Utilization of Poultry By-Products Meal (PBM) Protein in Eels (*Anguilla anguilla*) Diets.

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ABSTRACT

Eight-week laboratory feeding experiment was conducted to evaluate partial substitution of fish meal (FM) protein by poultry by-products meal (PBM) protein for eels *Anguilla anguilla* (2 g/fish). Five isonitrogenous diets (50 % crude protein) were formulated with different substitution levels of 0, 15, 30, 45 and 60 % PBM protein instead of FM protein. The experimental diets were fed to duplicate groups of eels with feeding rate 4 % of its live body weight for 56 days. The results revealed that replacing of 30 and 45 % FM protein with PBM protein significantly ($P < 0.05$) enhanced final weight, weight gain, average daily gain and specific growth rate % (SGR %) of eels, compared to other substitution PBM protein levels. Feed intake, feed conversion ratio (FCR), protein efficiency ratio (PER) and protein productive value % (PPV %) were significantly ($P < 0.05$) higher in eels fed 30 and 45 % PBM protein containing diets than other tested levels of PBM protein. Increasing the dietary level of PBM protein up to 60 % decreased of feed and energy utilization. Body composition (%) of eels was affected by increasing the dietary levels of PBM protein. The economic evaluation revealed that the cost of one kg gain of eels was decreased with increasing the dietary PBM protein levels. Finally it could be concluded that PBM protein could replace 30 or 45 % of FM protein in the practical diets of eels without impairing growth performance or feed utilization.

INTRODUCTION

Eels are members of the family *Anguilledae*, and consider as the most economical fish species all over the world. In nature, eels satisfy their nutritional requirements mainly by consumption of live food however, these species seem to require between 37 and 45 % crude protein in their diet (Spatrau *et al*., 1983). In captivity, fish cannot gain access to their preferable food, hence artificial feeds should meet all nutrients requirements in sufficient quantities and qualities (Hepher, 1988). Artificial diets have been formulated for different eels (Arai *et al*., 1972, Degani *et al*., 1985 and Gallagher, 1984). Fish meal (FM) is the major source of protein in fish diets (Gallagher and Degani, 1988). However, FM is one of the most expensive ingredients in fishdiets (Webster *et al*., 1992) and because of its high protein quality and palatability (Lovell, 1989), there is a continuing interest in replacing all or part of it with other less expensive protein sources.

One of the most promising alternative ingredients available to replace a protein of FM protein in fish feeds is poultry by-products meal (PBM) which contains 68 – 72 % crude protein and 8 – 11 % ash. The higher protein and lower ash content of PBM should improve its nutritive value (Fowler, 1991). Poultry by-products meal (PBM) has been studied as a partial FM replacement in the diets of channel catfish (Brown *et al.*, 1985), rainbow trout (Alexis *et al.*, 1985), chinook salmon fry (Fowler, 1991), and European eels (Gallgher and Degani, 1988). Gropp *et al.* (1976) reported that 75 % of FM protein could be replaced by 30 % PBM, however, 100 % replacement gave slightly poor results in trout diet.

Therefore, the present study aims to test the potential for partially substituting PBM protein instead of FM protein in the European eels *Anguilla anguilla* diets.

MATERIALS AND METHODS

The present experiment was carried out in the Fish Nutrition Laboratory, Faculty of Agriculture (Saba basha), Alexandria University in order to study the effect of partially substituting poultry by-products meal (PBM) protein instead of fish meal (FM) protein in the European eels *Anguilla anguilla* diets.

Fish and Culture Facilities

Eels *Anguilla anguilla* (2 g) obtained from Nobaria drain (West Alexandria) were used in the present study. Fish were graded, homogeneous and kept in circular tanks for one month to adapted to artificial conditions (captivity and artificial feeding). Ten glass aquaria (30 x 40 x 100 cm) with a capacity of 120 L of water were used in the present experiment. Each aquarium was allowed to contain 100 L of dechlorinated tap water. Fish were randomly stoked at a rate of 20 fish in each aquarium, with two replications per each treatment. Tanks and aquaria were covered with black plastic sheets to control the daily photo period (8 hr light and 16 hr dark). The experimental glass aquaria were cleaned every day before the first feeding, and about seventy percent of the water were replaced by fresh dechlorinated tap water daily. Water temperature was thermostatically controlled and ranged between 27 ± 1° C. Dissolved oxygen was kept close to saturated level by continuous aeration using small air pumps. Fish from each replicate were weighed at the start of the experiment and then every 2 weeks. The feeding rates readjusted as percentage of live body weight. About 20 fish were frozen for initial body chemical composition %.

