Tropical Agricultural Research & Extension 25 (3): 2022

RESEARCH ARTICLE

EFFECT OF FEEDING TWO TYPES OF LOCAL FISHMEAL RATIONS ON BROILER PERFORMANCE

Ramkumar S[1], Sinniah J[1*], Samarasinghe K[2] and Anand Kumar S[1]

[1]Department of Animal Science, Faculty of Agriculture, University of Jaffna, Sri Lanka.

[2]Department of Animal Science, Faculty of Agriculture, University of Peradeniya, Sri Lanka.

Received: 18 February 2022, Accepted: 13 August 2022

Abstract

Current study was conducted to find out the possibility of using two types of local fish meals as animal protein sources in broiler rations. Ninety-nine unsexed day-old broiler chicks of Hubbard Flex strain were randomly allocated to three dietary treatments each having three replicates of eleven chicks per replicate in a completely randomized design (CRD). Diets 1 and 2 contained 2.5 % of locally produced *Heteropneustes fossilis* (Stinging catfish) fish meal and *Spilotichthys pictus* (painted sweetlips) fish meal, respectively while diet 3 was a commercial feed containing imported fish meal. During the first 14 days, all the chicks were fed with a commercial broiler starter ration. From day 15 until 42 days, birds were fed with experimental diets *ad-libitum*. Feed intake and weight gain per bird in g/day for the dietary treatments diet 1, diet 2 and diet 3 were 89.00±2.54, 92.95±2.64, 100.56±4.66 and 50.34±1.48, 53.85±2.53 and 60.39±2.99, respectively. Diets with local fish meal recorded lower feed intake and weight gain compared to diet 3 (P<0.01). Higher feed intake and weight gain were recorded for diet 2 than for diet 1. Diet 2 recorded the highest profit per kg of carcass weight (Rs 103.37±2.80) (P< 0.02) while the differences between diet1 (Rs 93.78±3.00) and diet 3 (Rs 93.69±1.89) were not significant. As far as the cost of production per kg of carcass weight is considered diet 2 recorded the least cost (Rs 326.64 ± 2.79) (P< 0.01) while the differences between diet 1 (Rs 335.28±4.10) and diet 3 (Rs 336.50 ± 1.89 were not significant. Diet 2 was the most profitable treatment. It could be concluded that poultry feed formulated with 2.5% painted sweetlips fish meal or stinging catfish fish meal instead of commercial feed with the imported fish meal can be fed to broilers successfully and can make more profit. Painted sweetlips fish meal was better than stinging catfish fish meal in terms of broiler performance and profits. In addition, this will pave the way to make use of the trash fish which are mostly wasted otherwise and open up employment opportunities for the people involved in the value chain of broiler feed or broiler industry.

Keywords: Broiler, cost, imported fish meal, painted sweetlips, stinging catfish

INTRODUCTION

The poultry industry is the fastest-growing livestock industry in Sri Lanka. For the year 2020, poultry contributed 0.61 of nominal GDP (at the current price) which is 64% of the total GDP contribution of Sri Lankan livestock (Department of Animal Production and Health, 2021). Broiler meat production in the year 2019 was 224,000 MT with a 4% reduction in 2020 due to the impact of COVID 19. Contradictory results of reduction in broiler meat production were due to restrictions imposed by the government such as suspension of live animal imports, restriction on feed raw material importation etc. to prevent the spread of COVID 19 (Department of Animal Production and Health, 2021). The total poultry feed production recorded a 5% increase from 2019 to 2020 with an increase of 16% in commercial feed production and a 33% reduction in self-mixed fed production

Corresponding author: jeyalingawathani@gmail.com

(Department of Animal Production and Health~~,~~ 2021). Despite the current fluctuation, the general trend of rapid growth in the poultry sector demands a large quantity of good quality concentrate feeds. Among the ingredients for poultry feed production fish meal is an expensive ingredient but its inclusion is vital to supply the essential amino acids, minerals and vitamins to the birds. The amount of fish/meat meal imported to the country in 2019 was 30,410.183 MT which is valued Rs. 2,365,737,685 (Sri Lanka Customs, 2019). Ninety percentage of fish meal used in the feed industry of Sri Lanka is imported (Department of Animal Production and Health~~,~~ 2014).

