International Journal of Tropical Medicine 2 (2): 52-56, 2007

Health, Nutrional and Consumers' Acceptability Assurance of Maggotmeal Inclusion in Livestock Diet: A Review

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Abstract: The need to harness the potentials of maggot meal, a by-product of animal (manure) origin to replace an expensive conventional feed ingredient (fish meal) was brought into focus by showing the results of relevant studies (nutritional, microbiological, consumers' response) as evidence in support of idea that maggot meal is a good protein raw material that can be included in poultry diet to produce broiler-chicken meat and/egg. From all the results, the broiler meat produced was found to be nutritionally rich, microbiologically safe and acceptable to consumers. It was therefore, concluded that research and development should focus on the mechanization of maggotmeal production for industrial application in order to reduce labour and to make animal protein more available in developing countries where maggots are readily available.

Key words: Livestok diet, maggotmeal, consumer, assurance, inclusion

INTRODUCTION

The importance of feed to the livestock industry must be constantly emphasized to keep the business afloat and to make animal protein available to man at affordable cost. Feed composition according to Oluyemi (1984) should be balanced in composition in order to meet the requirements of the livestock in terms of growth, production and maintenance. Aletor (1986) cautioned that the success of any livestock industry in Nigeria would depend largely on the availability of good quality and relatively inexpensive feed ingredients for livestock feed formulation; his investigation into least cost feed formulations has informed the replacement of some expensive conventional feed raw materials such as groundnut cake and fishmeal which have alternative uses with cheaper alternatives in livestock dietary formulation which allow locally available ingredients such as maggot and earthworm to be used; the former (maggot) is much more available is the larva of dipterous flies which lays its egg on decaying organic matter.

Old scientists (Lindner, 1919; Feld-Musham, 1944; De Foliart, 1989) from their investigation recommended insect rearing for animal feeding; later, Ruddle (1973) recommend insect production for pond fish production in order to solve human nutrition problem. Today, maggot production is still in its infancy in Nigeria; currently, it is harvested from heaped poultry manure in which they develop and are harvested for fish feeding.

Including any feed ingredient in the checklist of acceptable protein raw materials for livestock feed formulation means such ingredient satisfies the nutritional and health consideration as well as the acceptability of the end product. These qualities are scientifically determined by thorough laboratory investigations.

From human and animal health consideration, the fact that maggots are harvested from decaying and filthy products and included in diets of chickens reared for meat purposes to some extent could negatively affect the acceptability and attitudes of consumers. For these reasons, microbiological implications of incorporating maggots in the diets of livestock deserve thorough investigations; the level of acceptability of products (meat/eggs) from chickens fed diets with maggotmeal inclusion should also be investigated.

This study highlights relevant research studies and findings that justify the use of maggotmeal which is a cheaper locally available protein raw material than the expensive imported ones like fishmeal, groundnut cake and soyabean.

INVESTIGATIONS WITH FINDINGS AS JUSTIFIABLE EVIDENCES

Nutrition studies: Maggots extracted from caged layer manure of proven healthy layer-chickens were extracted in quantity using the method of Awoniyi *et al*. (2000).

The maggots were sun dried as reported by Awoniyi *et al*. (2001) and milled in graded values of 0, 25, 50, 75 and 100% and was used to replace fishmeal on equi-protein basis as shown in Table 1.

From this study, performance characteristics (weight gain, feed consumption and feed efficiency) of the chickens fed maggot meal inclusion diets compared well

Table 1: Composition of the experimental diets (g 100 g^{-1})

