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CONTENTS

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CONTENTS

Evaluation of sun-dried and roasted maggot meal as a source of protein for laying hens in the tropics

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An eight week feeding trial involving 126 Nera breed laying hens in a completely randomized block design, was carried out to evaluate sun-dried and roasted maggot meal as protein sources in laying chickens diet. The sun-dried and roasted maggot meals incorporated in the diets at levels of 0, 50 and 100 percent, in replacement of equivalents of soyabean meal and soyabean plus fish meal. There were significant effects on some performance characteristics with increasing levels of sun-dried and roasted maggot meal in the diets. Hen-day production was generally improved in the maggot-based diets but was higher in SMM diets than in RMM and control diets. Shell thickness and shell weight were significantly affected (p<.05). Egg shell weight as percent of egg weight was higher (p<0.05) for chickens-fed RMM than sun-dried maggot meal [SMM] and control diets. Egg yolk, albumin and percentage of blood/meat sport were significantly affected (p<0.05) but did not follow a specific trend attributable to the diets. Cholesterol and content of egg yolk were significantly reduced (p<0.05) by maggot meal. Maggot meal also reduced cost/kg of egg, which was slightly higher for RMM than SMM diets. The use of maggot meal as the sole protein source in laying chickens' diet is possible without detrimental effect. The reduction of egg yolk cholesterol by maggot meal is of nutritional and health importance to consumers. therefore the use of maggot meal in laying hens should be encouraged.

Key words: Sun-dried, roasted, maggot meal, protein source, layers diet.

Introduction

The quest for alternative feed ingredients in poultry diets is to reduce production cost with the aim of improving animal protein intake of consumers and increasing the profit margin of the producers. This can only be achieved if the substitute feed is of comparative nutritive value to, and preferably cheaper than, conventional feed ingredients.

Processing generally improves the quality of feed ingredients and frequently facilitates an increased incorporation of the ingredient into animal tissues. The success of processing various feedstuffs has been reported (Ensminger, 1985; Aletor and Ojo, 1989; Ologhobo *et al*, 1993). Whereas processing may lead to improvement of the nutritional value of feedstuffs, an appropriate procedure and timing are necessary to prevent denaturation of essential nutrients. This is particularly critical for proteinaceous feedstuffs which need some form of heat treatment to enhance their nutritive value.

Most reports on the utilization of fly larvae (maggots) have adopted oven-drying as the processing technique prior to incorporation in animal diets (Teotia and Miller, 1974; Koo *et al*, 1980). These authors have utilized the fly larvae to substitute soyabean meal in the diets of broiler birds. However, oven-drying is not a popular processing method among feed producers in developing countries, because other less expensive heat treatment methods are available. Considering the abundance of sunshine in the tropics, processing by sun-drying is a much cheaper alternative, while during the wet season when there is little sunshine, roasting using wood fire would be another option. These two processing methods, sun-drying and roasting, are very popular among local farmers in the tropics and could be adopted in the treatment of fly larvae before being used as animal feed. The determined proximate and amino acid compositions of sun-dried and roasted maggot meals (Table 1), indicate a good source of animal protein that could be potentially useful for laying

Table 1: Composition and nutrients of the experimental layer rations (g/100g).

	Replacement Levels (%)*						
	0:100:100	50:50:100		100:0:100		100: 0: 0	
Ingredients	**1(Control)**	**2(SMM)**	**3(RMM)**	**4(SMM)**	**5(RMM)**	**6(SMM)**	**7(RMM)**
Maize	43.30	44.69	44.69	46.63	46.63	46.02	46.02
Maize offal	14.50	14.50	14.50	14.50	14.50	14.50	14.50
Wheat offal	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Soyabean meal (SBM)	18.00	9.00	9.00	–	–	–	–
Fish meal (FM)	3.00	3.00	3.00	3.00	3.00	–	–
Sun-dried maggot meal (SMM)	–	7.34	–	14.67	–	18.28	–
Roasted maggot meal (RMM)	–	–	7.34	–	14.67	–	18.28
Bone meal	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Oyster shell	7.50	7.50	7.50	7.50	7.50	7.50	7.50
Salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Premix[ϒ]	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Methionine	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Determined analysis %							
Crude protein	17.03	16.93	17.04	16.95	17.12	17.01	17.08
Crude fibre	6.50	6.82	6.90	6.30	6.25	6.28	6.25
Ether extract	3.80	3.82	3.80	4.19	4.10	4.00	4.20
Ash	6.35	6.40	6.37	6.41	6.40	6.52	6.49
Metabolizable energy** (KCal/Kg)	2 600	2 594	2 634	2 619	2 695	2 631	2 660