Total fish production in Sri Lanka in the year 2019 amounted to 505,830 metric tons (Fisheries Statistics 2020) which includes trash fish too. Trash fish have a great potential to contribute to local fish meal production. When appropriate technologies are used for the production of local fish meal this can be used to make the poultry feed at a low cost which in turn will increase the profitability of the poultry industry. At the same time, this can create employment opportunities in the field of fish processing and the fishermen's community also can make additional income through the sale of trash fish which is mostly wasted otherwise.

Prominent trash fish observed in the Pallikuda lagoon area which comes under the Kilinochchi district are Bristle-tail file-fish (*Monocanthusto mentosus*), Sand Bass (*Psammoperca waigiensis*), Stinging catfish (*Heteropneustes fossilis*), Painted sweetlips (*Spilotichthys pictus*), Black spot Snapper (*Lutjanus fulviflamma*) and Short silver belly (*Gerres abbreviates*).

H. fossilis is distributed throughout south and Southeast Asian countries including Bangladesh, India, Laos, Myanmar, Nepal, Pakistan, Sri Lanka and Thailand. This fish was previously abundant in the open (rivers and streams) and closed water ecosystems like ponds, floodplains, canals, beels and haors but has now been reduced dramatically. Stinging catfish inhabits freshwater and also (though rarely) brackish waters. This is mainly a fish of ponds, ditches, beels, swamps and marshes but is sometimes also found in muddy rivers. Its invigorating quality includes taste and its nutritional and medicinal values. Its muscle contains high amounts of protein, iron (226 mg/100g) and calcium. *H. fossilis* is elongated and highly compressed with maxillary barbells extending to the end of pectoral fins and mandibular pairs extended up to the base of the pelvis. Caudal fin is rounded and distinctly separated. Fin formula: D. 6-7; P1. 1/6-7; P2. 6; A. 62-70. Male has a thinner ventral line which is absent in female, (Dutta *et al.* 1993).

Spilotichthys pictus is widely distributed in the Eastern Indian Ocean and Western central pacific including the topical coasts of Australia. They are found in shallow coastal areas and coral reefs down to 80 m depth. They feed on bottom invertebrates and fishes. They have a small mouth, thick lips and chin with 6 pores without a median pit. Dorsal fin has 9 or 10 spines. The second spine is much longer than the first and it also has 21 to 26 soft rays. Scales are small and the lateral line has 82 to 117 scales. Colour is longitudinal black bands in juveniles, and spots in adults; in individuals that spot become small or indistinct, sometimes faint yellow spots on the head and body, (Giuseppe 1999).

Among these species stinging catfish and painted sweetlips are caught in high quantity and they are available throughout the year as well. Fishermen stated that these fishes have less consumer preference, are used to make dried fish and are sometimes discarded at sea. The general objective of the current study was to investigate the feasibility of incorporating local fish meal produced with Stinging catfish and Painted sweetlips fish into broiler rations. The specific objectives were to compare the growth performance of broilers under different feeding regimes with local fish meals and to study the cost-effectiveness of broiler production under different feeding regimes with local fish meals.

MATERIALS AND METHODS

Experiments were conducted at the livestock farm of the Department of Animal Science, Faculty of Agriculture, University of Jaffna, Ariviyal Nagar, Kilinochchi, Sri Lanka. Animal ethical guidelines were followed throughout the study period. Hubbard Flex day-old broiler chicks (n=99) were allotted three dietary treatments each having three replicates arranged in a Complete Randomized Design. Each replicate consisted of eleven chicks; and the three diets tested were, a diet with the local fish meal of stinging catfish (Diet 1), a diet with the local fish meal of painted sweetlips (Diet 2) and a commercial feed with the imported fish meal as the control (Diet 3). During the first fourteen days, all the chicks were fed with a commercial starter ration (ME 3400kcal/kg and CP 24%). The commercial starter ration had imported Danish fish meal in its composition. From day fifteen until the end of the experiment (42 days) chicks were allotted to each test diets (Table 1). Test diets were formulated according to the nutritional standard recommendations for broilers by NRC 1994.

