THE UTILIZATION OF FULL FAT SOYBEAN FOR EGG PRODUCTION AND EGG QUALITY IN THE LAYING HENS[1]

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Summary

To study the effects of utilizing extruded full fat soybean (FFS) in layer diets, 300 White Leghorn pullets were put in trial divided into 5 treatments; control (commercial soybean meal as protein source), FFS 50% (replacing 50% of soybean meal with FFS), FFS 100% (replacing all amount of soybean meal with FFS), soybean oil and tallow added treatment. Each treatment consisted of 5 replicates of 12 birds. Egg production and feed efficiency from hens fed control diet were significantly lower than from hens fed the other diets. Significant differences in egg production and feed efficiency were found between the control and the other treatments. Cholesterol concentration of serum and egg yolk were not affected by any dietary treatment. Feeding extruded full fat soybean did not cause pancreatic hypertrophy nor change in mortality. There was an indication that linoleic acid (C18:2), linolenic acid (C18:3) and iodine contents increased in the thigh and egg yolk lipid of the groups fed FFS or soybean oil, while there was a decrease in oleic acid. The results of this study showed that extruded full fat soybean can serve as effective protein source for layer diets if economically justified.
(Key Words: Full Fat Soybean, Egg Production, Egg Quality, Soybean Meal, Tallow)

Introduction

There has been recently a great deal of interest in the possibility of replacing soybean meal with unprocessed or processed full fat soybean especially in poultry diets. Soybean meal has long been used as a primary source of protein in poultry diets with the majority of the oil used for human consumption. However the economics in extracting oil from the beans has been changed. Increased soybean production and competition with other oils have rendered oil production unprofitable. Summers et al. (1966) demonstrated that raw soybeans could completely replace all of the soybean meal in diets containing 14 or 16% protein with no adverse effects. Pancreas weights increased but the mortality was not influenced. On the other hand, Nesheim and Garlich (1969) reported a marked reduction of protein digestibility and digestable energy value from unheated soybean meal fed to hens. Rogler and Carrick (1964) attained higher egg production and feed conversion from hens fed cooked soybeans than those provided raw soybean. The addition of lysine and methionine to the raw soybean diets did not support good performance (Waldroup et al., 1969). Waldroup and Hazen (1978) fed laying hen diets containing either soybean meal, roasted soybeans, extruded soybeans or raw soybeans fortified with 0.5% additional methionine. Production of hens fed the roasted and extruded beans was equal or superior to that of hens fed diets with soybean meal. Raw soybeans, even with the additional methionine, were not an acceptable protein supplement. Studies by Latshaw and Clayton (1976) have confirmed that roasted soybeans are satisfactory for laying hen diets.

The objectives of the research reported herein were to study the effects of replacing commercial soybean meal in layer diets with extruded full fat soybeans and to compare the effects of fats from plant and animal source on egg production, feed conversion, pancreas hypertrophy, the fatty acid

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compositions and iodine values of tissue and egg yolk lipid, and the cholesterol levels of blood plasma and egg yolk.

Materials and Methods

Three hundred White Leghorns of 27 wks old of age were randomly housed in twenty five wire cages of twelve birds each. Five experimental diets (table 1) were formulated to be isocaloric and isonitrogenous with 15.5% crude protein and 2800 ME kcal/kg. For control group, the 44% crude protein soybean meal was used as protein source. Two full fat soybean diets were formulated replacing 50% or 100% of soybean meal of the control group. The soybean meal and extruded full fat soybeans which passed urease activity test (less than 0.5) were obtained from a local feed mill. Crude soybean oil group and tallow group were also included to compare the effects of fats from plant and animal origin. Feed and water were supplied ad libitum. Egg production and egg weights were daily recorded and the results expressed on a hen-day basis. Feed consumption was weekly recorded. Estimated weight of eggs produced (g/bird/day) was calculated as egg production x average egg weight, and feed conversion computed as daily feed intake / average egg weight. Cholesterol contents of blood serum and egg yolk, pancreas hypertrophy, iodine values and the fatty acid compositions of thigh and egg yolk were analyzed at the end of the experiment by sacrificing 3 birds per treatment. For pancreas hypertrophy, their entire pancreas was immediately removed after sacrificing the hens, freed of extravenous tissue and weighed.