MM — Maggot meal, FM — Fish meal, SBM — Soyabean meal

ϒ Premix provided per kg diet: VitA, 10,000 iu; Vit. D_3, 200iu; Vit. E, 75iu; Vit. K, 2.00mg; Vit. B2, 45mg; Vit B_6, 3 Mg; Niacin, 250 mg; Pantothenic acid, 8.0mg, Vit B_{12}, 0.015mg; Folic acid, 0.50mg; choline, chloride, 300mg; Chlortetracycline, 20mg; Dinitro-ortholoInamides 125mg; Mn, 100mg, Fe, 50mg; Zn, 40mg; Cu, 2.40mg Iodine, 1.40mg; Co 0.30mg and Se, 0.08mg

* Replacement levels of MM: SBM: FM.

** Calculated.

hens. Currently, there is no information on the response of laying chickens to the dietary inclusion of sun-dried or roasted maggot meal in standard layers ration in the tropics.

The present study was conducted to evaluate the replacement effect of sun-dried maggot mean (SSM) and roasted maggot meal (RMM) for soyabean (SBM) in layers diet supplemented with or without fish meal.

Materials and methods

One hundred and twenty six 30 week old laying birds were housed in metabolic cages and fed the experimental diets shown in Table 1. The treatments consisted of increasing dietary levels of processed maggot meal obtained from sun-dried or roasted freshly harvested maggots. The maggots were raised in palm oil-enriched caged-layer droppings for 7 days after which they were harvested. A sufficient amount of water was added to completely submerge the droppings in containers and thereafter they were stirred to free maggots embedded in crumbs of droppings. The floating maggots were collected with the aid of a fine sieve, rinsed in clean water and freed of debris. These were collected into small bowls and killed by treatment with hot water. The maggots were divided into two equal parts, one part was spread sparingly on iron roofing sheets and dried in the sun for a period of two days. The second part was roasted in a frying pan placed on a wood fire until it was dry enough for milling. The dried maggots from the two processing methods were milled separately and incorporated into a standard layers diet in which SBM and SBM plus FM were partially or completely replaced.

Seven experimental diets were formulated to contain soyabean meal (SBM), fishmeal (FM) and sun-dried maggot meal (SMM) or roasted maggot meal (RMM) as the protein sources. The maggot meal was used to replace 0, 50 and 100 percent equivalent protein contributions from SBM and SBM plus FM in the control diet. Each diet was tested with three replicate cages each containing three layers, with feed and water supplied *ad libitum* for a period of eight weeks.

The birds were weighed at the beginning and end of the experiment to obtain the overall weight gain of birds. Data were collected on weekly feed intake, weight gain, hen-day production and egg weights. Internal egg quality characteristics, shell quality and egg yolk colour were assessed at the mid-point and last week of study using the Technicon Method SE4-0016F H4 (Technicon, 1974). Shell surface area (SSA) was calculated according to the methods of Lewis and Perry (1987) and egg shape index (ESI) was calculated by the procedures of Allen and Young (1980).

Test ingredients and feed samples were analysed for proximate composition by the methods of the AOAC (1990). Nitrogen was determined by the Kjeldahl procedure while fat was determined by petroleum ether (bp 60-80°C) extraction using a Soxhlet apparatus (AOAC, 1990). Sun-dried and roasted maggot meals were subjected to amino acid analysis using the method described by Lamkin and Gehrke (1965) using gas-liquid chromatography.

Statistical analysis

Data collected were subjected to statistical analysis using the General Linear Model of Statistical Analysis System (SAS) of the SAS Institute Inc. (1988). Means of treatment were compared using the Duncan's Multiple range test (Steel and Torrie, 1980).

Results

The proximate and amino acid compositions of sun-dried and roasted maggot meals are shown in Table 1. The crude protein contents fell within the range of 57 and 59 percent while ash contents were 11.20 and 11.70 percent for RMM and SMM respectively. The amino acids were high in most of the essentials amino acids and compared to many animal proteins.

