RESULTS
AND
DISCUSSION

4. RESULTS AND DISCUSSION

4. 1. Proximate Composition of Hydrolyzed Feather Meal and Poultry Offal Meal.

The proximate composition of HFM and POM samples used in this study are shown in Table 8.

Data obtained showed that the average CP content of HFM (80.21%) was markedly higher than that of POM (54.10%). However, the CP values obtained indicated that HFM and POM are considered as rich sources of protein compared with some other animal protein sources commonly used in poultry rations, such as fish meal (60.50 - 72.30%), meat meal (54.40%) and meat and bone meal (50.40%) as reported by NRC (1984).

The CP contents of HFM samples are in good agreement with those reported by Wisman et al., (1958) and Tsang et al., (1963), 81.8 and 81.7%, respectively. But, somewhat lower than values reported by Wessels (1972), Hubbell (1987), Han and Parsons (1990) and Dale (1992) as they claimed that HFM contained 86.40, 85.0, 86.25 and 84.5% CP, respectively.

Results of CP% for POM samples were in general lower than those reviewed in the literature. El-Sherbiny et al., (1985), Mohamed et al., (1988) and Han and Parsons (1990) mentioned that POM contained from 58.10 to 63.15% CP.

Table (8): The proximate analysis of HFM and POM samples.

Tested meals	On as fed basis %						On dry matter basis %				
	Moisture	CP	EE	CF	NFE	Ash	CP	EE	CF	NFE	Ash
HFM (1)	11.12	80.60	3.07	1.60	0.81	2.80	90.69	3.45	1.80	0.91	3.15
(2)	11.65	79.82	3.53	1.35	0.63	3.02	90.35	4.00	1.53	0.71	3.41
Mean	11.39	80.21	3.30	1.47	0.72	2.91	90.52	3.73	1.66	0.81	3.28
POM (1)	6.22	58.35	21.09	3.94	0.57	9.83	62.22	22.49	4.20	0.61	10.48
(2)	9.65	49.85	21.75	4.10	3.25	11.40	55.17	24.07	4.54	3.60	12.62
Mean	7.94	54.10	21.42	4.02	1.90	10.62	58.70	23.28	4.37	2.11	11.54

However, Dale et al., (1985) reported that CP% in POM was only 47.3.

Results of EE showed that HFM and POM samples contained, on average, 3.30 and 21.42% fat, respectively. The present values are within the normal ranges reported by Wisman et al., (1958), Tsang et al., (1963), NRC (1984) for HFM (3.20 - 3.45%), and by El-Sherbiny et al., (1985), Potter and Fuller (1967) and Jackson (1971) for POM (20.49 - 21.6%). However, Dale et al., (1985) found that POM contained 29.90% fat, while Mohamed et al., (1988) reported that EE in POM was 24.36%.

The noticeably high fat contents observed with POM samples indicate the presence of considerable amounts of abdominal fat in the raw material. Therefore, it is recommended to treat such products with an antioxidant after processing to avoid rancidity which may occur by prolonged storage under unfavorable conditions.

The average CF value for POM (4.02%) was higher than that for HFM (1.47%). The NFE values showed a similar trend.

The ash content averaged 2.91% for HFM samples and 10.62% for POM ones. The results of ash content for HFM and POM samples agreed closely with the findings of Wisman et al., (1958), INRA (1984), NRC (1984), Mohamed et al., (1988) and Dale (1992).

The higher CF and ash contents of POM samples could be attributed to the contamination of the raw material with some feet, heads or the presence of some residual feeds in the digestive tract of slaughtered birds.

Samples of HFM contained high percentage of moisture (11.39%) while those of POM recorded low one (7.94%). However, the level of moisture in the product depended largly on the drying process used and on type of raw material.

Generally, results of the proximate analysis for tested HFM and POM samples were within the published ranges of Naber and Morgan (1956), Doty (1969), Wessels (1972), Morris and Balloun (1973 a), INRA (1984), NRC (1984), Sibbald (1986), Mohamed et al., (1988), Latshaw (1990) and Dale (1992) for HFM and INRA (1984), NRC (1984), and Mohamed et al., (1988) for POM.

The wide variation noted in chemical analysis of POM samples might be due to the differences between batches in raw materials (feet and heads). The highly variable nature of the products, even from the same producer, may make nutrients composition of batches quite different.

It would be best if the consumer could measure the CP content of each lot of products received. A good extraction of fat during POM processing is suitable to obtain a reasonable level of fat in the product.

From the previous results, it could be concluded that HFM is may be considered as a source of protein, while POM is considered as a source of energy, protein and minerals.

4. 2. Amino Acid Composition of Hydrolyzed Feather Meal and Poultry Offal Meal.

Amino acid contents (gm/16gm N) for HFM and POM samples, along with those reported by the NRC (1984) for Menhaden fish meal and Anchovy fish meal are presented in Table 9.

Data in Table 9 showed that HFM samples had much higher arginine, threonine, serine, glycine, cystine, valine, TSAA, isoleusine, leucine, tyrosine and phenylalanine contents, while it contained lower lysine, histidine and methionine as compared with amino acid contents of Menhaden fish meal (72.3% CP).

The perevious results are in good agreement with those reported by Moran et al., (1966), Wessels (1972), Daghir (1975), Johnston and Coon (1979), Baker et al., (1981), El-Sherbiny et al., (1985), Mohamed et al., (1988), Latshaw (1990) and Han and Parsons (1991). They concluded that HFM contained higher levels of most amino acids but deficient in some amino acids such as lysine, methionine, histidine, tyrosine and tryptophan.

Comparing amino acid contents of POM samples with those

Table (9): Amino acid composition (gm/16 gm N) of HFM and POM samples.

Amino acid	HFM			POM			Anchovy fish meal	Menhaden fish meal
	1	2	Mean	1	2	Mean		
Lysine	2.02	2.05	2.04	3.92	3.41	3.67	3.28	5.70
Histidine	0.55	0.75	0.65	1.03	0.92	0.98	2.18	1.70
Arginine	5.85	5.42	5.64	4.09	3.53	3.81	2.78	4.84
Aspartic acid	6.20	6.63	6.42	5.30	5.07	5.19	---	---
Threonine	3.65	3.62	3.64	2.48	2.42	2.45	1.35	2.50
Serine	6.42	6.92	6.67	2.49	2.27	2.38	2.02	2.73
Glutamic acid	10.54	10.52	10.53	10.64	9.92	10.28	---	---
Proline	7.95	7.65	7.80	3.33	3.24	3.79	---	---
Glycine	6.40	6.50	6.45	5.01	4.59	4.80	5.89	4.61
Alanine	3.82	3.60	3.71	3.88	3.63	3.76	---	---
Cystine	4.92	4.95	4.94	0.65	1.08	0.87	0.66	0.72
Valine	5.03	6.62	5.83	2.50	2.79	2.65	2.22	4.38
Methionine	0.44	0.52	0.48	1.06	0.62	0.84	1.00	2.10
TSAA	5.36	5.47	5.42	1.71	1.70	1.71	1.66	2.82
Isoleucine	3.54	4.50	4.02	2.35	1.96	2.16	1.95	3.22
Leucine	5.50	6.25	5.88	4.19	4.05	4.12	3.16	5.34
Tyrosine	5.30	4.25	4.78	1.72	1.75	1.74	0.78	2.27
Phenyl-alanine	3.88	3.60	3.74	2.31	2.19	2.25	1.84	2.79
CP %	80.60	79.82	80.20	58.35	49.85	54.10	63.40	72.30
Recovery of AA-N (% total N analyzed)	82.01	84.35	83.22	56.95	53.44	55.74	----	----

of Anchovy fish meal (63.4% CP), it was found that POM contained almost higher concentrations from most amino acids except histidine, glycine and methionine ones.

