.0	3.0
Vitamin & mineral supplement‡		5.0	5.0
Yolk colorant§		0.6	0.6
Tryptophan supplement		0.6	0.6
Total		1000.0	1000.0
	Calculated analysis per kg		
ME	MJ	11.2	11.3
Protein	g	189.0	-
Calcium	g	43.2	43.2
Total phosphorus	g	7.5	7.5
Total fat	g	28.0	28.0
Linoleic acid	g	13.2	13.2

†Contained little digestible protein.
‡Provided the following vitamins and minerals per kg of diet: Vit. A, 5.5 mg; Vit. D3, 0.075 mg; Vit. E, 18 mg; Vit. K, 4 mg; Riboflavin, 6 mg; Pantothenic acid, 9 mg; Choline, 200 mg; Nicotinic acid, 20 mg; B12, 8 ug; Mn, 120 mg; Zn, 120 mg; Fe, 80 mg; Cu, 9 mg; Co, 0.4 mg; Iodine, 1.0 mg; Se, 0.2 mg; Antioxidant, 145 mg.
§Contained Carophyll orange as coloring agent.

The composition of the experimental diets is shown in Table 2. Diets two to five contained 30 g kg^{-1} of palmitic, stearic, oleic and linoleic acids, respectively. The ratio of unsaturated to saturated fatty acids in diets two and three was 0.6, which increased to 9.4 in diet four and to 9.8 in diet five. The fat contents of diets were 25.2, 70.9, 71.3, 70.7 and 70.2 g kg^{-1}, respectively. The fats and fatty acids used were palmitic acid, stearic acid, palm oil, sunflower oil, soybean oil and coconut oil. The calculated fatty acid composition of diets is shown in Table 3.

Table 2. Composition of experimental diets.

Ingredients g kg^{-1}	Diet No. 1	2	3	4	5
Summit†	750.0	750.0	750.00	750.0	750.0
Dilution†	140.0	140.0	140.0	140.0	140.0
Glucose	110.0	8.0	8.4	–	3.0
Cellulose	–	58.3	55.5	84.5	62.0
Palmitic acid	–	21.2	–	–	–
Stearic acid	–	–	30.0	–	–
Olein	–	–	–	34.5	9.0
Sunflower oil	–	–	–	–	7.0
Palm oil	–	20.0	8.8	6.0	–
Soybean oil	–	–	7.3	5.0	29.0
Coconut oil	–	4.5	–	–	–

†For composition see Table 1.

All diets were isoenergetic and calculated to contain 11.6 MJ kg^{-1} metabolizable energy, 142 g kg^{-1} protein and 4.62 g kg^{-1} SAA.

The hens were fed 110 g day^{-1} of a diet in order to control SAA intake to about 500 mg day^{-1}. Egg weight of three days accumulation of normal

Table 3. The calculated fatty acid composition of experimental diets.

Fatty acid $g\ kg^{-1}$	Diet No.				
	1	2	3	4	5
Palmitic C16	1.9	30.0	5.9	4.2	4.4
Stearic C18	0.4	3.5	30.0	0.6	0.4
Oleic C18:1	3.2	10.1	7.4	30.0	17.0
Linoleic C18:2	10.1	11.8	14.5	15.3	30.0
Total unsaturated	13.3	21.9	21.9	45.3	47.0
Total saturated	2.3	35.9	36.3	4.8	4.8
Unsaturated/ saturated (ratio)	5.8	0.6	0.6	9.4	9.8

eggs for each bird was determined every week. The data for egg production, egg weight, egg output, feed intake and feed efficiency were analyzed by a computerized program (9).

RESULTS

The results of feed intake, egg production, egg weight and egg output are presented in Table 4. Only supplemental palmitic acid significantly (P<0.05) increased egg production, however, oleic acid was numerically superior to stearic and linoleic acids.

Egg weight was increased significantly (P<0.05) only by supplemental linoleic acid (diet 5). Improvement in egg output was significant (P<0.05) only due to added palmitic acid (diet 2). There were no significant differences in feed intake and feed efficiency (Table 6) between treatments. Daily feed intake was less than 110 g.

Table 4. Egg production, egg weight and egg output of hens fed on diets containing different sources of fatty acids.

Diet No.	Added† fatty acid	SAA‡ intake mg/hen/d	Feed intake g/hen/d	Egg produc-tion %	Egg weight g	Egg output g/hen/d
1	None	430	102a**	67.9a	61.4b	41.6a
2	Palmitic	440	106a	76.0b	61.9bc	47.0b
3	Stearic	430	102a	68.6ab	60.2a	41.3a
4	Oleic	430	102a	70.2ab	60.0a	42.2ab
LSD				7.8	0.8	5.2

†Dietary content of each fatty acid under investigation was 30 g/kg.

‡SAA intakes were calculated on the basis of determined SAA content of the summit diet.

**Values followed by the same letters in each column are not different (P>0.05).

Table 5. Body weight during the experimental period.

Diet No.	Body weight (g) week 39	Change†	47	Change†	50
1	1880a**	-5.0	1740a	+0.6	1757a
2	2139b	-6.5	1876a	+0.7	1895a
3	1980ab	-5.6	1822a	+0.4	1844a
4	2000ab	-8.7	1756a	+0.6	1772a
5	1958a	-6.0	1790a	+0.7	1810a
LSD	154.5				

† g/hen/d.