The effects of increasing the dietary levels of sun-dried and roasted, maggot meal on the performance of laying hens are shown in Table 2. There were no significant ($p<0.05$) differences between treatment groups but feed intake tended to increase with the inclusion of SMM at 50 and 100 percent replacement levels for SBM, while the reverse was the case for both SMM and RMM when SBM plus FM were completely replaced. Feed conversion ratio (feed: egg weight), hen-day production and weight of eggs were also generally improved with increased dietary levels of SMM and RMM for SBM in the layers diets.

The external egg qualities shown in Table 4 indicated significant ($p<0.05$) treatment differences for egg shell thickness and egg shell weight but not for the other characteristics. Egg shell thickness measured in millimetres was poorest in treatments 2 and 4, which contained 50 and 100 percent replacements of SMM for SBM respectively. Other dietary treatments showed similarity ($p>0.05$) in their egg shell thickness compared with the control. Egg shell weight was also significantly ($p<0.05$) lowest in SMM-based diets although the diet with 50 percent replacement of SMM for SBM was not significantly different ($p>0.05$) from the control. The RMM-based diets consistently gave the highest ($p<0.05$) values for egg shell weight and egg shell weight as percentage of egg weight compared with the other treatments.

Table 2: Proximate and amino acid compositions of processed maggot meal (g/100g DM).

Proximate composition	Sun-dried maggot meal (SMM)	Roasted maggot meal (RMM)
Crude Protein	59.30	57.00
Fat	9.80	8.75
Crude Fibre	0.55	0.60
Ash	11.70	11.20
Calcium	0.89	0.89
Phosphorus	1.41	1.43
Amino acid composition		
Aspartic acid	5.00	5.10
Arginine	3.10	3.00
Glycine	2.26	2.25
Histidine	1.80	1.82
Isoleucine	2.24	2.20
Leucine	3.40	3.23
Lysine	3.81	3.60
Methionine	1.80	1.60
Phenylalanine	2.79	2.85
Threonine	2.21	2.20
Valine	2.56	2.50
Glutamic acid	6.80	7.10
Alanine	2.75	2.65
Tyrosine	3.10	3.00
Serine	2.40	3.00

Table 3: Performance characteristics of layers fed the experimental diets.

	Replacement Levels (%)*							
	0:100:100	50: 50: 100		100: 0: 100		100: 0: 0		
Characteristics	**1**	**2(SMM)**	**3(RMM)**	**4(SMM)**	**5(RMM)**	**6(SMM)**	**7(RMM)**	**SEM**
Feed intake (kg/bird/wk)	0.73	0.78	0.72	0.80	0.72	0.72	0.74	0.01
Feed intake (g/bird/day)	104.00	111.40	102.00	114.40	103.00	102.90	105.40	2.16
Hen/day production (%)	59.07	68.75	63.69	74.10	64.87	68.46	61.30	1.33
Total number of eggs/bird	33.17	40.00	35.67	41.50	36.33	38.33	33.67	1.11
Av. egg weight (g)	67.18	68.09	64.90	65.35	69.16	64.13	64.60	0.23
Total eggs weight/bird (kg)	2.22	2.69	2.33	2.71	2.46	2.44	2.19	0.01
Total feed consumed per bird kg)	5.83	6.24	5.72	6.40	5.93	5.76	5.90	0.01
Body weight gain (kg)	0.11	0.10	0.11	0.10	0.10	0.11	0.11	0.01
Feed conversion ratio (Feed: egg in kg)	2.64	2.39	2.53	2.37	2.41	2.36	2.60	0.07

Means not significantly different ($p>0.05$).
MM — Maggot meal as sun-dried (SMM) or roasted (RMM).
SBM — Soyabean meal.
FM — Fishmeal.
* Replacement level of MM: SBM: FM.

There were significant ($p<0.05$) decreases in egg yolk weight and albumin weight with increasing dietary levels of SMM and RMM as shown in Table 5. Blood/meat spots were prominent in all treatments with the exception of 50 percent SMM replacement for SBM and 100 percent SMM replacement for SBM plus FM.

The results of the egg yolk biochemical quality are presented in Table 6. There was a general reduction in egg yolk cholesterol, triglyceride and calcium contents with increasing levels of maggot meal in the layer diets. Cholesterol and Calcium contents were significantly ($p<0.05$) reduced at 100 percent replacements of SBM and SBM plus FM with either SMM or RMM. The reduction observed in cholesterol and Calcium contents were more apparent in layers on RMM diets than in those on SMM diets at similar levels of

Table 4: External egg quality characteristics of layers fed the experimental diets.