The mean amino acid recovery values were 83.22% for HFM samples and 55.74% for POM ones. In agreement with the present results, MacCasland and Richardson (1966), Morris and Balloun (1973 b), Burgos et al., (1974), Mohamed et al., (1991), and Williams et al., (1991), reported that the recoveries of amino acids for HFM were 84.26, 86.93, 82.42, 82.70 and 79.64%. Whereas, Dale et al., (1985) and Ravindran and Blair (1993) mentioned that these recovery values ranged between 50.1 and 51.7% for POM samples.

However, the amino acid composition and patternes of HFM and POM samples used in the present study were within the normal published ranges of Smith (1968), Baker et al., (1981), Latshaw (1990), Han and Parsons (1990) and (1991), Mohamed et al., (1991) and Williams et al., (1991).

Essential amino acids, calculated chemical score (CS) values along with limiting amino acids (LAA) in HFM and POM are presented in Table 10.

The total essential amino acid (TEAA) values for HFM and POM were 54.76 and 32.72%, respectively. In this

Table (10). Essential amino acid composition (gm/16 gm N), chemical score (CS) and limiting amino acid (LAA) of HFM and POM.

Amino acid	HFM	POM	Chick requirements*	
			0-3 weeks	6-8 weeks
Arginine	5.64	3.81	6.26	5.56
Histidine	0.65	0.98	1.52	1.44
Lysine	2.04	3.67	5.22	4.72
Phenylalanine +	---	---	---	---
Tyrosine	8.52	3.99	5.83	5.56
Methionine	0.48	0.84	2.17	1.77
Cystine	4.94	0.87	1.87	1.56
Methionine + Cystine	5.42	1.71	4.04	3.33
Threonine	3.64	2.45	3.48	3.78
Isoleucine	4.02	2.16	3.48	3.33
Leucine	5.88	4.12	5.87	5.56
Valine	5.83	2.65	3.57	3.44
Glycine + Serine	13.12	7.18	6.52	3.89
Total EAA	54.76	32.72	45.79	40.61
CS	22.12	38.71		
First LAA	Meth.	Meth.		
Second LAA	Lysine	Cyst.		
Third LAA	Hist.	Hist.		

* NRC (1984) Meth. = Methionine Cyst. = Cystine
Hist. = Histidine

concern, McCasland and Richardson (1966), Burgos et al., (1974), NRC (1984) and Williams et al., (1991), reported that the TEAA values for HFM were 57.96, 57.95, 55.96 and 49.30, respectively. Whereas, NRC (1984), Dale et al., (1985) and Ravindran and Blair (1993) mentioned that these values ranged between 28.0 and 50.7% for POM.

According to the calculated CS values and chick requirements for amino acids either during the starter period (0-3 weeks of age) or finisher period (6-8 weeks of age) tabulated by NRC (1984), methionine was the first limiting amino acid in both HFM and POM, while lysine and histidine were the second and third limiting ones for HFM. Whereas, cystine and histidine were the second and third limiting amino acids for POM. These results are in harmony with those reported by Baker et al., (1981) and Abd-El-Hakim (1993) that methionine, lysine and histidine were the first, second and third limiting amino acids in HFM. Similarly, Mohamed et al., (1988) mentioned that methionine was the first limiting amino acid in HFM, while histidine and lysine were the second and third ones. Whereas, Naber et al., (1961), Moran et al., (1966) and Morris and Balloun (1973 a) indicated that lysine, methionine, and histidine were the first, second and third limiting amino acids in HFM. Concerning POM, Dale et al., (1985), Mohamed et al., (1988) and Ravindran and Blair (1993) reported that the first limiting amino acid was methionine. However, the most limiting amino acids in poultry by-product meals are methionine, lysine, histidine and tryptophan as cited in the review.

Cystine and consequently total sulphur amino acids (TSAA) contents in HFM were considerably higher than those in POM. Both values for HFM are more than enough to cover chick requirements (NRC, 1984) either during the starter (0-3 weeks of age) or finisher (6-8 weeks of age) periods. Therefore, the high content of cystine in HFM is considered as a useful source of sulphur amino acids (SAA) which could remedy the deficiencies in methionine in broiler rations. Graber et al., (1971) reported that cystine can supply 55% of TSAA needs of young chickens and can provide increasing proportions of the TSAA needs with increasing chick weight and age. Also, MacAlpine and Payne (1977) indicated that at least 57% of TSAA requirements of broilers can be provided by cystine.

It could be concluded from the foregoing results for amino acid composition that HFM and POM tested could be considered as good sources for most amino acids required in broiler rations. But are inadequate in some critical amino acids (mostly methionine, lysine and histidine) and its use could accentuate existing and / or induce other amino acid deficiences.

4. 3. Pepsin Digestibility of Hydrolyzed Feather Meal and Poultry Offal Meal.

The pepsin digestibility percentages of HFM and POM samples are shown in Table 11. The mean pepsin digestibility value of HFM (79.89%) obtained in the present study is in good agreement with the values reported by Potter and Fuller (1967), Doty (1969), Daghir (1975), MacFarland and Coon (1984) and Latshaw (1990) being 81.93, 78.5, 78.1, 79.5 and 79.0%, respectively, for HFM. Whereas, it was higher than the values reported by Morris and Balloun (1973 b) and Mohamed et al., (1988) which were 73.20 and 57.33%, respectively. But it was lower than the value recorded by McCasland and Richardson (1966) being 87.1%.

The mean value of pepsin digestibility for POM (80.92%) agreed closely with the values obtained by Daghir (1975) and Escalona et al., (1986) who reported that POM pepsin digestibility values were 80.8 and 82.4%, respectively.

However, it should be pointed out that the nature and composition of the raw material used as well as the processing conditions had a marked effect on pepsin digestibility of slaughterhouse by-product meals.

Table(11). Percentages of pepsin digestibility for HFM and POM samples.

Tested meal	Pepsin digestibility %
HFM	
1	80.92
2	78.85
Mean	79.89
POM	
1	81.55
2	80.29
Mean	80.92

4. 4. Net Protein Utilization Values of Hydrolyzed Feather Meal and Poultry Offal Meal (Experiment 1).

This experiment was carried out to determine the net protein utilization (NPU) values of HFM and POM. All chicks used in this experiment were fed rations had the same non-protein constituents but varied in the protein source (14% CP) and amino acid supplementation. HFM was used as the sole source of protein without amino acid supplementation (T1) or supplemented with methionine (T2), lysine (T3) or both methionine and lysine (T4). Also, POM was used as the sole source of protein in T5, T6, T7 and T8 in the same order. Levels of methionine and lysine were adjusted to cover the chick requirements (NRC, 1984).

Along with the HFM and POM fed groups, three groups of chicks (5 chicks each) were fed on a free nitrogen diet (NFD) and data obtained was used in calculating the NPU values using the equation described by Bender and Miller (1953) and modified by Morris and Balloun (1973 b) as follows:

$$NPU\ \% = \frac{B_f - B_k + I_k}{I_f} \times 100$$

, where B_f and I_f denote carcass nitrogen and nitrogen intake of chicks fed the tested diet and B_k and I_k equal carcass nitrogen and nitrogen intake with the NFD.

Data for the NPU values of HFM and POM are summarized in Tables 12 and 13 and the detailed data are illustrated in Appendices A1 and A2.

Results in Table 12 showed that chicks fed on HFM treatments contained from 8.92 to 13.30 gm N/chick and consumed from 15.40 to 25.25 gm N/chick during the experimental period (10 days). The lowest NPU value (36.02%) was recorded by T1 (HFM without amino acid supplementation), whereas the highest one (49.64%) was achieved by T4 (HFM fortified with both methionine and lysine). The differences in NPU values due to amino acid supplementation were significant ($P < 0.01$), Table 14. Methionine and/or lysine supplementation significantly improved ($P < 0.05$) the NPU values of HFM. Moreover, the differences in NPU values between T1(HFM without amino acid supplementation) or T8 (HFM fortified with methionine and lysine) and all other treatments were significant ($P < 0.05$). Also, the differences between T2 (HFM supplemented with methionine) and T3 (HFM fortified with lysine) were significant ($P < 0.05$), Table 12.