Experimental Diets and Feeding Regime

Dietary FM protein was substituted by 0, 15, 30, 45 and 60 % of PBM protein in five isonitrogenous experimental diets (50 % protein) (Table 2). The diets were fed to the experimental fish two times a day (9 am and 9 pm) at a rate of 4 % of its live body weight and readjusted every two weeks for 56 days (6 days a week).

Samples Collection and Analysis

At the termination of the experiment, fish were weighed and counted per each replicate per each treatment. For whole-body composition analysis, fish samples were pulverized, autoclaved and after wards homogenized with ultra-tunax. The homogenized samples were oven dried at 60 – 80° C for 48 hrs.

Chemical analysis of fish and feeds were performed using standard AOAC, (1990) methods. All data were analyzed for statistical significance by using analysis of variance (SPSS/PC program). Multiple comparisons among means were made with the Duncan Multiple range Test (Puri and Mullen, 1980). Least significant difference (LSD) was used to test the difference among treatment means when *F* values from one–way ANOVA were significant.

RESULTS AND DISCUSSION

The proximate chemical analysis (%) of FM, and PBM protein sources are shown in Table 1. The results revealed that PBM contained higher contents of dry matter, ether extract, crude fiber and gross energy than FM. However, FM contained higher ash than PBM. On the other hand, crude protein was similar in both tested protein (58.11 and 58.5 % CP for FM and PBM, respectively) sources. Gropp *et al.* (1976) reported that PBM rich in protein and lipid than FM. El-Sayed (1994) showed that PBM contained 59.42, 30.3, 10 and 0.39 % crude protein, ether extract, ash and nitrogen free extract, respectively. Srour (2003) found that dry matter and ash contents of FM were higher than those in poultry vescira meal (PVM) however, ether extract and gross energy were lower in FM. On the other hand, crude protein was almost similar (60 and 59.75 % CP) in FM and PVM, respectively.

Table (1). Proximate chemical analysis (%) of the dietary protein sources (fish meal (FM) and poultry by-products meal (PBM)).

Protein source	DM* (%)	On DM basis (%)					Gross energy (Kcal/100g DM)
		Crude protein	Ether Extract	Ash	Crude Fiber	NFE**	
FM	90.50	58.11	15.94	18.9	1.00	6.05	510
PBM	92.10	58.50	18.50	14.0	1.60	7.00	540

*DM = Dry matter. **NFE = Nitrogen free extract.

The composition and proximate analysis (%) of the present experimental diets are shown in Table 2. The diets were formulated to be isonitrogenous and isoenergetic, and to contain about 50 % crude protein and 531.4 Kcal/100 g, gross energy. The average value of protein to energy (P:E) ratio in the tested diets was 95.45 mg protein/Kcal gross energy. Values of gross energy, ether extract and nitrogen free extract in the experimental diets were increased with increasing PBM levels, however, ash content decreased.

Table 2. Ingredient and nutrients composition (%) of the experimental diets containing different levels of poultry by-products meal (PBM) protein instead of fish meal (FM) protein.

Ingredient	Diet 1	2	3	4	5
Fish meal (FM)	85	72.25	59.50	46.75	34
Poultry by-products meal (PBM)	-	12.75	25.50	38.25	51
Biscuit by-product	7	7	7	7	7
Corn oil	5	5	5	5	5
Vit. & Min mixture*	2	2	2	2	2
Caboxy methyl cellulose	1	1	1	1	1
Chemical composition %:					
Dry matter (DM)	92.28	92.31	92.38	92.52	91.78
Nutrient (%), on dry matter basis:					
Crude protein (CP)	50.70	50.73	50.75	50.78	50.65
Ether extract (EE)	20.83	21.07	21.29	21.62	20.95
Ash	18.09	17.52	16.93	16.36	15.78
Nitrogen free extract (NFE)	10.38	10.38	10.52	10.53	11.70
Gross energy (Kcal/100g)	526.9	529.3	532.1	535.4	533.3
P/E ratio	96.22	95.84	95.38	94.84	94.98

Diets 1, 2, 3, 4 and 5 containing 0, 15, 30, 45 and 60 % PBM, respectively..
Gross energy, calculated on the basis of 5.65, 4.2 and 9.45 Kcal GE/g protein, NFE and lipid, respectively.
*Meveco premix, Vit. & Min., every 1.5 kg contain Vit. A 125 million UI, D_3 3 million UI, E 15 g, K_3 2.5 gm, B_1 1.5g, B_2 5 g, B_6 2 g, Pantothanic acid 10g, B_{12} 0.01g, Nicotinic acid 30g, , Folic acid 1.2 g, Fe 30g, Mn 60g, Cu 10g, I g, Cobalt 0.25 g, Se 10 g and Zn 55g.
** P/E ratio = Protein/Energy Ratio (mg/Kcal)

Table 3. Effect of dietary replacement of different levels of poultry by-products meal (PBM) protein instead of fish meal (FM) protein on growth performance of eels *A. anguilla*.