	Replacement Level (%)*							
	0:100:100	50: 50: 100		100: 0: 100		100:0:0		
Characteristics	**1**	**2(SMM)**	**3(RMM)**	**4(SMM)**	**5(RMM)**	**6(SMM)**	**7(RMM)**	**SEM**
Egg weight (g)	67.18	68.09	64.90	65.35	69.16	64.13	64.60	1.11
Egg shell thickness (MM)	0.34^{ab}	0.31^{c}	0.36^{a}	0.30^{c}	0.36^{a}	0.32^{bc}	0.33^{b}	0.01
Egg shell weight (g)	7.15^{bc}	6.82^{bc}	7.37^{b}	6.62^{c}	8.22^{a}	6.62^{c}	7.32^{b}	0.26
Egg shell weight (%)*	10.28^{b}	10.19^{b}	12.06^{a}	10.58^{b}	11.89^{a}	12.41^{a}	11.64	0.25
Shell surface area (SSA)	79.07	77.03	76.69	73.08	78.79	71.74	73.87	2.10
Egg shape index (ES)	0.70	0.72	0.75	0.75	0.72	0.70	0.74	0.02
Shell-less eggs (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

a, b, c, — Means with different superscripts within the same row are significantly different ($P<0.05$).

[1] Replacement level of MM: SBM: FM.

MM — Maggot meal as sun-dried (SMM) or roasted (RMM).

SBM — Soyabean meal.

FM — Fishmeal.

* Egg shell weight expressed as a percentage of egg weight.

Table 5: Internal egg quality characteristics of layers fed the experimental diets.

	Replacement Levels (%)[1]							
	0:100:100	50: 50:100		100:0:100		100:0:0		
Characteristics	**1**	**2(SMM)**	**3(RMM)**	**4(SMM)**	**5(RMM)**	**6(SMM)**	**7(RMM)**	**SEM**
Haugh unit	91.55	87.61	91.78	85.57	91.62	89.32	90.54	2.13
Yolk index	0.51	0.50	0.51	0.46	0.52	0.52	0.51	0.02
Yolk weight (g)	18.15^{a}	17.95^{a}	17.83^{ab}	17.08^{b}	17.02^{b}	15.78^{c}	16.36^{bc}	0.23
Yolk weight (%)*	26.11^{b}	25.55^{b}	29.18^{a}	29.00^{a}	25.21^{b}	26.15^{b}	26.21^{b}	0.77
Albumin weight (g)	44.25^{a}	43.02^{a}	40.91^{b}	38.39^{bc}	37.52^{c}	36.65^{c}	39.24^{b}	2.03
Albumin weight (%)*	63.63^{a}	64.24^{a}	58.77^{c}	60.42^{bc}	62.50^{ab}	60.98^{ab}	62.12	0.89
Egg yolk colour	8.00	7.50	7.00	7.50	7.50	6.50	6.50	0.51
Blood/meat spot (%)	15.00^{a}	5.00^{b}	15.00^{a}	15.00^{a}	10.20^{a}	9.20^{b}	15.00^{a}	1.61

a, b, c, — Means with different superscripts within the same row are significantly different ($p<0.05$).

* Yolk or albumin weight expressed as percentage of egg weight.

MM — Maggot meal as sun-dried (SMM) or roasted (RMM).

SBM — Soyabean meal.

FM — Fishmeal.

% Replacement level of MM: SBM: FM.

Table 6: Egg yolk cholesterol, triglyceride, calcium, and phosphorus of experimental birds.

	Replacement Levels (%)*							
	0:100:100	50:50:100		100:0:100		100: 0: 0		
Parameters	1(Control)	2(SMM)	3(RMM)	4(SMM)	5(RMM)	6(SMM)	7(RMM)	SEM
Cholesterol (mg/g)	13.64[a]	13.56[a]	13.55[a]	13.41[b]	13.39[b]	12.57[c]	12.51[c]	0.04
Triglyceride (mg/g)	39.52	39.61	39.58	39.47	39.02	38.32	38.47	0.01
Calcium (mg/g)	0.45	0.41	0.41	0.37	0.40	0.33	0.35	0.01
Phosphorus (mg/g)	0.24	0.25	0.25	0.23	0.23	0.24	0.24	0.01

a, b, c, — Means with different superscripts within the same row are significantly different ($p<0.05$).
* replacement level of MM: SBM: FM.
MM — Maggot meal as sun-dried (SMM) or roasted (RMM).
SBM — Soyabean meal.
FM — Fishmeal.