Table (12). Net protein utilization values* for HFM (Experiment 1)

Treatments	Body N/gm/chick	N intake/gm/chick	NPU %
T1	8.92	15.40	36.02^{d}
T2	11.50	17.50	46.44^{b}
T3	12.23	20.25	43.74^{c}
T4	13.30	20.00	49.64^{a}

* Mean body nitrogen (N) of the nitrogen free diet (NFD) fed group = 3.43 gm

* Mean nitrogen (N) intake of the NFD fed group = 0.057 gm

* Mean body N of the initial group = 7.17 gm

* NPU = Net protein utilization

T1 = HFM without amino acid supplementation.

T2 = HFM supplemented with methionine.

T3 = HFM supplemented with lysine.

T4 = HFM supplemented with methionine and lysine.

a, b, c and d Means on the same column with different superscripts are significantly different ($P < 0.05$).

In agreement with the previous results, Wessels (1972) reported that unsupplemented HFM had a NPU value of 38% and of 54% when supplemented with methionine, lysine, histidine and tyrosine. Whereas, Morris and Balloun (1973 b) found that nitrogen retention of HFM ranged between 25.2 and 54.3%. However, Johnston and Coon (1979) reported that the mean value of NPU of unsupplemented feather meal was only 27.13%.

Regarding POM fed groups, data in Table 13 showed that the mean body nitrogen contents ranged between 11.21 and 13.29 gm/chick, while the mean nitrogen intake varied between 14.00 and 18.00 gm/chick. POM ration fortified with methionine and lysine (T8) recorded the highest NPU value (59.78%), while POM ration without amino acid supplementation (T5) showed the lowest one (51.85%). The effects of methionine and/or lysine supplementation on NPU values of POM were significant ($P < 0.01$), Table 14. The differences in NPU values of T5 (POM without amino acid supplementation) and values of all other treatments were significant ($P < 0.05$). Similarly, the differences in NPU values of T8 (POM fortified with methionine and lysine) and those of all other treatments were also significant ($P < 0.05$), whereas the differences between T6 (POM supplemented with methionine) and T7 (POM fortified with lysine) in NPU values were not significant, Table 13.

Table (13). Net protein utilization values for POM (Experiment 1).

Treatments	Body N/gm/chick	N intake/gm/chick	NPU %
T5	11.98	16.60	51.85[c]
T6	13.29	18.00	55.09[b]
T7	11.21	14.00	55.98[b]
T8	12.34	15.00	59.78[a]

T5 = POM without amino acid supplementation.

T6 = POM supplemented with methionine.

T7 = POM supplemented with lysine.

T8 = POM supplemented with methionine and lysine.

Table (14). Analysis of variance for net protein utilization values of HFM and POM.

SOV	d.f	MS values	
		HFM	POM
Treat.	3	101.50**	52.35**
Rep.	2	0.11 N.S	0.15 N.S
Error	6	0.15	0.44
Total	11	------	-----

** = $P < 0.01$

NS = Not significant.

In this respect, Escalona et al., (1986) reported that NPU values ranged between 39 and 55% for 12 samples of poultry by-product meals. In Egypt, Attia (1987) found that the NPU value of a local poultry by-product meal sample was 35.19%, and that value was lower than that of imported fish meal, but higher than local fish meal and local bone and meat meal. While, Shaban (1992) reported that NPU values were 53.3, 44.2 and 39.8% for three different poultry by-product meal samples.

It is worth to note that HFM supplemented with methionine had better NPU value than that fortified with lysine, whereas the reverse was true with POM. However, supplementing either HFM or POM with both methionine and lysine resulted in higher ($P < 0.05$) NPU values than using each one singly.

4. 5. Effect of Using Different Levels of Hydrolyzed Feather Meal and Poultry Offal Meal Without Amino Acids Supplementation on Broiler Performance (Experiment 2).

This experiment was performed to study the effect of using HFM or POM in starter and finisher rations from 1 to 7 weeks of age on the performance of broiler chicks.

All chicks within all treatments were fed on a starter commercial ration during the first week of age. The initial live body weight of chicks within all treatments at one week of age were nearly similar (ranged between 121.8 gm and 124.6 gm, Table A.3).

A control ration was formulated to contain corn-soybean meal and fish meal. HFM was used in tested rations to substitute either 25, 50, 75 or 100% of soybean meal protein or to replace 50% or 100% of fish meal protein in the control ration. While POM was used to substitute 50 or 100% of fish meal in the control ration. The detailed data of this experiment are illustrated in Appendices (A.3-6).

4. 5. 1. Body weight gain.

The average body weight gain (BWG) of broiler chicks at the starter period (1-4 weeks of age), finisher period (4-7 weeks of age) and entire period (1-7 weeks of age) are shown in Table 15. Statistical analysis of BWG at different periods are presented in Table 16.

At 4 weeks of age, the average BWG of chicks varied between 674.3 and 823.3 gm for all treatments of the experiment. The highest average (823.3 gm) was recorded by chicks of T8 (POM replaced 50% of fish meal protein), followed by those of T1 (control, 816.3 gm), while the lowest value (674.3 gm) was shown by chicks receiving the ration in which HFM substituted 100% of soybean meal protein (T5).

Results in Table 15 showed that increasing the level of poultry by product meals (either HFM or POM) in tested rations almost had a depressed effect on BWG of broiler chicks during the starter period. However, replacing half or all fish meal protein by either HFM or POM resulted in better BWG values than those obtained by replacing part or all soybean meal protein by HFM.

Analysis of variance presented in Table 16 showed that the differences in BWG due to inclusion of HFM or POM in broiler rations were significant ($P < 0.05$). Chicks of T5 (100% of soybean meal protein from HFM) recorded the lowest ($P < 0.05$) BWG among all treatments, whereas no significant differences in BWG were detected between other treatments (Table 15).

Data presented in Table 15 showed that the average BWG for chicks of T1 (1132.7 gm) surpassed the corresponding values of the other treatments at the termination of the

Table (16). Analysis of variance for average body weight gain of broiler chicks fed HFM and POM at 1-4, 4-7 and 1-7 weeks of age.

SOV	df	MS values		
		1-4 weeks	4-7 weeks	1-7 weeks
Treat.	8	6167.79*	36598.17**	67369.42**
Rep.	2	2164.70NS	508.00NS	2760.78NS
Error	16	1482.75	3437.67	3449.57
Total	26	-----	-----	-----

* = Significant ($P < 0.05$).

** = Significant ($P < 0.01$).

NS = Not significant.

Similar tables follow the same notations.

finisher period (4-7 weeks of age), while those of T5 (100% of soybean protein replaced by HFM) recorded the lowest value (705.3 gm) of all the 9 treatments.

Statistically, BWG for T1 was significantly ($P < 0.05$) higher than that of all other treatments, while that for T5 (HFM replaced 100% of soybean meal protein) was significantly ($P < 0.05$) the lowest. Whereas, no significant differences were observed between T2, T3, T4, T6, T7, T8 and T9 in BWG values (Tables 15 and 16).

Results of BWG during the entire period (1-7 weeks of age) showed the same trend observed during the finisher period (4-7 weeks of age). Chicks fed the control ration (T1) showed the highest BWG (1949.0 gm), while those of T5 (HFM replaced 100% of soybean meal protein) recorded the lowest value (1379.6 gm), Table 15.

The differences in BWG between chicks of T1 (control) and all other treatments were significant ($P < 0.05$). Also, the differences between chicks of T5 and all other treatments in BWG were significant ($P < 0.05$). Whereas, no significant differences in BWG were detected between treatments T2, T3, T4, T6, T7, T8 and T9 (Tables 15 and 16).