Diet No.	PBM level %	Initial weight (g/fish)	Final weight (g/fish)	Gain (g/fish)	ADG[1] (mg/fish/day)	SGR[2] (%/day)
1	0	2	4.88^{c}	2.88^{c}	51.43^{c}	1.595^{c}
2	15	2	5.01^{b}	3.01^{b}	53.75^{b}	1.645^{b}
3	30	2	5.11^{a}	3.11^{a}	55.54^{a}	1.680^{ab}
4	45	2	5.15^{a}	3.15^{a}	56.25^{a}	1.695^{a}
5	60	2	4.91^{c}	2.91^{c}	51.97^{c}	1.605^{c}

Means in each column not sharing the same superscript are significantly different ($P < 0.05$).
ADG[1] = Average daily gain (g/fish/day): gain/experimental period.
SGR[2] = Specific growth rate (%/day): *(ln wt-ln wi/T) x 100*, where *wt* is weight of fish at time *t*, *wi* is weight of fish at time 0, and *T* is the experimental period in days.

The effects of replacement of PBM protein instead of FM protein in the diets on the growth performance of eels are illustrated in Table 3. The results showed that the highest values of final weight, weight gain, average daily gain (ADG) and specific growth rate % (SGR %) were recorded with fish fed diets containing 30 and 45 % PBM protein instead of FM protein. Increasing the dietary level of PBM protein up to 60 % PBM decreased final weight, gain, ADG, and SGR % of eels. According to Higgs *et al.*, (1979) at least 28 % of PBM protein may be included in the diet of coho salmon. Also Gallagher and Degani (1988) reported that PBM protein could be substitution in part for FM protein in diet formulation for European eels *Anguilla anguilla*. Bishop *et al.* (1995) reported that hydrolized feather meal could replace up to 50 and 66 % of the FM within diets for *O. niloticus* fingerlings and fry with no loss in growth performance, respectively. Additionally El-Sayed (1998) reported that no difference was observed between diets containing 25 and 50 % PBM, and performance was better than the control, 75 and 100 % PBM diets of tilapia (*O. niloticus*). Also, Srour (2003) demonstrated that 25 % and up to 50 % of FM protein could be successfully replaced within *O. niloticus* and *Clarias gariepenus*, feeds, respectively by poultry viscera meal (PVM) protein without any retardation in growth performance. Whilst, Tacon *et al.* (1983), Viola and Zohar (1984) and Davies *et al.* (1989), all reported poor growth of tilapia when fed hydrolyzed feather meal.

Table 4. Effect of dietary replacement of different levels of poultry by-products meal (PBM) protein instead of fish meal (FM) protein on feed and nutrients utilization of eels *A. anguilla*.

Diet No.	PBM level %	Feed intake (g/fish)	FCR[1]	Protein utilization		EU[4] %
				PER[2]	PPV[3] %	
1	0	6.39[c]	2.22[c]	0.90[b]	17.19[b]	17.55[ab]
2	15	6.52[bc]	2.17[abc]	0.92[ab]	18.10[b]	17.85[ab]
3	30	6.57[ab]	2.12[a]	0.95[a]	19.46[a]	18.23[a]
4	45	6.69[a]	2.13[ba]	0.95[a]	20.05[a]	18.27[a]
5	60	6.36[c]	2.19[cb]	0.92[ab]	17.19[b]	17.04[b]

Means in each column not sharing the same superscript are significantly different ($P < 0.05$).
[1]FCR = Feed conversion ratio: total dry diet fed (g)/total wet weight gain (g).
[2]PER = Protein efficiency ratio: wet weight gain (g)/amount of protein fed (g).
[3]PPV = Protein productive value (%): $(P-P_0)\ 100/P_i$ where P is protein content in fish carcass at the end of the experiment, P_0 is the protein content in fish carcass at start of experiment and P_i is the protein in feed intake.
[4]EU = Energy utilization (%): $(E-E_0)\ 100/E_i$ where E is the energy in fish carcass (Kcal) at the end of the experiment, E_0 is the energy in fish carcass (Kcal) at the start of the experiment, and E_i is the energy in feed intake (Kcal).