Table 7: Composition analysis of egg production in layers fed the experimental diets.

	Replacement Levels (%)[3]						
	0:100:100	50:50:100		100: 0:100		100:0:0	
Parameters	1(Control)	2(SMM)	3(RMM)	4(SMM)	5(RMM)	6(SMM)	7(RMM)
Total feed consumed/bird (kg)	5.83	6.24	5.70	6.41	5.70	5.76	5.90
Feed cost/kg (N)*	16.00	15.66	15.70	15.39	15.47	12.46	12.59
Cost of total feed consumed (N)*	93.20	97.71	89.73	98.60	89.23	71.80	74.25
Total eggs weight per bird (kg)	2.22	2.67	2.32	2.71	2.51	2.44	2.19
Cost/kg egg (N)*	41.99	36.35	38.61	36.42	35.78	29.41	33.86
Gain/kg egg (%)[1]	–	13.43	8.05	13.27	14.79	29.96	19.36
Relative cost benefit(%)[2]	100.00	115.52	108.75	115.29	117.36	140.15	124.01

All costs were computed from single mean values and were not statistically analysed.

1. Percentage gain/kg egg = $\frac{\text{Cost/kg egg (Control) - Any other}}{\text{cost/kg egg (Control)}} \times \frac{100}{1}$
2. Relative cost benefit (%) = $\frac{\text{Cost/kg egg (Control)}}{\text{cost/kg egg (Any other)}} \times \frac{100}{1}$

* 80 = US$ (Eighty Naira is equivalent to one US dollar).

replacement. Triglyceride and phosphorus contents of the egg yolk did not show any significant differences ($p>0.05$) among treatment means.

Computed data on the economics of egg production presented in Table 7, indicate a general reduction in costs per kilogram of feed and per kilogram of eggs with incremental levels of maggot meal in the layers diet. These cost were slightly higher for RMM than SMM diets resulting in higher cost benefit for SMM-based diets.

Discussion

The proximate and amino acid compositions of sun-dried and roasted maggot meal ordinarily suggest that they are potentially good sources of nutrients for poultry. The fibre-free maggot meal gave a protein content that exceeded that of SBM but less than that of FM. They meet the NRC (1984) amino acid requirements for layers, especially for methionine, lysine and threonine which are deficient or borderline in SBM.

The results of the feeding trial showed comparable feed intake, weight gain and control diets. Gado *et al*, (1983) and Akpodiete (1992) reported similar trends in the performance of broiler chicks when maggot meal was used as a substitute for SBM. However, the non significant increases in feed intake recorded for dietary treatments with SMM than the corresponding RMM diets, may be associated with the energy content of the diets, as dietary ME increased as RMM inclusion increased. This may have resulted from the processing methods as it is likely that roasting concentrated the nutrient content of the maggot meal by reducing moisture content. Therefore, their incorporation in the diet to replace the equivalent crude protein contributions of SBM and SBM plus FM, may have affected the nutrient compositions of the diets including energy. This in effect was probably responsible for the slight differences observed since birds feed consumption could generally be moderated by the feed nutrient density.

Hen-day production followed a trend similar to that of feed intake suggesting that reduced RMM intake played an important role in the reduced number of eggs laid per bird, total eggs weight per bird and hen-day production (percent). This observation between the processing methods tends to suggest a likely destruction of some nutrients, especially protein during processing. Since the temperature and time of roasting were not regulated, there could have been denaturation of some protein components of the maggots which led to a reduction of some essential amino acids required for enhancement of laying performance. However, this did not appear to be severe as there were no significant differences between treatment means and layers fed RMM diets still produced a numerically higher hen-day percent than the control. This infers a good potential for maggot meal either sun-dried or roasted, as a plausible alternative feed ingredient for both SBM and FM in the diet of laying hens. The improved feed conversion ratio (feed:egg weight) obtained at 100 percent replacements of SBM with SMM or RMM further confirms this assertion.