TABLE 1. FORMULA AND CHEMICAL COMPOSITION OF THE EXPERIMENTAL DIETS (%)

	Control	FFS 50%	FFS 100%	Soybean oil	Tallow
Ingredients:					
Corn	47.50	37.72	40.00	40.00	40.00
Wheat	20.00	25.40	15.00	15.00	15.00
Corn gluten meal	–	–	1.04	–	–
Wheat bran	2.32	6.94	12.99	10.99	10.71
Soybean meal	19.78	9.89	–	19.78	19.78
Full fat soybean	–	9.89	19.78	–	–
Crude soybean oil	–	–	–	3.3	–
Tallow	–	–	–	–	3.3
Limestone	7.21	7.36	8.09	7.73	7.91
Tricalcium phosphate	2.35	2.18	1.97	2.34	2.34
NaCl	0.2	0.2	0.2	0.2	0.2
Vit-Min mixture[1]	0.5	0.5	0.5	0.5	0.5
Methionine	0.14	0.19	0.16	0.26	0.26
Lysine	–	0.13	–	–	–
Antibiotics	+	+	+	+	+
Chemical analysis:					
Moisture	10.56	10.60	10.33	10.89	10.60
Crude protein	15.40	15.63	15.72	15.35	15.43
Ether extract	1.64	3.30	5.40	6.61	4.52
Crude fiber	2.84	4.53	3.62	1.91	3.97
Ca	3.98	3.75	3.58	4.09	3.77
P	0.89	1.01	0.90	1.09	0.94

[1] Vit-min. mixture contains the followings in a kg; 2,000,000 IU of Vit. A, 400,000 IU of Vit. D_3, 900 IU of Vit. E, 200 mg of Vit. K_3, 100 mg of thiamin, 1,200 mg of riboflavin, 200 mg of Vit. B_6, 1.50 mg of Vit. B_{12}, 1,500 mg of pantothenate, 2,000 mg of niacin, 60 mg of folacin, 3,000 mg of chlorine, 4,000 mg of iron, 500 mg of copper, 9,000 mg of zinc, 250 mg of iodine, 100 mg of cobalt and 20,000 mg of dried yeast.

Proximate composition of the feed and urease activity of extruded full fat soybeans were determined following the method of AOAC (1984). Total cholesterol content of egg yolk was determined according to Zak and Zak (1969) with the total lipid extracted from egg yolk (Folch and Sanley, 1957). Concentrations of HDL–, LDL– and total cholesterol of serum were determined by the method of Noma et al. (1979). Iodine value of egg yolk and thigh was analyzed according to the method of Yasuda (1931). The fatty acid composition was analyzed by gas liquid chromatography (PYE UNICAM, PU 4500) using flame ionization detector (Delmore and Lupien, 1976).

Data collected were subjected to analysis of variance as outlined by Steel and Torrie (1960) with significant differences among treatment means determined by the Duncan's multiple range test (Duncan, 1955).

Results and Discussion

Table 2 shows data on percent egg production, feed intake and feed conversion. Egg production and feed conversion from hens fed control diet were significantly ($p < 0.05$) lower than from hens fed the other diets. Daily feed intakes of hens fed soybean oil or tallow diets were significantly ($p < 0.05$) higher, possibly because of improved palatability due to the oil or fat addition. Significant differences ($p < 0.05$) were noted for estimated weight of eggs produced which means grams of eggs produced in one day by each bird (average egg weight x egg production rate). The estimated weight of eggs produced (g/bird/day) was the highest in soybean oil group (52.62%), followed by 100% FFS group (52.10g) > tallow added group (51.79g) > 50% FFS group (50.65%) and control (48.66g). The result shows that extruded full fat soybean can serve well as source of protein for egg production, as the observation by Rogler and Carrick (1964), Arends et al. (1971) and Waldroup and Hazen (1978). Rate of egg production and egg weight were increased with the addition of fat, especially soybean oil. As shown in figure 1, the soybean oil group and 100% FFS group stayed predominant over the other groups in average egg weight during the experimental period. Egg weight, although not statistically significant, might have been improved probably by the high level of linoleic acid in the soybean oil and is in line with the results of Whitehead (1981), Bougon et al. (1984) and Kan et al. (1988). It can be concluded that the use of

TABLE 2. EGG PRODUCTION, EGG WEIGHT AND FEED CONVERSION IN HENS FED FULL FAT SOYBEAN, SOYBEAN OIL OR TALLOW DIETS[1]

Treatment	Egg production rate (%)	Daily feed intake (g)	Average egg weight (g)	Feed conversion (intake/egg wt)	Estimated wt. of eggs produced (g/bird/day)
Control	83.28 ^{b}	119.91 ^{b}	58.44	2.44	48.66 ^{c}
FFS 50%	85.83 ^{a}	118.19 ^{b}	59.08	2.34	50.65 ^{b}
FFS 100%	87.92 ^{a}	119.22 ^{b}	59.13	2.29	52.10 ^{a}
Soybean oil	88.15 ^{a}	123.10 ^{a}	59.75	2.34	52.62 ^{a}
Tallow	87.81 ^{a}	123.10 ^{a}	59.19	2.38	51.79 ^{ab}

[1]Means in the same column with different superscripts are significantly different ($p < 0.05$).