Raw feed materials	Diets 1	2	3	4	5
	FM Protein replaced by MGM Proteins (%)				
	0	25	50	75	100
Maize	57	56.83	56.66	56.47	56.47
GNC (45.1%)	28.00	28.00	28.00	28.00	28.00
FM (64.5%)	4	3	2	1	0.00
MGM (55.1%)	0.00	1.17	2.34	3.51	4.68
BDG	5.00	5.00	5.00	5.00	5.00
Oil	2.00	2.00	2.00	2.00	2.00
Boee meal	2.50	2.50	2.50	2.50	2.50
Oyster shell	2.50	0.50	2.50	0.50	0.50
Vitamin/Mineral	0.50	0.50	0.50	0.50	0.50
Premix*	0.50	0.50	0.50	0.50	0.50
Salt	100	100	100	100	100
Calculated analysis					
Crude protein (g100g^{-1})	21.78	21.76	21.75	21.73	21.7
ME (Mcal kg^{-1})	3.09	3.09	3.09	3.09	3.09
Methionine+cystine	0.54	0.60	0.60	0.50	0.50
Lysine	1.20	1.20	1.20	1.20	1.20

Source: Awoniyi (2000)

Table 2: Amino acid composition (%) of diets formulated with varying percentages of maggotmeal

Amino acid	Diets 1	2	3	4	5
	FM Protein replaced by MGM proteins (%)				
	0	25	50	75	100
Arginene	5.51	5.49	5.49	4.81	5.48
Histidine	3.49	3.50	3.50	3.50	3.52
Isoleucine	3.28	3.29	3.29	3.28	3.28
Leucine	9.45	9.43	9.19	9.30	9.38
Lysine	3.00	2.95	2.95	2.92	2.90
Methionine	0.94	0.96	0.93	0.97	0.98
Cystine	0.14	1.13	0.16	0.14	0.18
Methionine+Cystine	1.08	0.54	1.09	1.11	1.16
Tryptophan	0.58	0.57	0.56	0.55	0.54
Phenylalanine	4.21	4.22	4.22	4.24	4.25
Threonine	3.80	3.61	3.62	3.62	3.62
Valine	4.29	4.29	4.28	4.18	4.27
Glycine	6.23	5.71	6.19	6.16	6.00

Source: Awoniyi (2000)

with those chickens fed fishmeal. The 25% level of fishmeal replacement with maggotmeal was recommended as the best for broiler feed formulation (Table 2). The interesting result of this experiment and findings from earlier study by Teotia and Miller (1973) motivated the determination of the protein composition of maggotmeal which was carried out by calculating the amino acid content of the various experimental diets in which fishmeal was replaced with maggotmeal. The values from this study was compared with those of fishmeal. Table 3 shows that maggotmeal favourably compares with fishmeal because all amino acids values for maggotmeal slightly vary from diet to diet, even in the 100% fishmeal inclusion diet which contains no trace of maggotmeal.

Table 3: Amino acid content (%) of the commonly used conventional raw materials (GNC and FM) compared to maggotmeal

	GNC		FM		MGM
	*	***	*	***	**
Arginene	6.41	12.30	4.35	5.87	4.20
Histidine	1.20	3.04	1.41	33.42	2.60
Isoleucine	2.17	3.56	3.48	4.78	3.50
Leucine	4.02	7.07	5.54	7.92	5.30
Lysine	2.50	3.90	7.94	7.84	5.10
Methionine	0.40	0.91	2.17	2.81	2.60
Cystine	-	-	1.74	-	-
Tryptophan	0.54	1.20	0.98	1.02	-
Phenylalanine	2.93	5.60	2.83	5.18	4.20
Threonine	1.63	3.04	2.83	5.00	3.20
Valine	3.04	4.27	3.48	4.73	3.40
Glycine	-	6.30	5.44	6.78	3.90

Source and NAS (1969**: Teotia and Miller 1973; Awoniyi, 2000*** Tewe, 1986)