4. 5. 2. Feed consumption.

Results of feed consumption during the starter period showed that chicks of T3 (50% of soybean meal protein replaced by HFM) consumed the highest amounts of feed (1523.3 gm), while those of T5 (HFM replaced 100% of soybean meal protein) and T1 (control) consumed the lowest amounts (1411.6 and 1413.3 gm, respectively) as shown in Table 17. It could be noticed that feed consumption tended mostly to increase with increasing the level of HFM or POM in the ration. However, increasing the level of HFM to replace 75 and 100% of soybean meal protein (T4 and T5) had an adverse effect on feed consumption and this may be due to the friable nature of HFM which is bulky.

Data presented in Table 18 showed that the inclusion of either HFM or POM in broiler rations had no significant effect on feed consumption during the starter period.

The effect of using HFM or POM in broiler rations on feed consumption at the finisher period showed a reverse trend indicating that the amount of feed consumed tended, almost, to decrease with increasing the level of HFM or POM in the ration (Table 17).

Differences in feed consumption of broilers due to the use of poultry by-product meals (HFM or POM) in place of part or all soybean meal protein or fish meal protein during the finisher period were significant ($P < 0.01$) as presented in Table 18. Chicks of T2 (HFM substituted 25% of soybean meal protein) showed the highest feed consumption value (2791.3 gm), while those of T5 (HFM substituted 100% of

Table (17). Average feed consumption (gm) ± SE of broiler chicks fed HFM and POM at 1-4, 4-7 and 1-7 weeks of age, (Experiment 2).

Treatments	No. of chicks	Feed consumption		
		1-4 weeks	4-7 weeks	1-7 weeks
T1 Control	30	1413.3 ± 16.01	2666.7^{cb} ± 5.46	4080.0^{bc} ± 11.55
T2	30	1482.0 ± 39.21	2791.3^{d} ± 37.35	4273.3^{f} ± 26.67
T3	30	1523.3 ± 28.48	2651.0^{b} ± 26.16	4174.3^{ed} ± 22.29
T4	30	1505.0 ± 33.29	2623.6^{b} ± 36.13	4128.6^{dc} ± 4.33
T5	30	1411.6 ± 31.14	2496.7^{a} ± 1.67	3908.3^{a} ± 29.49
T6	30	1508.3 ± 31.42	2651.7^{b} ± 12.41	4160.0^{ed} ± 20.00
T7	30	1513.3 ± 6.67	2686.7^{cb} ± 13.33	4200.0^{e} ± 11.55
T8	30	1477.7 ± 21.61	2732.3^{cd} ± 31.39	4210.0^{e} ± 10.41
T9	30	1506.7 ± 29.63	2553.3^{a} ± 12.02	4060.0^{b} ± 20.00

Table (18). Analysis of variance for average feed consumption of broiler chicks fed HFM and POM at 1-4, 4-7 and 1-7 weeks of age.

SOV	df	MS values		
		1-4 weeks	4-7 weeks	1-7 weeks
Treat.	8	5325.20^{NS}	23222.87^{**}	34192.56^{**}
Rep.	2	3029.59^{NS}	2406.26^{NS}	375.81^{NS}
Error	16	2268.59	1527.68	1179.19
Total	26	-----	-----	-----

soybean meal protein) and T9 (POM replaced 100% of fish meal protein) recorded the least ($P < 0.05$) values (2496.7 and 2553.3 gm, respectively). Whereas, no significant differences were observed between T1, T3, T4, T6 and T7; T1 and T8; T2 and T8 in feed consumption (Table 17).

The effect of different treatments on feed consumption during the whole experimental period (1-7 weeks of age) showed nearly the same trend observed at the finisher period as the amount of feed intake decreased, in most cases, with increasing the level of either HFM or POM in the ration (Table 17). Feed consumed by chicks of T2 was the highest ($P < 0.05$) being 4273.3 gm, whereas that consumed by chicks on T5 (3908.3 gm) was the lowest ($P < 0.05$), followed by that of chicks on T9, T1 and T4 being 4060.0, 4080.0 and 4128.6 gm, respectively, with no significant differences. Similarly, the differences in feed consumption between T3, T6, T7 and T8 were not significant (Table 17).

4. 5. 3. **Feed conversion.**

Data presented in Table 19 revealed that feed conversion values (gm feed consumed / gm weight gain), almost increased with increasing the level of HFM or POM in the rations during the starter period (1-4 weeks of age). Chicks of T5 (HFM in place of 100% soybean meal protein) recorded the highest feed conversion values, while those of

Table (19). Average feed conversion ± SE of broiler chicks fed HFM and POM at 1-4, 4-7 and 1-7 weeks of age, (Experiment 2).

Treatments	No. of chicks	Feed conversion (gm feed / gm gain)		
		1-4 weeks	4-7 weeks	1-7 weeks
T1 Control	30	1.731^{a} ± 0.03	2.354^{a} ± 0.11	2.093^{a} ± 0.07
T2	30	1.882^{ab} ± 0.06	2.923^{b} ± 0.05	2.452^{c} ± 0.03
T3	30	1.957^{bc} ± 0.15	2.776^{b} ± 0.23	2.408^{bc} ± 0.05
T4	30	1.925^{abc} ± 0.03	2.907^{b} ± 0.05	2.451^{c} ± 0.02
T5	30	2.093^{c} ± 0.01	3.540^{c} ± 0.10	2.833^{d} ± 0.05
T6	30	1.858^{ab} ± 0.05	2.923^{b} ± 0.05	2.420^{bc} ± 0.04
T7	30	1.872^{ab} ± 0.05	2.775^{b} ± 0.07	2.364^{bc} ± 0.05
T8	30	1.795^{ab} ± 0.01	2.906^{b} ± 0.10	2.387^{bc} ± 0.05
T9	30	1.866^{ab} ± 0.11	2.602^{ab} ± 0.05	2.270^{b} ± 0.06

Table (20). Analysis of variance for average feed conversion of broiler chicks fed HFM and POM at 1-4, 4-7 and 1-7 weeks of age.

SOV	df	MS values		
		1-4 weeks	4-7 weeks	1-7 weeks
Treat.	8	0.032^{*}	0.301^{**}	0.114^{**}
Rep.	2	0.031^{NS}	0.002^{NS}	0.006^{NS}
Error	16	0.012	0.037	0.007
Total	26	-----	-----	-----

T1 (control) showed the lowest ones (2.093 vs 1.731). In other words, birds of T1 converted feed more efficiently than those of T5 (Table 19). Differences in feed conversion values between T5 and all treatments, except T3 and T4, were significant ($P < 0.05$), whereas no significant differences were observed between all other treatments (Tables 19 and 20).

Averages of feed conversion values during either the finisher period (4-8 week of age) or all the experimental period (1-7 weeks of age) followed a trend similar to that observed at the starter period (1-4 weeks of age). This trend indicate that chicks of T1 showed the best feed conversion values while those of T5 recorded the poorest ones ($P < 0.05$) and that feed conversion values mostly decreased with increasing HFM or POM level in the ration, but with no significant differences (Tables 19 and 20).

Results of experiment 2 showed that average BWG of broilers fed different levels of HFM or POM were lower than that of chicks fed the control, during the starter, finisher and entire periods. The differences in BWG between chicks of the control and those of all other treatments were significant during the finisher and entire periods, while the reverse was true through the starter one. Average BWG mostly decreased with increasing the level of tested by-product in the ration but the differences were almost insignificant.

Feed consumption decreased with increasing the level of HFM or POM in the ration and the differences were significant in most cases during the finisher and whole periods, whereas a reverse trend was observed during the starter period.