TABLE 3. PANCREAS HYPERTROPHY AND MORTALITY OF HENS FED FULL FAT SOYBEAN, SOYBEAN OIL OR TALLOW DIETS

Treatment	Control	FFS 50%	FFS 100%	Soybean oil	Tallow
Pancreas hypertrophy (mg/B.W. 100g)	165.35	165.00	167.62	163.90	163.90
Mortality (%)	3	1.33	3.33	1.33	3.33

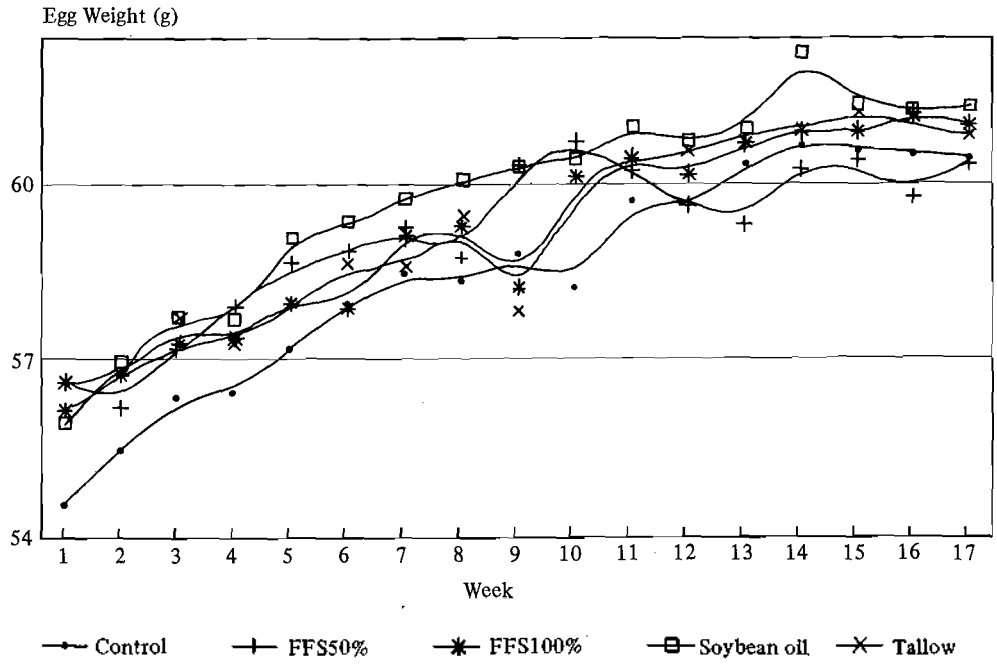

Figure 1. The average egg weight during the experimental period.

soybean oil may improve egg production, egg weight and feed efficiency.

Feeding extruded full fat soybean did not cause any change in pancreas weight nor mortality in hens (table 3). This result is in line with the observations of Bray (1964) indicating full fat soybean as a safe protein source for poultry.

There were slight differences in the cholesterol levels of blood serum and egg yolk observed among treatments, but they were not significant (table 4). No increased or decreased incidence of blood cholesterol was encountered upon feeding of FFS or tallow. This result confirms the works of Reiser (1951), Fisher and Leveille (1957), Wheeler et al. (1959), Johnson et al. (1959), Walker et al. (1951), Treat et al. (1968), Marion et al. (1960), Chung et al. (1965) who also documented that dietary fat have no effect on serum or plasma cholesterol levels. Other reasearchers, however, reported that serum cholesterol was reduced upon feeding either 20% sunflower oil (Fisher and Leveille, 1957) or soybean oil at levels of 20% (Fisher and Leveille, 1957) and increased with 5 to 10% animal fat (Weiss and Fisher, 1957). This controversy may be explained by different dietary fat levels in the experimental diets.