Two types of local fish meals were produced from two trash fish species; stinging catfish and painted sweetlips. Fish were collected from the Pallikuda fish landing site in the Kilinochchi district of Sri Lanka. Collected fish were transported to the Jayapuram Fisheries Federation feed mill. There fish were washed thoroughly, chopped and dried in an oven at 70°C for around four and half hours until drying. Dried fish was ground with the help of an electric grinder. The ground particles were sieved and the fish meal was obtained. The fish meal was stored in a sealed polythene bag until used for feed mixing. Prior to the formulation of ration proximate analysis of local fish meals was done at the animal nutrition laboratory of the Department of Animal Science, University of Peradeniya. Proximate composition of Danish 999 (the imported fish meal mostly available in Sri Lanka) was obtained from the literature for comparison purposes. The nutrient content of other feedstuff was obtained from the NRC feeding table 1994 and the nutrient content of different diets was calculated. Analytical procedures of proximate composition determination of fish meal are summarized below:

Table 1: Percentage composition of test di ets

Ingredients (kg/100 kg)	Diet 1	Diet 2
Rice polish	12.30	12.75
Maize	50.50	50.45
Fish meal	2.50*	2.50**
Soybean meal (CP 44%)	25.20	24.8
Coconut poonac	5.00	5.00
Lys.HCl	0.05	0.05
DL-Met	0.05	0.05
Palm oil	2.10	2.20
Salt	0.25	0.25
DCP	0.30	0.20
Meat and bone meal	1.30	1.30
Coccidiostat	0.05	0.05
Allzymessf (Manufacturers: Alltech Biotechnology Corporation, Bangalore, India)	0.05	0.05
Toxin binder	0.10	0.10
Vitamin mineral premix	0.25	0.25

* stinging catfish; ** - Painted sweetlips, DCP – Di Calcium Phosphate

Dry matter determination

The clean porcelain crucibles were placed in YAMATA IC600 drying oven (YamatoScientific Co, Ltd., Japan) for one hour at 100^{O}C and placed in a desiccator until cooled. The crucibles were weighed accurately using an analytical balance. Then, 0.5-1.0g of ground sample was weighed into a crucible and placed in the YAMATO IC600 space drying oven (Yamato Scientific Co, Ltd., Japan) overnight at 105 ^{O}C. Dried samples were removed from the drying oven and placed in the desiccator until cooled. Then, the dried sample with the crucible was weighed accurately (AOAC 2005).

Dry matter % = space Sample dry weight with crucible – Crucible weight × 100 / Sample weight

Determination of gross energy

Gross energy was determined by Bomb Calorimeter (model- IKA® C 7000Calorimeter, made in German). Samples of approximately 0.5g Space removed were pelleted and weighed accurately before being ignited with oxygen. Thereafter the energy content of the sample was measured.

Determination of crude protein

Crude protein was determined by the micro Kjeldahl method. 0.25g sample was weighed and transferred into a Kjeldahl flask. Samples were analyzed in duplicates. One teaspoon of digestion mixer was added into the Kjeldahl flask and added 5ml of con.H_2SO_4. After the Kjeldahl flask was placed on the digestion apparatus (model – VELP® UDK 129) and boiled until the solution becomes clear. After the digestion flasks were removed and allowed to room temperature. Then 25ml of 4% boric acid solution was added to each series of 250ml conical flasks and placed on the distillation apparatus. 5ml of distilled water was added to each tube. Then conical flask and Kjeldahal tube were attached to the distillation unit and preheated. The distillation continued till 100 ml of boric acid and ammonia solution was obtained. A flask containing boric acid was titrated with 0.1N H_2SO_4.

% of crude protein = (burette reading * Normality of H_2SO_4 * 8.75) / (Weight of sample * dry matter %)

Crude fibre determination

1g of sample was weighed and put into a fibre extracting beaker. After that 50ml of 0.3N H_2SO_4 was added. The fibre extracting beaker was placed on fibre determination apparatus and boiled exactly for 30 minutes. Quickly as possible 25ml of 1.5N NaOH was added and boiled for another 30 minutes. 0.5g of EDTA was added and boiled for 5 minutes. Then the content was filtered into a glass filter crucible. The beaker was washed with hot distilled water and 50ml 0.3N HCl. At the end of the filtration, the crucible was placed in a drying oven overnight at 100°C. Crucible was placed in a desiccator for cooling. Crucible was placed in a muffle furnace at 520°C for four hours. The crucible was removed from the muffle furnace and allowed to cool and accurately weighed.