Chicks fed the control ration recorded the best feed conversion values, and the differences between the control and other treatments in feed conversion values were significant during the finisher and entire periods and almost insignificant through the starter one. Also, the differences in feed conversion values due to increasing the level of tested by-products in the ration were almost insignificant.

Data of experiment 2, also revealed that chicks fed rations with 50 or 100 of fish meal protein of the control ration replaced by either HFM or POM, showed somewhat better performance than those fed rations in which 50 or 100% of soybean meal protein was substituted with HFM.

The adverse effect of poultry by-product meals (HFM or POM) on the performance of broilers is mainly due to the deficiency of these by-products in certain amino acids, namely, lysine, methionine and probably histidine and tryptophan as previously described and discussed in amino acid composition of HFM and POM. In agreement with these findings, several investigators (McCasland and Richardson, 1966; Moran et al., 1966 and Wessels, 1972) concluded that feather meal protein was found to be distinctly deficient in four amino acids, i.e., methionine, lysine, histidine and tryptophan.

With chicks fed rations composed largely of corn and a single high protein feedstuff, Naber et al., (1961) found that the corn-feather meal ration without amino acid supplements maintained the chicks, but allowed little growth. However, growth on the corn-feather meal diet supplemented with 0.7% lysine, 0.4% methionine and 0.1% for each of tryptophan and histidine, was substantially lower than that obtained with the corn-soybean oil meal basal diet. Moreover, the quantity of amino acid supplements that improved performance on the corn-feather meal diet had only small effects when added to the corn-soybean basal or a corn fish meal diet. They added that the most likely explanation for failure to obtain maximum growth on diets high in feather protein is poor amino acid availability. Summers et al., (1965) reported that using feather meals as the sole source of protein in purified diets did not support weight gain in growing chicks. Supplementation with limiting amino acids supported only moderate growth and proved to be inferior to isolated soybean protein with methionine. They added that feather meal protein was not only imbalanced with respect to the chicks requirement for amino acids but also it was poorly absorbed.

Mor⌒an et al., (1966) concluded that the removal of all the soybean protein and its replacement with feather meal and corn to 20% of protein in practical rations led to a growth depression significantly greater than that observed with dropping the protein level to 15%.

Morris and Balloun (1973 b) found that when feather meal protein was increased from 3 to 9% in corn-soybean meal diets, with no additional of amino acids, weight gains, nitrogen retained and protein intake per bird daily decreased on average by 38.4, 9.1 and 21.1%, respectively. Similarly, Baker et al., (1981) reported that, without DL-methionine supplementation, graded levels of feather meal reduced gain and gain feed ratio linearly ($P < 0.01$).

Concerning poultry by-product meals, either known as PBPM or POM, many investigators concluded that the protein quality of these by-products is lower than that of fish meal, but comparable to that of meat meal (Daghir, 1975; Bhargava and O'Neil, 1975). Methionine and lysine are the limiting amino acids in these poultry by-product meals (Jackson and Fulton, 1971 and Escalona and Pesti, 1987). However, it is pertinent to mention that practical poultry diets in those areas of the world where soybean meal is used in lesser quantity and animal protein products such as fish meal used in greater quantity, would perhaps benefit more from the high cystine concentration in feather meal than would be the case in countries using soybean in higher quantities. Soybean meal has a methionine : cystine ratio (wt / wt) of approximately 1, whereas fish meals have a ratio over 3. Therefore, with an ingredient like feather meal, it is thus very important to have accurate information on the methionine and cystine concentrations in the diet and ingredients being dealt with. Also, accurate information on the total SAA requirement and the maximum percentage of this requirement that can be provided as cystine must be known. In this regard, NRC (1984) tabulated a cystine replacement value of 46% (wt / wt) in place of methionine.

In addition, most of the literature dealt with feather meals concluded that HFM have a high supplementary value in corn-soybean meal rations fortified with methionine. While feather meal is low in lysine, tryptophan, methionine and histidine, these amino acids with the exception of methionine are supplied in adequate quantities by rations containing large amounts of soybean meal and corn. The amino acid deficiency in a ration composed largely of corn, soybean meal and feather meal would appear to be that of methionine.

4. 6. Effect of Supplementing Hydrolyzed Feather Meal and Poultry Offal Meal With Lysine and Methionine on Broiler Performance (Experiment 3).

This experiment was designed to study the effect of supplementing the experimental rations used in experiment 2 with lysine and methionine on the performance of broiler chicks. The outlines of experiment 3 were similar to those considered in experiment 2, except that the experimental rations were fortified, if needed, with lysine and methionine according to broiler requirements (NRC, 1984). HFM replaced 25, 50, 75 or 100% of soybean meal protein of the control ration, and 50 or 100% of fish meal protein of the control. Whereas, POM was used to substitute either 50 or 100% of fish meal protein in the control.

The initial body weight of chicks at the starting of the experiment was nearly similar and ranged between 118.0 and 119.0 gm, (A.7). Detailed data of experiment 3 are shown in Appendices (A.7 - A.10).

4. 6. 1. Body weight gain.

The average BWG of broilers at the starter, finisher and entire periods of experiment 3 are shown in Table 21, while analysis of variance for BWG values recorded during the different periods of the experiment is presented in Table 22.

Data in Table 21 showed that chicks fed on different levels of HFM or POM supplemented with lysine and methionine recorded higher BWG values than those fed the control ration at the end of the starter period (1-4 weeks of age), and the effect of poultry by-product meals inclusion in broiler rations was significant (Table 22). Chicks of T3 (HFM replaced 50% of soybean meal protein) achieved the highest BWG (865.7 gm), while those of the control (T1) recorded the lowest one (683.3 gm). Moreover, BWG of chicks on T3 was significantly ($P < 0.05$) higher than that of all other treatments except for those on T9, while BWG of chicks fed the control was significantly ($P < 0.05$) lower than that of T2, T3, T5, T7 and T9. In general, increasing the level of poultry by-product meals in broiler ration resulted in higher BWG values, but the differences were almost non-significant (Table 22).

At the termination of the finisher period (4-7 weeks of age), the highest BWG (1081.3 gm) was recorded by chicks fed the control ration (T1), showing a reverse trend to that observed at the starter period. While, the lowest BWG value (876.0 gm) was shown by chicks on T9 (POM replaced 100% of fish meal protein) as presented in Table 21. The average BWG of chicks on T1 was not significantly different from that of chicks on T3, T4, T6 and T7, but was significantly ($P < 0.05$) higher than that of other treatments. It seems

Table (21). Average body weight gain ± SE of broiler chicks fed HFM and POM at 1-4, 4-7 and 1-7 weeks of age, (Experiment 3).

Treatments	Body weight gain		
	1-4 weeks	4-7 weeks	1-7 weeks
T1 Control	683.3^{c} ± 21.99	1081.3^{a} ± 33.62	1764.6^{ab} ± 44.35
T2	773.0^{b} ± 21.03	898.6^{c} ± 46.74	1671.6^{b} ± 66.68
T3	865.7^{a} ± 41.57	1049.3^{ab} ± 36.73	1915.0^{a} ± 67.00
T4	755.3^{bc} ± 5.70	1066.3^{ab} ± 57.02	1821.6^{ab} ± 58.28
T5	777.3^{b} ± 11.26	927.7^{bc} ± 54.86	1705.0^{b} ± 50.29
T6	745.6^{bc} ± 3.28	965.7^{abc} ± 37.32	1711.3^{b} ± 37.60
T7	773.3^{b} ± 5.78	937.7^{abc} ± 51.67	1711.0^{b} ± 49.33
T8	741.7^{bc} ± 8.19	930.3^{bc} ± 28.99	1672.0^{b} ± 20.82
T9	795.3^{ab} ± 37.83	876.0^{c} ± 32.08	1671.3^{b} ± 30.33

Table (22). Analysis of variance for average body weight gain of broiler chicks fed HFM and POM at 1-4, 4-7 and 1-7 weeks of age.