**Values followed by the same letters in each column are not different (P>0.05).

It seems that the amount of 110 g feed per day was overestimated. All hens lost weight during the first 8 wk of the experiment (Table 5). There were no significant differences between body weight changes during the last 4 wk of the experiment.

The efficiency of feed, protein, SAA and energy utilization is presented in Table 6. Only palmitic acid improved the utilization of protein, SAA and energy. Improvements in efficiencies of protein, SAA and energy utilization were about 2.6%, 6% and 1.8%, respectively.

Table 6. Efficiency of utilization of protein, sulphur amino acids, energy and feed for egg output.

Diet No.	Added fatty acid	Efficiency† Protein %	SAA %	Energy %	Efficiency g feed/ g egg
1	None	31.2‡	57.2	20.4	2.48
2	Palmitic	33.8(2.6)	63.2(6.0)	22.2(1.8)	2.32
3	Stearic	31.2	56.7	20.2	2.57
4	Oleic	31.2	57.7(0.5)	20.7	2.48
5	Linoleic	30.0	56.8	20.0	2.58

†Protein, SAA and energetic efficiencies were calculated on the basis of 0.108 g, 5.91 mg and 0.0058 MJ of protein, SAA and energy contents per gram of shell egg, respectively (14).

‡Figures in parentheses represent percent changes in the protein, SAA and energy efficiencies of corresponding diets without added lipids. Only improved data are indicated.

DISCUSSION

Daily SAA intake was nearly the same for all treatments. The egg production during the 2 wk before the experiment was not significantly different from each other (90.5, 88.1, 87.5, 88.1 and 86.3 % for treatments one to five, respectively). Also the body weight changes during the first 8 wk and the last 4 wk of the experiment were in the same trend for all treatments (Table 5). Therefore, the egg production and egg weight response were attributed to the effect of added palmitic and linoleic acids, respectively.

The data on egg production indicated that some saturated fatty acids, specially medium chain fatty acids, can improve egg production due to improved ME concentration of the diet (8). Stearic acid did not increase egg production probably due to its chain length and form of inclusion. Stearic acid was added in the form of free fatty acid and when the free fatty acid content of the diet was high absorbability and utilization of fats and fatty acids may be reduced. The effect of increasing free fatty acid content of the diet in depressing absorbability has been reported (10), which is in agreement with this result. Wiseman and Cole (15) observed that when dietary free fatty acid content was raised the digestible energy of added fat was reduced, which indicated the depressing role of dietary free fatty acids in utilization of supplemental fat.

A part of palmitic acid was supplied by pure free fatty acid and another part by palm oil. An increase in egg production and egg output due to added palmitic acid indicated that when an included saturated fatty acid was mixed with other fats, its absorbability increased and hence better utilized. This suggests a synergism between different sources of fatty acids and fats. Atteh and Leeson (2) reported better utilization of palmitic acid when mixed with oleic acid which is congruous with these results. Their report disagrees with the results of this experiment as far as the beneficial effect of palmitic acid in increasing egg production is concerned. Ketels and DeGroote (4) observed that palmitic acid from lard was utilized better than palmitic acid in the tallow, because of the positional arrangement on the glycerol molecule.

The data showed that oleic acid was not as effective as linoleic acid in increasing egg weight and it caused only a slight increase in egg production. Similar observations for the ineffectiveness of oleic acid in raising egg size has been reported (2). In contrast, linoleic acid was the only fatty acid which increased egg weight, suggesting that polyunsaturated fatty acids are involved in increasing egg size, apparently due to their effects on plasma very low density lipoproteins (VLDL) and also by increasing blood estrogen. Akiba and Jensen (1) reported a rise in blood estrogen due to added corn oil. Also the effect of increasing dietary corn oil on increased VLDL and their incorporation in yolk fat has been suggested (3). The results of this experiment support the reports of Shutze *et al.* (13) and Menge *et al.* (7) considering the egg weight response to linoleic acid.

Comparing egg production response due to supplemental palmitic acid and egg weight response due to added linoleic acid it became clear that different fats and fatty acids have different metabolic effect on egg production and that the ratio of unsaturated to saturated fatty acids is not important in increasing performance. Linoleic acid increased egg weight, probably by being incorporated into the VLDL and increasing yolk fat content. Palmitic acid by improving protein, SAA and energy utilization efficiency (Table 6) increased egg production rate. This is important as far as public-health and yolk fat is concerned, because production can be improved by manipulating dietary fat and fatty acids without a significant increase in yolk fat content.

In conclusion, the results indicated that some saturated fatty acids, specially shorter chain fatty acids, can be well utilized if mixed with other fats. Polyunsaturated fatty acids are more effective than saturated fatty acids in raising egg weight. Some fats and fatty acids increase production by improving dietary nutrient utilization rather than by increasing yolk fat content, which is important from public health point of view. The type, level, and form of inclusion of fats and fatty acids are more important than the ratio of unsaturated to saturated fatty acids in increasing the performance of hens.

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