The composition of fatty acids and the degree

TABLE 4. CHOLESTEROL CONCENTRATION OF BLOOD SERUM AND EGG YOLK

Treatment	Control	FFS 50%	FFS 100%	Soybean oil	Tallow
Serum					
Total cholesterol (mg/100ml)	130.42	127.8	131.05	132.70	135.20
HDL-cholesterol (mg/100ml)	80.94	77.95	80.65	81.00	81.45
LDL-cholesterol (mg/100ml)	49.48	43.95	50.40	51.70	53.75
HDL/total cholesterol	0.62	0.49	0.62	0.61	0.60
Egg yolk					
Total cholesterol (mg/100g)	1440.6	1378.01	1319.42	1416.37	1411.61

TABLE 5. FATTY ACID COMPOSITION AND IODINE VALUE OF EGG YOLK AND THIGH LIPID (%)

Treatment	Lipid source	Fatty acid[1]									Iodine value
		12:0	14:0	16:0	16:1	18:0	18:1	18:2	18:3	20:4	
Control	Egg yolk	–	0.4	28.1	4.1	9.6	41.6	11.9	0.4	1.9	97.1
FFS 50%		–	0.4	25.7	3.1	10.2	39.8	17.8	0.7	1.9	90.4
FFS100%		–	0.3	23.3	2.7	10.8	38.7	22.4	1.1	2.2	95.7
Soybean oil		–	0.3	23.1	2.8	10.7	38.4	21.9	1.0	2.9	97.3
Tallow		–	0.5	21.0	2.9	15.4	45.7	11.0	0.4	2.0	82.9
Control	Thigh	0.2	0.7	21.9	6.2	5.9	40.7	24.3	0.8	0.6	88.1
FFS 50%		0.1	0.7	18.4	5.7	3.9	36.9	34.2	0.8	0.6	110.3
FFS100%		0.1	0.6	16.1	4.9	3.8	34.2	35.9	2.1	0.4	118.6
Soybean oil		0.1	0.6	16.0	4.4	3.8	35.7	35.7	2.0	0.4	116.4
Tallow		0.1	0.7	24.7	4.9	9.0	44.6	24.8	0.9	0.6	83.0

[1] Carbon chain length: number of double bond

of unsaturation of fat in egg yolk and thigh lipid are shown in table 5. In general, it could be seen that polyunsaturated fatty acids, especially linoleic (C18:2) and linolenic acid (C18:3) and iodine value increased and oleic acid (C18:1) decreased in egg yolk and thigh lipid of the groups fed FFS or soybean oil. Tallow decreased the degree of unsaturation of fat in thigh and egg yolk. The results indicated that the iodine value and amount of polyunsaturated fatty acids increased by plant oil and decreased by animal fat (Wheeler et al., 1959; Chung et al., 1965).

The economics of using full fat soybean in layer diet was tested by the following formula (Park, 1986),

$$A = (0.8636xY) + (WxRxZ) - (S+C)$$

Where A is the cost advantage or disadvantage for using whole soybeans, Y is the local cost per ton for 44% protein soybean meal and 0.8636 is the relationship between whole soybeans (38% protein) and the 44% protein soybean meal. W is the percentage of oil in whole soybeans (17.5%) and R (1.292) is the relative relationship of the energy value in soybean oil to animal fat. Z is the local cost per ton of animal fat (tallow). The first two segments of the formula calculate

TABLE 6. ECONOMICS OF USING FULL FAT SOYBEAN AS LAYER DIET

Price (US$/ton)	1666.7	500	400	310.9	250	200
A value	−1355.79	−189.09	−89.09	0.01	60.91	110.91

the relative value of the energy and protein supplied by the whole soybeans. From this is subtracted S and C which are the prices per ton for whole soybeans and cost of processing whole soybeans. Accordingly the A values could be obtained as shown in table 6.

When the price of whole soybean was 1666.7 US$/ton as we purchased in the market, it wasn't in the economical range to use. It could be seen from table 6 that it was not economical to use whole soybean when the price was higher than 310.9 US$/ton. The A value becomes positive and economical to use when the price was less than 310.9 US$/ton. The price of whole soybean for 1988 in Chicago was from 173.38 US$/ton in Jan. 29th to 226.45$ in May 31th (NACF, 1988). As the price did not exceed 310.9 US$/ton, the extruded full fat soybean can be used economically.

The results of this study showed that the total amount of soybean meal could be substituted by full fat soybeans without any harmful effects on

the hen's performance and cholesterol level. Properly processed full fat soybeans may be an effective source of protein for layer diets if economically justified.

Literature Cited

Association of Official Analytical Chemists. 1984. Official methods of analysis. 13th ed. Assoc. Offic. Anal. Chem. Washington, D.C.

Arends, L. G., C. E. Brewer and M. H. Ehle. 1971. Evaluation of heat processed soybeans for caged layers. Poult. Sci. 50:1546.

Bougon, M., R. L'Hospitalier, M. Launay and M. Le Menec. 1984. Estimation of the energy content of soybean oil and reasons for its use in the nutrition of laying hens. Zootechnical International. June, 1984:38-43.