SOV	df	MS values		
		1-4 weeks	4-7 weeks	1-7 weeks
Treat.	8	7105.26**	17370.83*	20538.59*
Rep.	2	513.81^{NS}	2730.33^{NS}	3286.93^{NS}
Error	16	1569.11	5980.29	7849.97
Total	26	-----	-----	-----

that BWG during the finisher period tended to decrease with increasing the level of either HFM or POM in the ration, but the differences, in most cases, were not significant.

Results of the entire period (1-7 weeks of age) followed the same trend observed at the starter period as chicks fed on T3 (50% of soybean meal protein replaced by HFM) showed the highest average BWG being 1915.0 gm. Whereas, the lowest BWG values were recorded by chicks of T9 (100 % of fish meal protein replaced by POM), T2 (25% of soybean meal protein substituted by HFM) and T8 (50% of fish meal replaced by POM) being 1671.3, 1671.6 and 1672.0 gm, respectively. The average BWG of chicks on T3 was significantly ($P < 0.05$) higher than that of chicks on all other treatments except for T4 and T1. However, the differences between BWG of chicks of T2 and that of each of other treatments were not significant. Similarly, the differences in BWG values due to the inclusion of poultry by-product meals in the ration were mostly non significant (Table 22).

4. 6. 2. Feed consumption.

Results of average feed consumption for the 9 treatments throughout the different experimental periods are shown in Table 23. Analysis of variance for feed consumption values is presented in Table 24. The average feed consumption by chicks during the starter period ranged from 1166.7 gm for chicks of T1 (control) to 1516.7 gm for those on T3 (50% of soybean meal protein replaced by HFM). Feed consumption of chicks fed the control ration was not significantly different from that consumed by chicks on neither T4 (HFM replaced 75% of soybean meal protein) nor T6 (HFM substituted 50% of fish meal protein), but was significantly ($P < 0.05$) lower than those of all other treatments. Chicks on T3 consumed significantly ($P < 0.05$) higher amounts of feed than that of each of all other treatments. However, feed consumption tended almost to increase with increasing the level of poultry by-product meal in the ration (Table 22).

Feed consumption from 4-7 weeks of age (finisher period) showed that the lowest feed consumption (2333.3 gm) was recorded by chicks of T2 (25% of soybean meal protein replaced by HFM), whereas the highest value (2716.7 gm) was shown by those of T6 (HFM replaced 50% of fish meal protein). However, the analysis of variance failed to show any significant differences in feed consumption due to the inclusion of poultry by-product meals in broiler rations (Table 23).

At 7 weeks of age, the average feed consumption during the whole experimental period (1-7 weeks of age) followed nearly the same trend observed during the starter period.

Table (23). Average feed consumption (gm) ± SE of broiler chicks fed HFM and POM at 1-4, 4-7 and 1-7 weeks of age, (Experiment 3).

Treatments	Feed consumption		
	1-4 weeks	4-7 weeks	1-7 weeks
T1 Control	1166.7^{a} ± 16.67	2533.3 ± 33.33	3700.0^{ab} ± 50.00
T2	1316.7^{cd} ± 44.10	2333.3 ± 145.29	3650.0^{a} ± 180.28
T3	1516.7^{e} ± 44.10	2600.0 ± 132.29	4116.7^{c} ± 101.38
T4	1223.3^{ab} ± 14.35	2450.0 ± 104.08	3673.3^{a} ± 107.45
T5	1350.0^{cd} ± 00.00	2416.7 ± 44.06	3766.7^{ab} ± 44.06
T6	1256.6^{ab} ± 23.33	2716.7 ± 101.38	3973.3^{abc} ± 118.51
T7	1333.3^{cd} ± 44.10	2683.3 ± 60.10	4016.6^{bc} ± 92.80
T8	1346.6^{cd} ± 14.53	2516.7 ± 60.10	3863.3^{abc} ± 47.02
T9	1400.0^{d} ± 28.87	2416.7 ± 60.09	3816.7^{abc} ± 60.09

Table (24). Analysis of variance for average feed consumption of broiler chicks fed HFM and POM at 1-4, 4-7 and 1-7 weeks of age.

SOV	df	MS values		
		1-4 weeks	4-7 weeks	1-7 weeks
Treat.	8	31366.67**	49884.26NS	80792.59*
Rep.	2	4411.11NS	20092.59NS	23392.59NS
Error	16	2415.28	25092.59	29792.59
Total	26	-----	-----	-----

Chicks of T3 consumed the highest amount of feed being 4116.7 gm, which was not significantly different from that of chicks on each of T6, T7, T8 and T9, but was significantly (P < 0.05) higher than that of other treatments (T1, T2, T4 and T5). The lowest feed consumption (3650.0 gm) was shown by chicks fed on T2 followed by those on T4 (3673.3 gm) and T1 (3700.0 gm). However, the differences in feed consumption between chicks fed the control ration (T1) and those on all other treatments were not significant except for chicks on T3 (Table 23).

4. 6. 3. Feed conversion.

The average feed conversion values (gm feed / gm gain) of the different treatments during the starter, finisher and whole experimental periods are presented in Table 25, and the statistical analysis for values obtained are shown in Table 26.

The average feed conversion values ranged from 1.620 to 1.816 during the starter period (1-4 weeks of age). The lowest feed conversion values were recorded by chicks of T4 (75% of soybean meal protein replaced by HFM) and T6 (50% of fish meal protein replaced by HFM), 1.620 and 1.685, respectively. Whereas, the highest values (1.816 and 1.766) were for T8 (POM substituted 50% of fish meal protein) and T9 (POM substituted 100% of fish meal protein), Table (25). Average feed conversion ± SE of broiler chicks fed HFM and POM at 1-4, 4-7 and 1-7 weeks of age, (Experiment 3).

Treatments	Feed conversion (gm feed / gm gain)		
	1-4 weeks	4-7 weeks	1-7 weeks
T1 Control	1.709 ± 0.03	2.343^{a} ± 0.07	2.097^{ab} ± 0.04
T2	1.703 ± 0.02	2.596^{bc} ± 0.03	2.183^{bc} ± 0.02
T3	1.755 ± 0.04	2.518^{ab} ± 0.06	2.172^{b} ± 0.06
T4	1.620 ± 0.03	2.298^{a} ± 0.03	2.016^{a} ± 0.01
T5	1.737 ± 0.03	2.621^{bc} ± 0.14	2.209^{bcd} ± 0.07
T6	1.685 ± 0.03	2.813^{cd} ± 0.08	2.322^{de} ± 0.04
T7	1.724 ± 0.05	2.873^{d} ± 0.10	2.348^{e} ± 0.04
T8	1.816 ± 0.02	2.705^{bcd} ± 0.04	2.311^{cde} ± 0.01
T9	1.766 ± 0.06	2.759^{cd} ± 0.04	2.284^{cde} ± 0.04

Table (26). Analysis of variance for average feed conversion of broiler chicks fed HFM and POM at 1-4, 4-7 and 1-7 weeks of age.

SOV	df	MS values		
		1-4 weeks	4-7 weeks	1-7 weeks
Treat.	8	0.009^{NS}	0.122^{**}	0.038^{**}
Rep.	2	0.002^{NS}	0.009^{NS}	0.002^{NS}
Error	16	0.004	0.022	0.007
Total	26	----	----	----

almost insignificant (Table 25).

In general, results obtained from experiment 3 proved that supplementing the rations containing HFM or POM with lysine and methionine according to chick requirements improved body weight gain, feed consumption and feed conversion values compared with those of unsupplemented rations described in experiment 2.