% of crude fibre = (sample dry weight – sample ash weight) / (weight of dry sample * dry matter) * 100

Determination of ash

The porcelain crucible was weighed and placed in a drying oven for one hour. Crucible was removed from a drying oven and placed in a desiccator. 1g space removed of dry sample was weighed and transferred into the crucible. A sample with the crucible was placed in a muffle furnace at 600°C for four hours. After four hours the sample and crucible were removed from the muffle furnace and placed in a desiccator for cooling. Then the sample was weighed accurately after the cooling.

% of Ash (dry matter basis) = (sample ash weight / sample dry weight) * 100

Determination of ether extract

Fat extracting beakers were cleaned and placed in a drying oven for one hour at 100°C. The beakers were removed from the oven and placed in a desiccator to cool. Beakers were weighed accurately after cooling. 1g Space removed of dry sample was weighed and put in the asbestos thimble. 310ml space removed of acetone was added into the fat extracting beakers which were dried and weighed earlier. The beakers were fixed to the fat extracting apparatus with the sample tube and heated for 4-5 hours with a heating point 60°C. After the extraction thimble with the extracted sample was removed and the fat extracting beakers were transferred into a vacuum oven at 80°C. Beakers were weighed again.

Crude Fat % = (weight of fat / weight of dry sample *dry matter) *100

The estimated cost of production of local fish meals was Rs.100/kg. When computing the price of test feeds, the actual purchasing prices of feed raw materials were used. The price of commercial feed was assumed as the existed retail price in the local market (year 2016).

Data collection and calculations

Initial weights of day-old chicks were recorded before introduction to pens. Daily feed intake and weekly body weights were recorded. Birds were slaughtered on day 42 and at the time of slaughtering carcass weight of three birds from each replicate was estimated. From the collected data weekly

body weight gain, weekly feed conversion ratio, and dressing percentage were calculated and the equations used were given below:
Weight gain = Final weight - Initial weight
Feed conversion Ratio = Feed intake / Live weight gain
Dressing percentage (%) =Carcass weight/ Live weight ×100
Feed costs based on the price of ingredients in 2016 and incomes generated through the sale of birds were used to perform a cost-benefit analysis. The experiment was conducted in a completely randomized design.

All the data obtained during the study were subjected to the analysis of variance (ANOVA) using SAS Statistical software package (SAS 9.1). Mean separation was done using Duncan's multiple range test.

RESULTS AND DISCUSSION

The formulated broiler ration was incorporated with 2.5% of fish meal. Samarasinghe (2007) recommended that the average inclusion level of fish meals in broiler starter and finisher rations could be 8-10% and 6-8%, respectively. However, a 5% inclusion level of fish meal is widely recommended in the literature (Idowu and Eruvbetine 2005). At high levels, it may give a fishy flavor to meat and eggs. Feeds formulated with high levels of fish meal, exceeding 20%, cause detrimental effects on the environment as they contain excess amounts of phosphorus (Ketola 1975; NRC 1981). Since test diets were formulated with an intermediate inclusion level of 2.5% of local fish meal for the current study.

The proximate composition of two local fish meals produced from stinging catfish and painted sweetlips and imported fish meal (Danish fish meal) is given in Table 2. Variation in proximate composition, in general, is attributed to the types of fish used, different processing methods employed for the fish species and pre-treatment of the fishmeal before use in rations (Ademola *et al.* 2017). The imported fish meal had a higher level of crude protein than the local fish meals and 0% of crude fibre, these two will may increase the feed efficiency of imported fish meal. Comparatively higher levels of gross energy recorded in stinging catfish could be due to the higher level of crude fat content. The other two types of fish had similar gross energy values. High crude fat content of stinging catfish might lead to rancidity during storage of fish meal or ration. This could be overcome by improved processing methods which include cooking and pressing which enables the removal of fat and the addition of antioxidants. It was reported that the gross energy of commercially available fish meal (Danish 999) and fish meal made by tuna is equivalent to Stinging catfish fish meal (Samarsinghe 2007) and Painted sweetlips fish meal (Gohl 1975). All three fish meals had a crude fibre levels of less than 4% which is the permissible limit for broilers. The two major reasons for the very high percentage of the mineral content of local fish meals could be the low flesh: bone ratio or maturity level of the local fish used for processing. Olomu and Nwachuku (1977) also reported higher levels of ash content for a local fish meals than that of the commercial fish meal.