Results in Table 4 show the effects of replacement of PBM protein for FM protein in the diet on feed and nutrient utilization of eels *A. anguilla*. Fish fed diets contained 30 and 45 % PBM protein from FM protein had the highest values of feed and nutrient utilization compared with those of control group. Meanwhile there was insignificantly different among fish received diets contained 15, 30 and 45 % PBM protein in FCR. Also insignificantly different was recorded among fish received different levels of PBM protein in the diets in PER. Another insignificantly different was found among fish had 0, 15, 30 and 45 % PBM protein in the diet in energy utilization. The previous results are in agreement with the findings of Higgs *et al.* (1979) who reported that raising the dietary proportion of PBM for coho salmon up to complete replacement of FM resulted in poor FCR. Steffens (1994) found that raising the level of PBM in the diet of rainbow trout (*Oncorhynchus mykiss*) resulted in increases in FCR and the consumption of gross energy. The author observed a decrease in PER, PPV and EU. A progressive reduction in PER and PPV % in fish fed diet containing 60 % PBM protein was observed. This effect may be attributed to the lower efficiency of protein utilization or alternatively leading to a depression in feed intake as reported by Hilton and Slinger (1986) and Dabroski *et al.* (1989). Also, El-Sayed (1998) found that feed intake decreased in tilapia (*O. niloticus*) fed on high levels of PBM (75 and 100 %). Protein efficiency ratio and protein retention values in fish fed 25 and 50 % PBM protein were higher than the control group; values were lowest with 100 % PBM protein substitution. Srour (2003) reported that the values of protein and energy utilization were similar in tilapia and catfish, which received the control diet, 25 % and 50 % PVM protein instead of FM protein. In contrast, Fowler (1991) found that juvenile of chinook salmon fed diet with 30 % PBM had poorer appetite than those fed the other diets. Feed intake, FCR, PER and PPV % of seabream (*Rhabdsargus sarba*) fingerlings fed diets contained up to 75 % PBM protein substitution level were not significantly different ($P > 0.05$) from those fed the control diet (100 % FM) as reported by EL-Sayed (1994).

Table 5. Effect of dietary replacement of different levels of poultry by-products meal (PBM) protein instead of fish meal (FM) protein on carcass composition of eels *A. anguilla*.

Diets No.	PBM level %	Dry matter %	% on dry matter basis			Gross energy (Kcal/100g)
			Crude protein	Ether extract	Ash	
Initial		25.51	55.21	38.66	5.13	677.27
1	0	28.79^{c}	58.86^{e}	35.56^{a}	5.58^{b}	668.60^{a}
2	15	29.11^{b}	59.73^{d}	34.77^{b}	5.50^{c}	666.06^{a}
3	30	29.17^{b}	61.65^{b}	32.91^{d}	5.44^{d}	658.32^{b}
4	45	29.55^{a}	62.57^{a}	32.16^{e}	5.27^{e}	658.94^{b}
5	60	28.89^{c}	61.15^{c}	33.21^{c}	6.69^{a}	659.33^{b}

Means in each column not sharing the same superscript are significantly different ($P < 0.05$).

The effect of PBM protein replacement for FM protein in the diet on carcass composition of eels *A. anguilla* are summarized in Table 5. The obtained results indicated that the higher values of dry matter and crude protein were observed in fish received diets contained 45 % PBM protein from FM protein. Fish received the control diet (100 % FM protein) revealed higher body ether extract compared to fish received other tested diets. The higher ash content was noticed in eels fed 60 % PBM protein diet. Meanwhile the highest values of gross energy were recorded by fish received the control and 15 % PBM protein diets. These results are in agreement with that reported by El-Sayed (1994) and El-Eraky and Saleh (1989). Srour (2003) reported that tilapia, body protein was decreased significantly ($P < 0.05$) with increasing the dietary PVM . Meanwhile, body lipid was increased significantly ($P < 0.05$) with increasing PVM % in the diet. The same trend of tilapia body protein was observed in catfish protein content. Dry matter was significantly ($P < 0.05$) lower in all PVM treatments as compared with the control diet containing FM only. In contrast of these findings, Fowler (1991) and Steffens (1994) observed a significantly ($P < 0.05$) lower protein and high body lipid in rainbow trout fed PBM protein compared with the control group containing FM protein.