Shell thickness was inferior when SMM was used comparatively to RMM at 50 and 100 percent replacement levels for SBM. The reason for this occurrence could not be readily accounted for. Perhaps some intrinsic factors associated with the processing methods were responsible. Heat treatment has been shown to increase the availability of nutrients and roasting (dry heat treatment) may have therefore enhanced the bioavailability of calcium from diets containing RMM. However, a conclusive statement cannot be made because when both SMB plus FM were replaced, shell thickness became slightly lowered for RMM treatment. This may then suggest a synergistic and/or additive nature of FM plus SMM on calcium bioavailability to the laying chicken.

Belyavin (1988) asserted that egg shell thickness and egg weight, shell surface area (SSA) and egg shape index (ESI) are important indices for measuring shell strength. These parameters with the exception of shell thickness were similar among the dietary treatments. Also, no shell-less eggs were laid. These are indications that adequate minerals required for egg shell formation were available from the diets supplemented with sun-dried and roasted maggot meal.

Data on internal egg qualities showed no significant differences in Haugh Unit, yolk index and egg yolk colour. Eggs laid by hens on all dietary treatments gave high values for these parameters. This accordingly indicates that the eggs were of high quality (Gardner and Young, 1972). The variations observed for albumin weights were a reflection of egg sizes which were related to the hen-day production. Although significant differences were observed for albumin weight, the non-sequential reduction makes it difficult to attribute the differences to the utilization of maggot meal either as SMM or RMM. This is because, even at complete replacement of SBM alone or SBM plus FM with RMM and at 50 percent replacement of SBM with SMM, albumin weights were not different from control treatment.

The occurrence of blood/meat in eggs has been associated with conditions such as cold environment, marked temperature change, continous light, low vitamins K and A and stress at ovulation (Gordon, 1979). The incidence of blood/meat spots observed in this study did not indicate any pattern that may be attributed to the inclusion of maggot meal in the layers diet. It may not be unconnected with high ambient temperature during the laying period, which may have caused stress factors in the hens during ovulation, leading to breakage of blood vessels before ovulation and resulting into blood spots. Thus, the individual differences among the laying birds for coping with stressful conditions might have contributed to the differences observed in this study rather than differences in dietary composition.

The significant reduction in egg yolk cholesterol upon increasing dietary level of maggot meal in layers diet is of importance in human nutrition and health. A large number of experiments have been carried out with the aim of modifying egg cholesterol content but the most significant outcome has been that cholesterol content may be altered only within very narrow limits (Grashorn, 1995). This is perhaps not surprising when the metabolism of cholesterol is considered. Its metabolism dictates that the only feasible way to alter the cholesterol content of eggs is alter its composition of lipoproteins. However, human nutrition studies have shown that feeding high levels of poly-unsaturated fatty acids reduces the cholesterol content of the blood and therefore, a surplus of poly-unsaturated fatty acids is descrable due to the expected anti-arteriosclerotic effects (Hargis and Elswyk, 1993; Grashorn, 1995). Earlier, Anderson *et al,* (1989) observed increased levels of omega-3 fatty acids in the yolk of eggs when diets contained fish oil and linseed oil, showing that the fatty acid profile in the diet can be transferred to the tissues. Farrel (1993) enriched eggs with linoleic acid, an omega-3 fatty acid of different origin, and observed that an accumulation of omega-3 fatty acids was possible in the egg. The significant reduction in egg yolk cholesterol observed in this study may be due to characteristic fatty acid composition of maggot meal rich in poly-unsaturated fatty acids. Changing the fatty acid profile of egg yolk by feeding ingredients rich in poly-unsaturated fatty acids to hens may lead to dietary advantage in human nutrition. This is because a high level of cholesterol in the blood (hyper-cholesteriolemia) usually leads to disease problems of arteriosclerosis and cardiovascular disorder. These problems have increased people's interest in the high concentration of cholesterol in eggs and have contributed to the decline in *per capita* egg consumption in Europe.

From the results of this study, it can be concluded that maggot meal is a possible alternative for SBM and SBM plus FM, as protein source in the diet of laying chickens. Sun-dried maggot meal was found to be slightly better than roasted maggot meal and it was relatively cheaper due to the additional cost of processing RMM. Both the SMM and RMM could be adopted depending on the prevailing season of the year and the slight differences observed for the cost of producing a kilogram of feed and eggs could be further reduced with effective management.

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