Table 2: Proximate composition of test fish meals and imported Danish fish meal (on dry matter basis)

	Stinging catfish	Painted sweetlips	Danish fish meal (Ojewola and Annah 2006)
Dry matter %	95.61±0.09	94.55±0.05	90.32
Gross Energy kcal/g	3.336±0.057	2.717±0.054	2.614
Crude protein %	40.72±0.58	44.49±1.76	61.34
Crude fat %	15.57±0.13	4.04±0.01	6.94
Crude fibre %	2.01±0.71	1.24±0.15	0.00
Ash %	42.75±0.37	36.16±0.24	6.32

The crude protein percentage of local fish meals in the present study lies within the range reported for local fish meals in the literature (NRC 1994). Despite the crude protein content of two types of local fish meals ranging from 40-45%, it has been considered a poor quality protein source. The reasons cited in the literature were improper processing and storage and failure to adopt quality control measures during receiving of raw materials (Ravindran 1992; Ravindran and Blair 1993). According to the NRC (1994), the range of dry matter in fish meals should be between 90-94%, both formulated fish meals fulfilled the standard requirements. The dry matter content of both formulated fish meals is in agreement with the previous findings of Ademola *et al* 2017 who reported a range of 89% to 93% for imported and local fish meals.

The cost of production of fish meal was around two-thirds of the cost of commercially available imported fish meal. Olomu and Nwachuku (1977) also reported similar costs of production for local fish meals.

Calculated nutrient contents and prices of experimental diets are given in Tables 3 and 4, respectively. The nutrient compositions of test diets were calculated based on the nutrient composition tables of feed ingredients by NRC 1994, except for local fish meal where actual analytical values were used. Local fish meal incorporated diets cost around Rs 19.00 to 23.00 less than that of commercial feed per kg of feed (Table 4).

Feed Intake

Effects of dietary treatments and age of the birds on broiler performance are summarized in Tables 5 and 6 and Figures 1 and 2. Space Commercial diet recorded higher feed intake and weight gain than diets with local fish meal. Though there was no significant difference in feed intake between diet 1 and diet 2, lower weight gain was recorded for diet 1. This could be a result of inferior quality of crude protein content of diet 1 fish meal than the fish meal of diet 2. However, dietary treatments did not influence the FCR and dressing percentage (Table 5). The decline in feed intake and weight gain from the fifth to the sixth week indicated that broilers have reached the maturity stage, (Figures 1 and 2).

Gradual increase in feed intake and weight gain with the age of the birds are due to the growth of birds with time and the decline in

Table 3: Nutrient composition of test and commercial diets

Nutrient Composition	Diet 1 (calculated)	Diet 2 (calculated)	Commercial diet (starter)	Commercial diet (finisher)
Metabolizable Energy (kcal/kg)	3200	3200	3300	3200
Crude Protein %	20	20	24	18
Crude fat %	7	7	5	7
Crude Fibre %	4.5	4.5	4.5	4.5
Ca%	0.95	0.95	0.9	0.95
P%	0.38	0.38	0.42	0.38

Diet 1- Stinging catfish *(Heteropneustes fossilis)* fish meal incorporated diet
Diet 2 - Painted sweetlips *(Spilotichthys pictus)* fish meal incorporated diet
Diet 3 – Commercial diet

Table 4: Prices of commercial and test diets (Rs/kg)

Commercial broiler starter	Commercial broiler finisher	Stinging catfish fish meal incorporated diet (Diet 1)	Painted sweetlips fish meal incorporated diet (Diet 2)
90	86.40	67.30	68.10

feed intake and weight gain from the fifth to the sixth week depicts that broilers reached the maturity stage, hence reduction in feed intake and weight gain (Figures 1 and 2). These results are in agreement with the findings of May and Lott (2001) who reported that the weight gain of the bird is the highest in the later part of the growing period.