The overall results of experiment 3 showed that chicks fed on different levels of HFM or POM supplemented with lysine and methionine recorded higher BWG values than those fed the control ration at the end of the starter period (1-4 weeks of age). Whereas, a reverse trend was observed at the termination of the finisher period (4-7 weeks of age), as chicks fed the control ration recorded the highest BWG values, and BWG tended to decrease with increasing the level of either HFM or POM in the ration, but the differences were almost not significant. Similarly, the differences in BWG values due to the inclusion of either HFM or POM in broiler rations during the whole period (1-7 weeks of age) were mostly nonsignificant.

Feed consumption tended almost to increase with increasing the level of poultry by-product meals in the ration at the starter and whole periods. The differences in feed consumption between chicks fed the control ration and those on most other treatments were not significant during the whole period, but the reverse was true during the starter period. Whereas, the inclusion of poultry by-product meals in broiler rations had no significant effect on feed consumption during the finisher period.

The best feed conversion values were achieved by chicks of T4 (75% of soybean meal protein replaced by HFM) during the three experimental periods, followed by those of the control in most cases, and the poorest ones were shown by chicks on T6 (HFM replaced 50% of fish meal protein) and T7 (HFM substituted 100% of fish meal) during the finisher and entire periods. However, the differences in feed conversion values among all experimental treatments were not significant during the starter period, and the effect of increasing the level of HFM or POM in the ration on feed conversion values during the finisher and whole periods were almost insignificant.

In addition, data of replacing 50 or 100% of fish meal protein in the control rations by either HFM or POM (BWG, feed consumption and feed conversion values through the three experimental periods) followed nearly the same trend observed when substituting the same levels of soybean meal protein in broiler rations with HFM. Moreover, the differences in BWG, feed consumption and feed conversion values during the different experimental periods due to replacing 50 or 100% of soybean meal protein or fish meal protein in the control rations by either HFM or POM were not significant in most cases (T3 vs T6 and T8;T5 vs T7 and T9).

From the foregoing results, it could be concluded that HFM can replace up to 75% of soybean meal protein in broiler rations containing adequate levels from methionine and lysine. Whereas, HFM or POM could be incorporated in broiler rations fortified with methionine and lysine to substitute 50% of fish meal protein.

The use of HFM in poultry feeds has been reported by numerous authors and various levels of HFM were tested either in isonitrogenous diets or in isonitrogenous and isocaloric ones. However, results of experiment 3, in which HFM was used to replace 25, 50, 75 or 100% of soybean meal protein and 50 or 100% of fish meal protein in starter and finisher broiler rations (incorporated at levels varied between 1.5 and 10.5% of the diet), agreed with the findings of several investigators. Naber and Morgan (1956) reported that feather meal and poultry meat scrap were capable of replacing 1/4 of the protein in a broiler ration containing large amounts of soybean meal and corn fortified with fish meal, dried whey product, methionine, minerals, vitamins and antibiotics. They added that feather meal providing 5% protein was found to be a satisfactory replacement for 2% fish meal and 2% dried whey product in the basal ration. Lillie et al., (1956) showed that HFM could replace fish meal up to 5% (on weight basis) with respect to growth and efficiency of feed utilization of broilers at 10 weeks of age. Whereas, Sullivan and Stephenson (1957) found that diets containing 2.5% HPF supported growth equivalent to the corn-soybean meal basal diet, also in most trials the 5% level of HPF supported chick growth responses equivalent to the basal diet. But the addition of 7.5% of HFM to chick diets caused a highly significant decrease in growth.

Mckerns and Rittersporn (1958) indicated that steam hydrolyzed feather meal can substitute effectively 50% of the soybean oil meal protein in a commercial chick broiler diet. The feather meal was rated at 80% available protein and substituted at a level equivalent to 25% of the total protein. Naber et al., (1961) found that using processed feather meal to supply up to one-quarter of the CP in chick starting rations and the remain amounts of protein from soybean meal and corn gave an excellent chick growth and dietary nitrogen utilization was not impaired. When feather meal was used to supply one-third more of the total dietary protein, amino acid deficiency problems were encountered. In experimental diets where corn, soybean meal and feather meal each contributed one-third of the CP, lysine and methionine were required to restore maximum growth rate. When one-half or more of the protein was contributed by the feather meal, the amino acid deficiencies extended to tryptophan, histidine and perhaps other amino acids.

Tsang et al., (1963) revealed that HFM could be used in broiler rations containing 20% protein at levels up to 4% of the diet, and in rations containing 22 to 26% protein up to 8%. Morris and Balloun (1973 a) reported that chicks were able to utilize HFM well when provided 2.5, 5.0 or 6.0% of corn-soybean meal diets containing adequate protein level (20 or 22%). They added that methionine and lysine supplementation was not necessary when feather meal protein provided 2.5% of the diet. But should be supplemented when feather meal protein provided 5% or more of the diet. Baker et al., (1981) found that, with methionine fortified corn-soybean meal diets, feather meal was capable of supplying 10% of the dietary protein (24%), and even at 40% of the total dietary protein, rate and efficiency of gain were quite good. With both methionine and lysine supplementation, up to 40% of the dietary protein could be provided as feather meal with little depression in rate of gain and no depression in gain : feed ratio. Abd_El-Hakim (1993) reported that all chicks fed on starter and finisher broiler diets containing 5% treated feather meal gave a satisfactory growth response during the experimental period (1-7 weeks of age).

In agreement with our findings, Low (1986) concluded that it was feasible to incorporate up to 10% of HFM in practical poultry starter diets. Similarly, Mohamed et al., (1988) reported that up to 10.5% of HFM could be incorporated to supply 36% of the CP in a corn-soybean meal broiler ration fortified with methionine and lysine. They added that from economical point of view, fish meal in broiler rations could be completely replaced by HFM.

Results of replacing 50 or 100% of fish meal in starter and finisher broiler diets by POM (levels of POM used varied between 2.5 and 10.0% of the diet) are in accordance with those reported by some investigators who concluded that broiler chicks performed normally when up to 15% of the diets was supplied by PBPM or POM. Jackson and Fulton (1971) reported that the substitution of fish meal with up to 10% of feather and offal meal in broiler rations had no adverse effect on live weight during the 8 weeks of age, and the optimum efficiency of feed utilization was recorded for chicks fed on that level. Bhargava and O'Neil (1975) showed that 10% poultry by-product and hydrolyzed feather meal (PBHHF) could replace an equivalent amount of soybean meal protein in broiler rations without detelerious effects. Lysine supplementation to diets containing adequate amounts of methionine showed significant improvement in growth. They added that the addition of 10.9% PBHFM to replace all the soybean meal in chick starter diets supplemented with adequate methionine and lysine levels resulted in equal performance as measured by body weight and feed efficiency. Akkilic (1977) found that PBPM could successfully replace all the amount of fish meal (12%) in broiler rations without any adverse effect on weight gain and feed efficiency at 8 weeks. Pezzato et al., (1979) reported that up to 12% PBPM could be used to replace up to 21% of soybean meal in broiler starter ration containing 37% soybean.

Pokiniak et al., (1984) concluded that PBPM was a useful alternative for fish meal in poultry diets, provided that lysine and methionine were maintained. Mohamed et al., (1988) reported that up to 15% POM can replace up to 36% of the crude protein in a corn-soybean meal broiler ration fortified with methionine and lysine. They added that, from economical point of view, fish meal in broiler rations can be completely replaced by POM. However, Escalona and Pesti (1987) found that at the level of 5% PBPM in corn-soy meal based practical diet, no differences in 20-day gain or feed efficiency could be detected in comparison with the effects of feeding an all corn-soy meal based control diet. But chick growth and feed efficiency were significantly depressed when PBPM was incorporated at 10% level.

4. 7. Economic Efficiency of Using Hydrolyzed Feather Meal and Poultry Offal Meal in Broiler Rations.