Microbiological (health) investigation: Public attention has been drawn to the health implication of including maggot in livestock diet because it develops in decaying and filthy products (Atteh and Adedoyin, 1993) and because the adult form (the fly) have been implicated in the dissemination of disease-causing organisms (Matanmi, 1990). *Escherichia coli*, a major cause of losses in poultry industry commonly occurs in poultry litter and faecal material; biodeterioration, a normal metabolic activity within poultry faecal material involves a number of bacteria some of which are pathogenic. They also occur in larvae which develop in the manure. Based on this, investigation on the implications of including maggotmeal in the diets of broiler-chicken were carried out by isolating and characterizing the bacterial organisms in the development medium of the maggot, the diets formulated with varying levels of maggotmeal, freshly voided chicken

Table 4: Bacteria isolated in different broiler-chicken diets formulated with graded maggotmeal

Diets	Micro-organism
1	*Bacillus* sp.; *Clostridia* sp.; *Micrococcus* sp.; *Pseudomonas* sp.; *Staphylococcus*.
2	*Escherichia* sp.; *Micrococcus* sp.; *Pseudomonas* sp.; *Staphylococcus* sp.; *Yersinia* sp.
3	*Bacillus* sp.; *Corynebacterium* sp.; *Escherichia* sp.; *Micrococcus* sp.; *Pseudomonas* sp.; *Yersinia* sp.; *Staphylococcus* sp.
4	*Bacillus* sp.; *Clostridia* sp.; *Corynebacterium* sp.; *Escherichia* sp.; *Micrococcus* sp.; *Yersinia* sp.
5	*Bacillus* sp.; *Clostridia* sp.; *Corynebacterium* sp.; *Escherichia* sp.; *Staphylococcus* sp.; *Yersinia* sp.

Source: Awoniyi(2000)

Table 5: Bacteria identified in the excised visceral organs of mature broiler-chickens fed the different maggotmeal-based diets

Diets organ	1	2	3	4	5
Heart	*Micrococcus* sp. *Staphylococcus* sp	*Micrococcus* sp. *Bacillus* sp.	*Staphylococcus* sp. *Bacillus* sp.	- *Bacillus* sp.	*Staphylococcus* sp.
Spleen	*Micrococcus* sp. *Staphylococcus* sp. *Bacillus* sp.	*Micrococcus* sp. *Staphylococcus* sp.	*Staphylococcus* sp. *Bacillus* sp.	*Staphylococcus* sp. *Bacillus* sp.	*Bacillus* sp.
Lungs	*Micrococcus* sp. *Staphylococcus* sp.	*Micrococcus* sp. *Staphylococcus* sp. *Bacillus* sp.	*Staphylococcus* sp. *Bacillus* sp.	*Staphylococcus* sp. *Bacillus* sp.	*Bacillus* sp.
Kidney	*Staphylococcus* sp.	*Micrococcus* sp. *Bacillus* sp.	*Staphylococcus* sp.	*Staphylococcus* sp. *Bacillus* sp.	*Staphylococcus* sp. *Bacillus* sp.
Liver	*Micrococcus* sp. *Staphylococcus* sp.	*Micrococcus* sp. *Bacillus* sp.	*Staphylococcus* sp. *Bacillus* sp.	*Staphylococcus* sp. *Bacillus* sp.	*Staphylococcus* sp. *Bacillus* sp.
Pancreas	*Micrococcus* sp. *Staphylococcus* sp.	*Micrococcus* sp. *Bacillus* sp.	*Staphylococcus* sp. *Bacillus* sp.	*Bacillus* sp. *Bacillus* sp.	*Staphylococcus* sp.

Source: Awoniyi (2000)

Table 6: Bacteria identified in the weekly faecal collection of broiler-chickens fed various maggot meal-based diets