The commercial diet recorded significantly higher feed intake than the test diets; the differences could be attributed to the form of the diet (commercial diet pellet form vs. test diet mash form) and the palatability of the diets. Previous studies concluded that fish meal as an exceptionally good source of high quality protein, rich in minerals, B-vitamins, essential fatty acids and encompasses unidentified growth factors. The amino acid profile of fishmeal makes it attractive as a protein supplement. All these attributes of fish meal result in higher weight gain in broiler birds (Miles and Chapman 2006; and Ravindran$_a$ 2013).

Overall weekly weight gain along with FCR revealed, that as weight gain increases with age space removed FCR also increases but the

Table 6: Weekly average body weight gain and mean FCR of birds during the experimental period

Week	Weight gain (g/bird/day)	Mean FCR
1	17.42^{d}	1.31^{d}
2	51.42^{c}	1.35^{d}
3	66.50±4.55^{b}	1.33±0.02^{d}
4	72.30±6.33^{a}	1.69±0.11^{c}
5	71.10±7.31^{ab}	2.11±0.21^{b}
6	50.39±7.95^{c}	2.30±0.42^{a}
Overall	54.86±16.35^{c}	1.69±0.04^{c}

Means with different superscripts are significantly different (*P*<0.01).

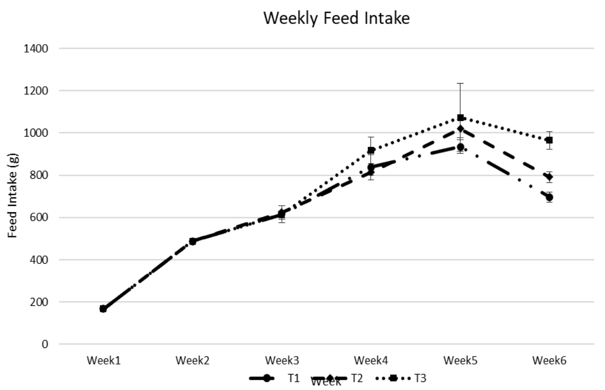

Figure 1: Change in feed intake per bird with age and treatment

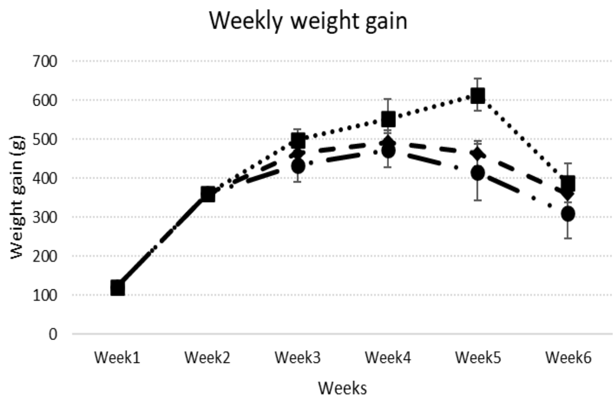

Figure 2: Changes in weight gain per bird with age and dietary treatments

Table 5. Performance of broilers fed with different test diets

Parameter	Test diets		
	Diet1	Diet 2	Diet 3
Average weight gain (g/bird/day)	50.34±1.48^{c}	53.85±2.53^{b}	60.39±2.99^{a}
Average feed intake (g/bird /day)	89.00±2.54^{b}	92.95±2.64^{b}	100.56±4.66^{a}
Average (FCR)	1.74±0.02^{a}	1.68±0.06^{a}	1.65±0.06^{a}
Average dressing %	70.95±1.33^{a}	70.00±0.58^{a}	72.15±2.40^{a}
Total feed intake (g/bird)	3738.00±106.75^{b}	3904.20±111.14^{b}	4223.50±196.05^{a}
Total weight gain (g/bird)	2129.33±89.94^{b}	2270.00±130.93^{ab}	2513.00±153.15^{a}
Survival rate (%)	88	91	96

a, b, c : Means with different superscripts within the row are significantly different (P<0.01).

FCR differences were significantly ($P<0.01$) high during the third, fourth and fifth week of the growing period (Table 6). This result infers that with an increment of age from the third week the feed utilization efficiency decreases. The current findings of increment of FCR with age are in agreement with the findings of (Onsongo *et al*. 2018). Dietary treatments did not influence the FCR. The range of FCR values for both painted sweetlips fish meal and Stinging catfish fish meal diets were in the spectrum of Australian yellow tail fish (*Seriola quinqueradiata*) and European seabass (*Dicentrarchus labrax*) (FAO 2008; Tacon and Metian 2008).