Table 6. Cost (L.E) of feed required for production of one Kg gain of eels *A. anguilla* fed diets containing different levels of PBM protein instead of FM protein.

Diets No.	PBM level %	Amount of feed /one Kg gain (Kg)	Cost of one kg fish gain (LE)	% Change in feed cost/ kg gain
1	0	2.22	10.26	-
2	15	2.17	8.87	11.27
3	30	2.12	7.46	27.29
4	45	2.13	6.36	38.01
5	60	2.19	5.36	47.76

PBM = Poultry by-products meal. Diet 1 used as a base for calculation.
Cost in LE/ton: Fish meal 5000, Poultry by-products meal 800, Biscuit by products 300, corn oil 3000, Mineral mix. 2000, Vitamins mix. 6000 and Carboxy cellulose 12000.

Feed cost required for production of one Kg gain of eels fed various levels of PBM protein instead of FM protein are presented in Table 6. The cost of feed required to produce one Kg gain of eels decreased with increasing the levels of dietary PBM protein instead of FM protein respectively. The lowest cost of feed /Kg gain values was 5.60 LE obtained with diet containing 60 % PBM protein. Abd El-Maksoud (2000) demonstrated that the diet contained poultry offal, up to 50 % of FM protein could be used to reduce the feeding cost and increase the profit of Nile tilapia. Additionally in the line with the present findings, Srour (2003) showed that increasing the dietary levels of PVM, the cost of one Kg fish gain of tilapia and catfish were decreased.

Finally it could be concluded that the diet containing 45 % PBM protein instead of FM protein could be used successfully as FM protein replacer for eels.

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الملخص العربى

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١) قسم الانتاج الحيوانى والسمكى – كلية الزراعة – سابا باشا – جامعة الاسكندرية

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أجريت هذه الدراسة لتقدير مدى استفادة الحنشان من الإحلال الجزئى لبروتين مسحوق مخلفات مجازر الدواجن محل بروتين مسحوق السمك بعد ثمانية أسابيع من التغذية على علائق تحتوى صفر و١٥ و٣٠ و٤٥ و٦٠ % من بروتين مسحوق مخلفات مجازر الدواجن بدلا من بروتين مسحوق السمك فى علائق تحتوى على ٥٠ % بروتين خام. وكان معدل تغذية الأسماك اليومى يعادل ٤ % من ون الجسم الحى فى مكررتين لكل معاملة وذلك لتقدير اثر هذه المعاملات على كفاءة النمو ومعدل الاستفادة من الغذاء والتركيب الكيماوى لجسم الأسماك. وقد أظهرت النتائج أن معدل الإحلال٣٠ و ٤٥ % لمسحوق مخلفات مجازر الدواجن محل نفس الكمية من بروتين مسحوق السمك كمصدر للبروتين قد حسن من كفاءة ومعدل النمو للأسماك وذلك مقارنة بالأسماك التى غذيت على عليقة قياسية (١٠٠ % بروتين مسحوق سمك) بدون إحلال كذلك قد تحسنت معدلات استهلاك الغذاء و التحويل الغذائى والاستفادة من الغذاء فى معدل الإحلال ٣٠ و ٤٥ % لمسحوق مخلفات مجازر الدواجن محل نفس الكمية من بروتين مسحوق السمك كمصدر للبروتين عنه فى باقى المعاملات. وقد وجد انه برفع مستوى الإحلال الى ٦٠ % لمسحوق مخلفات مجازر الدواجن محل مسحوق السمك كمصدر للبروتين فان ذلك قد تسبب فى انخفاض كفاءة الإستفادة من الغذاء والطاقة. وقد تأثر محتوى جسم الأسماك من المادة الجافة والبروتين والدهون والرماد والطاقة بزيادة معدل الإحلال ا الجزئى لبروتين مسحوق مخلفات مجازر الدواجن محل مسحوق السمك كمصدر للبروتين. وعليه تظهر هذه الدراسة أنه يمكن إحلال بروتين مسحوق مخلفات مجازر الدواجن محل بروتين مسحوق السمك فى علائق الحنشان بنسبة ٤٥ % بدون أى تأثير سلبى لهذا الإجلال على نمو الأسماك أو كفاءة استفادتها من الغذاء. وكان الأداء الاقتصادى فى صالح زيادة نسبة إحلال مسحوق مخلفات مجازر الدواجن كمصدر للبروتين محل بروتين مسحوق السمك.