Diets	(%) FM protein replaced by MGM protein	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
1	0	*Nocardia* sp. *Staphylococcus* sp. *Moraxella* sp.	*Bacillus cereus* *Listeria grayi* *Listeria* sp.	*Nocardia* sp *Corynebacterium bovis* *Listeria murrayi*	*Actinomyces* sp. *Actinomyces* sp. *Neisseria* sp.	*Staphylococcus* sp. *Staphylococcus* sp. *Actinomyces* sp.	*Corynebacterium hofmani* *Nocardia* sp. *Branhamella* sp.
2	25	*Staphylococcus* sp. *Staphylococcus* sp. *Staphylococcus* sp.	*Listeria grayi* *Bacillus pumiles* *Bacillus cereus*	*Corynebacterium bovis* *Corynebacterium bovis* *Staphylococcus* sp.	*Nocardia* sp. *Bacillus ceremy* *Bacillus* sp.	*Staphylococcus* sp. *Staphylococcus* sp. *Bacillus* sp.	*Nocardia asteriodes* *Micrococcus roseus* *Micrococcus varians*
3	50	*Neisseria* sp. *Veillonella* sp. *Bacillus*	*Bacillus cereus* *Bacillus primilus*	*Bacillus pumils* *Listeria murpogyi* *Nocardia*	*Corynebacterium* sp. *Nocardia* sp. *Actimony* sp.	*Rothia dentocariosa* *Actinomyces* sp. *Rothis dentocariosa*	*Neisseria* sp. *Brucella* sp. *Branchamella* sp.
4	75	*Staphylococcus* sp. *Veillonella* sp. *Alkaligenes* sp.	*Actinomyces israelli* *Listeria* sp.	*Listeria gifayi* *Bacillus cereus* *Bacillus anthracis*	*Bacillus* sp. *Moraxella* sp. *Bacillus pumilis*	*Staphylococcus* sp. *Bacillus* sp. *Bacillus* sp.	*Branchamella* sp. *Corynebacterium hofmani* *Neisseria* sp.
5	100	*Veillonella* sp. *Veillonella* sp. *Neisseria* sp.	*Actinomyces israelli* *Bacillus cereus* *Propionsbacterium acnes*	*Bacillus anthracis* *Bacillus anthracis* *Listeria mutrayi*	*Actinomyces* sp. *Listeria* sp. *Moraxella* sp.	*Staphylococcus* sp. *Bacillus* sp. *Bacillus* sp.	*Staphylococcus* sp. *Corynebacterium hofmani* *Neisseria* sp.

Source: Awoniyi (2000)

manure and some organs (heart, spleen, lungs, kidney, liver and pancreas) of broiler-chickens raised to maturity on maggotmeal based diets.

Table 4- 6 show the different organisms characterized from the respective parts mentioned above (Awoniyi, 2000). Bains (1979), Thornton and Gracey (1976) reported that most bacterial associated with the broiler-chickens fed maggotmeal-based diets are by far the same as those man/animal are exposed in their day-to-day dealings and to which their bodies have developed a level of relative immunity. Although some pre-disposing factors exist that could favour the infectivity of some of these organisms to pathogenic status; these include poor farm and farm personnel's hygiene, deteriorative changes in the ration which depend on their keeping quality (Awoniyi *et al.*, 2004) and the immune status of the chickens and their consumers. These factors would influence the population of the microorganism thus potentiating their pathogenecity.

As control measures to disease that may arise from maggot inclusion in livestock diet. El Boushy *et al.* (1985) suggested that maggot extraction for the purpose of diet

Table 7: Consumer preference assessment (Hedonic score analysis) for broiler-chickens fed diets with various levels of fish meal replaced with maggotmeal

Acceptability-determining characters		Diets/Males 1	2	3	4	5	Diets/Females 1	2	3	4	5
Carcass appearance	X	6.8	7.4	7.3	6.4	7.3	5.9[a]	5.8[a]	7.4	7.5[b]	6.6[b]
	SD	2.0	1.0	1.5	0.5	0.7	2.1	10.0	0.7	1.2	1.4
Boiled (taste)	X	7.3	8.0	6.9	6.8	7.2	7.1[a]	7.3[a]	8.2[b]	7.0[a]	6.8[a]
	SD	1.3	1.0	0.7	12.0	1.2	1.0	0.7	0.8	1.2	1.1
Fried (taste)	X	7.5	7.8	7.3	7.1	7.8	7.0[a]	8.0[b]	8.6[b]	7.4	6.8[a]
	SD	0.9	1.0	12.0	0.7	0.8	1.1	1.1	0.5	1.0	0.3