Moreover, the overall weight gain was the highest in the commercial diet (2513.00±153.15g) followed by diet 2 (2270.00±130.93g) and diet 1 (2129.33±89.94g). The results obtained in this study are in agreement with the findings of Karimi (2006) who observed an overall weight gain of 2155g with a 2.5% fish meal incorporated diet.

Cost benefit analysis

The results of the cost-benefit analysis are summarized in Table 7. The highest profit per kg of carcass weight was recorded for diet 2 while the differences between diet 1 and diet 3 were not significant. Lower profit per kg of carcass weight for diet 1 and diet 3 could be a result of higher value for FCR of diet 1 and higher feed cost of diet 3 than diet 2.

Poultry industries in the majority of the developing countries are reluctant to use fish meal in making rations due to higher cost compared to other protein sources, diminishing fish meal supplies due to depleting global fisheries (Ravindran_b 2013) Due to that there is a growing trend worldwide to feed poultry diets containing only plant material or vegetable protein diets (Hossain and Iji 2015). However, most of the research findings recommended that the effective utilization of underutilized fish species to formulate broiler ration as an alternative for the imported fish meal would be an innovative approach.

Accordingly, the present study successfully demonstrated that imported fish meal can be replaced by local fish meal produced with two different underutilized fish species.

Evaluating the feeding value of other trash fishes available island-wide, further improved techniques of processing the local fish meal, testing for amino acid profiles and testing for the presence of toxic substances in the local fish meal are the ways forward to ensure efficient utilization of local fish meal in place of imported fish meal in the poultry industry of Sri Lanka.

CONCLUSIONS

It could be concluded that poultry feed formulated with 2.5% painted sweetlips fish meal or stinging catfish fish meal can be used to feed broilers successfully as an alternative to commercial feed with imported fish meal and also is more profitable.

ACKNOWLEDGEMENT

Sincere gratitude are expressed to the University of Jaffna, Sri Lanka for the financial support, the Head/ Department of Animals Science, University of Peradeniya for allowing to conduct part of the experiment at their laboratory, fishermen along the Pallikuda fish landing site for unconditional help, and the president of Jayapuram Fisheries Federation for allowing the researchers to make use of the feed mill to prepare the fish meal and mix the mash.

Table 7: Cost benefits of birds by dietary treatments

Parameter	Diet 1	Diet 2	Diet 3
Profit per kg of carcass weight (Rs)	93.78±3.00^b	103.37±2.80^a	93.69±1.89^b
Cost of production per kg of carcass weight (Rs)	335.28 ± 4.10^b	326.64 ± 2.79^a	336.50 ± 1.89^b

Means within the same row with different superscripts are significantly different ($p < 0.01$).

AUTHOR CONTRIBUTION

JS, KS and SR designed the study. SR performed the experiment with the guidance of JS and KS. JS wrote the paper with input from KS and SAK. SAK contributed for manuscript preparation

REFERENCES

Ademola SG, Shittu MD, Owoeye TT, Ayoade TO and Akintola KA 2017 Response of Broilers to Improved and Local Fishmeal. Nigerian Journal of Animal Science, 2:132 – 139.

AOAC International, 2005 Official Methods of Analysis, 18th ed. AOAC International, Washington, DC.

Department of Animal Production and Health, Sri Lanka. 2021. Poultry sector analysis and forecast 2021. Livestock planning and economic division. Viewed 6 May 2022, <http://www.daph.gov.lk/web/images/content_image/publications/other_publications/2021/Poultry_Sector_Forecast_2021_oct.pdf.>

Department of Animal Production and Health (DAPH). 2014. Anual report-2014, Peradeniya: Department of Animal Production and Health- Sri Lanka. Viewed 15 December 2021, <http://www.daph.gov.lk/web/images/content_image/publications/annual_reports/annual_report_2014.pdf.>

Dutta HM, Adhikari S, Singh NK, Roy PK and Munshi JS 1993 Histopathological changes induced by malathion in the liver of a freshwater catfish, Heteropneustes fossilis (Bloch). Bulletin of environmental contamination and toxicology, 51:(6) 895-900.