Bray, D. J. 1964. Pancreatic hypertrophy in laying pullets induced by unheated soybean. Poult. Sci. 43:382-384.

Chung, R. A., J. C. Rogler and W. J. Stadelman. 1965. The effect of dietary cholesterol and different dietary fats on cholesterol content and lipid composition of egg yolk and various body tissues. Poult. Sci. 44:221-228.

Delmore, C. B. and P. J. Lupien. 1976. The effect of vitamin B deficiency on the fatty acid composition of the major phospholipid in the rat. J. Nutr. 106: 169-180.

Duncan, D. B. 1955. Multiple range and multiple F tests. Biometrics. 11:1-24.

Fisher, H. and G. A. Leveille. 1957. Observations on the cholesterol, linoleic acid and linolenic acid content of eggs as influenced by dietary fats J. Nutr. 63: 119-129.

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

Johnson, D. Jr., A. L. Mehring, Jr. and H. W. Titus. 1959. Variability of the blood plasma cholesterol of laying chickens. Poult. Sci. 38:1109-1113.

Kan, C. A., C. W. Scheele and W. M. M. A. Janssen. 1988. The energy content of full-fat soybeans in meal and pelleted feeds for adult cocks and broilers. Animal Feed Science and Technology. 19:97-104.

Latshaw, J. D. and P. C. Clayton. 1976. Raw and heated full fat soybeans in laying diets. Poult. Sci. 55:1268-1272.

Marion, W. W., N. J. Daghir, S. L. Balloun and R. H. Forsythe. 1960. Egg yolk and serum cholesterol values as influenced by dietary fats and fatty acids. Pout. Sci. 39:1271-1271.

National Agricultural Cooperative Federation. 1988. Monthly Review. June, 1988.

Nesheim, M. C. and J. D. Garlich. 1969. Digestibility of unheated soybean meal for laying hens. J. Nutrition. 88:187-192.

Noma, A., H. Okabe, K. N. Nakayama, Y. Ueno and H. Shinohara. 1979. Improved methods for simultaneous determination of cholesterol in high- and low- density lipoproteins. Clin. Chem. 25:1480-1481.

Park, H. S. 1986. Utilization of dietary fat and nutritive values of full fat soybeans. Korean Society of Animal Nutrition and Feedstuffs. 10:251-263.

Reiser, R. 1951. The synthesis and interconversions of polyunsaturated fatty acids by the laying hen. J. Nutr. 44:159-175.

Rogler, J. C. and C. W. Carrick. 1964. Studies on raw and heated unextracted soybeans for layers. Poult. Sci. 43:605-612.

Steel, R. G. D. and J. H. Torrie. 1960. Principles and procedures of statistics. McGraw-Hill Book Company, Inc. New York.

Summers, J. D., J.D. McConachie, S. J. Slinger and W.F. Pepper. 1966. The value of raw unextracted soybeans for laying hens. Poult. Sci. 45:165-169.

Treat, C.M., B.L. Reid, R.E. Davies and J.R. Couch. 1960. Effect of animal fat and mixtures of animal and vegetable fats containing varying amounts of free fatty acids on performance of cage layers. Poult. Sci. 39:1550-1555.

Waldroup, P. W., D. R. Sloan and R. F. Davenport. 1969. The use of raw and extruded soybeans in layer diets. Poult. Sci. 48:1481-1486.

Waldroup, P. W. and K. P. Hazen. 1978. An evaluation of roasted, extruded and raw unextracted soybeans in the diet of laying hens. Nutrition Reports International. 18:99-103.

Walker, H. A., M. W. Taylor and W. C. Russel. 1951. The level and interrelationship of the plasma lipids of the laying hen. Poult. Sci. 30:525-530.

Weiss, H. S. and H. Fisher. 1957. Plasma lipid and organ changes associated with the feeding of animal fat in laying chickens. J. Nutr. 61:267-280.

Wheeler, P., D. W. Peterson and G. D. Michaels. 1959. Fatty acid distribution in egg yolk as influenced by type and level of dietary fat. J. Nutr. 69:253-260.

Whitehead, C. C. 1981. The response of egg weight to the inclusion of different amounts of vegetable oil and linoleic acid in the diet of laying hens. British Poultry Science. 22:525-532.

Yasuda, M. 1931. Iodine value of lipids or fatty acids or long chain aldehyde moieties. J. Biol. Chem. 94:401.

Zak, A. and B. A. Zak. 1969. A study of a new cholesterol reagent. Anal. Biochem. 29:143-148.