Means are for 10 broiler-chickens/treatment (X ± SD), Means with different superscripts in the same row are significantly different ($p<0.05$), Source: Awoniyi *et al.* (2001)

Table 8: Consumer preference assessment (Factorial analysis) for broiler-chicken fed diets with various levels of fish meal replaced with maggotmeal

Acceptability-determining characters	Treatment (diets)	Sex	Interaction (sex x diet)
Defeathering (appearance)	NS	NS	*
Boiled (taste)	NS	NS	NS
Fried (taste)	*	NS	*

NS:Not significant ($p>0.05$),*$p<0.05$, Source: Awoniyi *et al.* (2001)

inclusion should be sourced from manure of disease-free poultry flock. Farms where routine hygiene and vaccination programmes are religiously carried out should be the ideal places to explore.

Consumers' responses to meat product of broiler-chickens fed diets with maggotmeal inclusion: The acceptability of the product (dressed carcasses and meat from the carcasses of the broiler-chickens which were fed diets with maggotmeal inclusion) was investigated using consumer preference study. This involved using a male and a female broiler-chicken from each of the 5 diet groups; each chicken was slaughtered and defeathered, the head and shanks were removed before placing the dressed carcass in a labelled plates for evaluation by a panel of judges who gave scores based on questionnaires given to each of them (Larmond, 1982).

For the taste panel study, carcass cuts (keel, thigh, drumstick) were used for meat quality (palatability) assessment by a taste panel of 10 judges. Twenty pieces of 28g each from each carcass were boiled for 15 min. Ten boiled pieces were presented to 10 judges (5 males, 5 females) while the remaining 10 pieces were fried before presenting to the judges. The boiling and frying of the samples conformed with routine culinary practices. Both boiled and fried meat samples were presented in labeled coded plate to the taste panel who scored for each carcass based on the questionnaire they were given. Rating and grading of scores were done using hedonic scale (Larmond, 1982) ranging from 1 (dislike extremely) to 9 (like extremely), the data were subjected to a 2×5 factorial Analysis of Variance (ANOVA) after square root transformation of raw data (Steel and Torrie, 1980). Results from this study are shown in Table 7 and 8.

The analysis of the judges assessment revealed in Table 7 that replacement of fishmeal with maggotmeal in the diet of male broiler-chickens had no significant effect on either the appearance or the taste (of boiled nor fried meat), whereas, the converse was observed for the female. The factorial analysis of the judges' assessment (Table 8) showed that sex/diet interaction significantly ($p<0.05$) influenced the appearance and taste of the fried broiler-chicken meat while the sex of the birds alone influenced neither the appearance nor the taste of the broiler meat.

The various aspect of investigation carried out on maggotmeal has shown that:

- Nutritionally, the protein value is good enough to replace fish meal in broiler chicken diet formulation without any shortcoming.
- Health wise, the bacteria characterized in maggotmeal are not too different from those commonly experienced by animal or man in their daily exploits they therefore pose no threat to the chickens or their consumers.
- The consumer preference study revealed that the appearance of chicken fed maggotmeal inclusion diet was not different from that fed fishmeal infact meat from female broilers-chickens on maggotmeal inclusion tasted better probably because of the characteristic fat which is more in the female broiler chickens.

From the findings on the various aspects of investigation on the maggotmeal, it is evident that the valuable protein ingredient deserves more focus through research and development to enable its industrial production for massive utilization. In the authors recommendation for massive (commercial) production, the various stages of production can be mechanized to reduce labour and save time. It should also enable continuity sustainability and sufficiency in the livestock production sector in developing countries where protein raw material for livestock feed formulation have hitherto been scarce and expensive.

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