FAO Statisctics 2008 Food and Agricultural Organization of the United Nations (FAO), Viewed 15 December 2021, <http://faostat.fao.org/.>

Fisheries Statistics 2020 Ministry of Fisheries, Maligawatta, Colombo -10. Viewed 12 May 2022, < http://www.seafdec.org/fishstat2015/.>

Giuseppe Mazza, 1999, Viewed 15 February 2016, <www.photomazza.com/?Arichthys-tomentoses-Spilotchthyspictus.>

Gohl B 1975 Tropical feeds. Tropical G. Food and Agriculture Organization of the United Nations.

Hossain MMB and Iji PA 2015 Nutritive value of vegetable protein diets for broiler chickens and selection of diets containing different vegetable or animal proteins. World's Poultry Science Journal, 71:15-25.

Idowu OMO and Eruvbetine D 2005 Performance, digestibility and carcass yield of broiler chickens fed diets containing two types of fish meal. Nigerian Journal of Animal Production, 32 (2):204-214.

Karimi A 2006 The effects of varying fishmeal inclusion levels on performance of broiler chicks. International Journal of Poultry Science, 5(3):255-258.

Ketola HG 1975 Requirement of Atlantic salmon for dietary phosphorus. Transactions of the American Fisheries Society, 104(3):548-551.

May JD and Lott BD 2001. Relating weight gain and feed: gain of male and female broilers to rearing temperature. Poultry Science, 80(5):581-584.

Miles RD and Chapman FA 2006 The benefits of fishmeal in aquaculture diets. Viewed 08 August 2022, < w w w . thefishsite.com/articles/200/the -benefits-of-fish-meal-inaquaculture-diets>

National Research Council (NRC) 1981 Nutrient requirements of coldwater fishes. National Academy Press, Washington, DC, United States.

National Research Council (NRC) 1994 Nutrient Requirements of Poultry. National Academies Press. Washington, United States.

Ojewola GS and Annah SI 2006 Nutritive and economic value of Danish fish meal, Crayfish dust meal and shrimp waste meal inclusion in broiler diets. International Journal of Poultry Science, 5(4):390-394.

Olomu JM and Nwachuku DA 1977. Nutritive value of locally prepared fish meals for broiler chickens. Nigerian Journal of Animal Production, 4(2):24 -30.

Onsongo VO, Osuga IM, Gachuiri CK, Wachira AM, Miano DM, Tanga CM, Ekesi S, Nakimbugwe D and Fiaboe KKM 2018 Insects for Income Generation Through Animal Feed: Effect of Dietary Replacement of Soybean and Fish Meal With Black Soldier Fly Meal on Broiler Growth and Economic Performance. Journal of Economic Entomology*,* 111(4): 1966 - 1973.

Ravindran V 1992 Chemical composition and energy utilization values of common Sri Lankan feedstuffs for growing pigs. Journal of the National Science Foundation of Sri Lanka, 20(1): 91-98.

Ravindran V and Blair R. 1993 Feed resources for poultry production in Asia and the Pacific. III. Animal protein sources. World's Poultry Science Journal, 49(3):219-235.

Ravindran$_a$ V 2013 Main ingredients used in poultry feed formulations. In FAO (ed.), Poultry Development Review. Rome, Italy. Viewed 8 August 2022, <http:// www.fao.org/3/a-al705e.pdf. Accessed on 08.08.2022.>

Ravindran$_b$ V 2013 Poultry feed availability and nutrition in developing countries: main ingredients used in poultry feed formulation . Poultry Development Review 2013, FAO, Rome Italy, pp 67 - 69.

Samarasinghe K 2007 Feeds and feed formulation for poultry in Sri Lanka. Department of Animal Science, Faculty of Agriculture, University of Peradeniya, Sri Lanka.

SAS Institute, 2004. SAS® Qualification Tools User's Guide. Version 9.1.2. SAS Institute Inc., Cary, NC.

Sri Lanka Customs 2019 Import data livestock sector 2019.

Tacon AG and Metian M 2008 Global overview on the use of fish meal and fish oil in industrially compounded aquafeeds: Trends and future prospects. Aquaculture, 285(1-4):146-158.