The total feed cost and economical efficiency of using HFM and POM without amino acids supplementation in broiler rations (experiment 2) are shown in Table 27, while those of using these poultry by-product meals fortified with adequate levels of methionine and lysine (experiment 3) are listed in Table 28. The economical efficiency values were calculated according to the official prices of different feed ingredients used for formulating the experimental rations prevailed in the Egyptian market throughout the experimental period in 1992. The economical efficiency values of the control rations were taken as standards for comparison between treatments.

Results in Table 27 showed that the highest total feed cost during the 2 experiment (HFM and POM were used without amino acids supplementations) was shown by T2 (25% of soybean meal protein replaced by HFM) being 315.60 PT followed by that of T1 (control) being 315.02 PT, whereas the lowest value (267.71 PT) was recorded by T9 (100% of fish meal protein replaced by POM). However, chicks of T1 achieved the highest total and net revenue values (584.70 and 269.68 PT, respectively). While those of T5 (HFM replaced 100% of soybean meal protein) showed the least values (414.00 and 144.42 PT, respectively). The economical

Table (27): Economic efficiency of experimental rations used in experiment 2.

Items	Treatments								
	T1 Control	T2	T3	T4	T5	T6	T7	T8	T9
Price/Kg feed (PT)*									
Starter rations	88.08	82.35	80.95	78.65	76.95	76.65	67.55	76.65	70.15
Finisher rations	71.45	69.35	68.15	66.25	64.45	66.25	62.15	66.90	63.45
Feed consumption (Kg)									
Starter rations	1.413	1.482	1.523	1.505	1.412	1.508	1.513	1.478	1.507
Finisher rations	2.667	2.791	2.651	2.624	2.497	2.652	2.687	2.732	2.553
Feed cost (PT)									
Starter rations	124.46	122.04	123.29	118.37	108.65	115.59	102.20	113.29	105.72
Finisher rations	190.56	193.56	180.67	173.84	160.93	175.70	167.00	182.77	161.99
Total feed cost	315.02	315.60	303.96	292.21	269.58	291.29	269.20	296.06	267.71
Average BWG (Kg)	1.949	1.743	1.733	1.685	1.380	1.719	1.777	1.764	1.789
Feed cost/Kg BWG (PT)	161.63	181.07	175.40	173.42	195.35	169.45	151.49	167.83	149.64
Total revenue (PT)	584.70	522.90	519.90	505.50	414.00	515.70	533.10	529.20	536.70
Net revenue (PT)	269.68	207.30	215.94	213.29	144.42	224.41	263.90	233.14	268.99
Economic efficiency**	0.461	0.396	0.415	0.422	0.349	0.435	0.495	0.441	0.501
Relative economic efficiency	100.00	85.90	90.02	91.54	75.70	94.36	107.38	95.66	108.68

* Based on prices of the Egyptian market during the experimental period (1992).

The price of one ton of yellow corn, soybean meal, HFM, POM, imported fish meal, corn oil, wheat bran, bone meal, vit & mineral mix., methionine and lysine were 500, 900, 900, 1000, 3400, 2700, 200, 250, 3250, 12000 and 12000 LE, respectively. The price of one Kg body weight on selling was 3 LE.

** $\text{Economic efficiency} = \dfrac{\text{Net revenue (PT)}}{\text{Total feed cost (PT)}}$

*** Similar tables follow the same notations.

efficiency values calculated by dividing the net revenue by the total feed cost for different treatments during the 2 experiment ranged between 0.501 for T9 (POM replaced 100% of fish meal protein) and 0.349 for T5 (HFM substituted 100% of soybean meal protein). Assuming that the economical efficiency value of the control (T1) equals 100, all treatments showed lower relative economical efficiency values except T9 (100% of fish meal protein replaced by POM) and T7 (100% of fish meal protein replaced by HFM) as they recorded the highest values being 108.68 and 107.38, respectively. Among the four treatments in which HFM replaced soybean meal protein, all levels of HFM substitution showed lower economical efficiency values than the control (T1). However, within these treatments, T4 (HFM replaced 75% of soybean meal protein) recorded the best relative economical efficiency value (91.54), whereas T5 (HFM substituted 100% of soybean meal protein) showed the poorest one (75.70) among all experimental treatments. It is worth to note that the better (higher) economical efficiency values recorded for the highest HFM and POM levels (T9, T7 and T4) were mainly due to the lower total feed cost and not to the higher BWG, whereas the lowest value showed by T5 was due to the poor BWG rather than lower total feed cost.

Concerning the effect of using HFM and POM supplemented with adequate levels of methionine and lysine on the economical efficiency of broiler rations (experiment 3), data in Table 28 revealed that T3 (HFM replaced 50% of soybean meal protein) recorded the highest total feed cost (309.31 PT) followed by T1 (control) and T6 (HFM substituted 50% of fish meal protein) being 281.76 and 281.11 PT, respectively, while the lowest value was shown by T9 (POM replaced 100% of fish meal protein) being 256.78 PT. However, chicks of T3 recorded the highest total revenue (574.50 PT), while those of T4 (HFM substituted 75% of soybean meal protein) achieved the highest net revenue (275.15 PT). On the other hand, chicks of T9, T8 (POM replaced 50% of fish meal protein) and T2 (HFM substituted 25% of soybean meal protein) showed the least total revenue values being 501.30, 501.60 and 501.60 PT, respectively, whereas those of T8 and T2 recorded the lowest net revenue values, 226.74 and 228.76 PT, respectively. The economical efficiency values for experimental rations used in experiment 3 varied between 0.503 for T4 and 0.452 for both T6 and T8. The highest (best) relative economical efficiency values were recorded by T4, T9 and T7 (HFM replaced 100% of fish meal protein) being 107.48, 104.27 and 101.50, respectively, whereas the least ones were shown by T6 and T8 (96.58 for both treatments). It is interesting to note

Table (28): Economic efficiency of experimental rations used in experiment 3.

Items	Treatments								
	T1 Control	T2	T3	T4	T5	T6	T7	T8	T9
Price/Kg feed (PT)									
Starter rations	86.36	83.50	83.94	83.25	83.16	79.18	72.96	78.61	72.68
Finisher rations	71.45	69.81	69.99	69.24	68.94	66.83	64.22	67.13	64.14
Feed consumption (Kg)									
Starter rations	1.167	1.317	1.517	1.223	1.350	1.257	1.333	1.347	1.400
Finisher rations	2.533	2.333	2.600	2.450	2.417	2.717	2.683	2.517	2.417
Feed cost (PT)									
Starter rations	100.78	109.97	127.34	101.81	112.27	99.53	97.26	105.89	101.75
Finisher rations	180.98	162.87	181.97	169.64	166.63	181.58	172.30	168.97	155.03
Total feed cost	281.76	272.84	309.31	271.45	278.90	281.11	269.56	274.86	256.78
Average BWG (Kg)	1.765	1.672	1.915	1.822	1.705	1.711	1.711	1.672	1.671
Feed cost/Kg BWG (PT)	159.64	163.18	161.52	148.98	163.58	164.30	157.55	164.39	153.67
Total revenue (PT)	529.50	501.60	574.50	546.60	511.50	513.30	513.30	501.60	501.30
Net revenue (PT)	247.74	228.76	265.19	275.15	232.60	232.19	243.74	226.74	244.52
Economic efficiency	0.468	0.456	0.462	0.503	0.455	0.452	0.475	0.452	0.488
Relative economic efficiency	100.00	97.44	98.72	107.48	97.22	96.58	101.50	96.58	104.27

that the treatments showed the higher relative economic efficiency values recorded the lowest total feed cost ones.

The previous results indicated that, from the economical point of view, HFM could be incorporated in broiler rations to replace up to 75% of soybean meal protein, whereas fish meal protein could be completely substituted by either HFM or POM. Therefore, it could be concluded that the local processed HFM and POM could be economically used in broiler rations in Egypt rather than importing tremendous amounts of the highly expensive soybean and fish meals which, in turn, would help in decreasing the feed cost of the experimental rations and save appreciable amount of money.