NATIONAL AGRICULTURAL AND FOOD CENTRE
RESEARCH INSTITUTE FOR ANIMAL PRODUCTION NITRA

Slovak J. Anim. Sci., 56, 2023 (2): 21–27
ISSN 1337-9984, E-ISSN 1338-0095
SCICELL

THE IMPACT OF EMPTY PEA SHELL IN FEED ON GROWTH PERFORMANCE OF COMMON CARP (*CYPRINUS CARPIO*)

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ABSTRACT

The present study was intended to assess the potential of a mature empty pea shell (*Pisum sativum*) as a feed additive to the common carp (*Cyprinus carpio*) diet. This study was conducted for 90 days with the inclusion of 15 % pea shells into the feed with one control without pea shells in common carp feed. Pea shell was used as an additive to the feed in three experimental groups (T1, T2, T3) and the control group. In the T1 group, inclusion of pea shell partially replaced the fish meal, in the T2 group – partially replaced the fish meal and de-oiled groundnut cake, in the T3 group – partially replaced the de-oiled groundnut cake and fully replaced the de-oiled mustard cake. An increase in the average weight gain was observed in the T3 group (11.17 ± 0.08) with respect to the T1 (10.89 ± 0.11) and T2 (11.05 ± 0.11) groups but lower than that of control (11.84 ± 0.09; at $p < 0.05$). In the T3 group, the specific growth rate (SGR) was significantly lower (1.04 ± 0.01) than the control (1.08 ± 0.02; at $p < 0.05$) but not significantly different with T1 (1.01 ± 0.03) and T2 (1.03 ± 0.03) groups. In the T3 group, the feed conversion ratio (FCR) was comparably higher (1.07 ± 0.01) than control (1.01 ± 0.01) but lower than T1 (1.10 ± 0.01) and T2 (1.09 ± 0.01) groups ($p < 0.05$). The study revealed that the inclusion of pea shells into fish feed can replace plant-based protein sources (mustard cake and groundnut cake).

Key words: feed conversion ratio; specific growth rate; partial replacement; pea shell; vegetable waste; *Cyprinus carpio*

INTRODUCTION

Food waste is a prevailing global issue both in developed and developing countries (Skaf *et al*., 2021). Food waste is responsible for environmental issues like the emission of greenhouse gases as well as sanitary issues (Thi *et al*., 2015; Katsarova, 2016; Scherhaufer *et al*., 2018; Tonini *et al*., 2018; Joardder and Masud, 2019). There is an urgent need to manage food waste through an integrative approach from a sustainable point of view (Thi *et al*., 2015) or turning food waste into a food additive or value-added products (Torres-Leon, 2018; Plazzota *et al*., 2020). Vegetables and fruits account for the main food waste (FAO, 2019), which mainly comprises seeds, skin, rind and pomace (Sagar *et al*., 2018). The pomace of carrot, gourd, baby corn, husk of wheat and rice, mango banana peels, pea peels and citrus pulp can be utilized in livestock feed to manage food waste (Wadhwa and Bakshi, 2013). Waste generated after the processing of legumes can be better utilized in animal feed due to greater acceptability and digestibility (de Boer *et al*., 2006; FAOSTAT, 2017). Legumes and waste generated from legumes contribute positively to nutrition with low anti-nutritional factors (Mateos-Apararicio *et al*., 2010; Mateos-Aparicio *et al*., 2012; Tassoni *et al*., 2020). Pea is an important crop grown worldwide (Klupsaite *et al*., 2015). China is the leading producer of green peas that contribute above 60 % of production followed by India with 26 % (FAOSTAT, 2017). Empty pea shells

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Received: February 9, 2023
Accepted: May 15, 2023

https://doi.org/10.36547/sjas.810

are one of the vegetable waste rich in nutritional and non-nutritional bioactive compounds that have anti-oxidant and anti-inflammatory properties supporting the well-being of an individual (Mejri *et al*., 2019; Zhang *et al*., 2020; Tassoni *et al*., 2020). Pea shells are rich in protein and dietary fibre (Wadhwa and Bakshi, 2013; Millar *et al*., 2019; Hanan *et al*., 2020) and have the potential to be utilized as both the functional foods of humans and animal feed (Wadhwa *et al*., 2006; Bakshi *et al*., 2016; Nasir *et al*., 2022; Abebe *et al*., 2022). In the present study, the inclusion of pea shells as vegetable waste into fish feed, as one of the ingredients concerning growth, partial replacements with other feed ingredients, survivability and water quality was studied.

MATERIAL AND METHODS

Common carp (*Cyprinus carpio*) was brought from the local fish farm of Bhopal. Fish were acclimatized for 15 days before the experiment. A further experiment was conducted in the Department of Zoology and Applied Aquaculture department, Barkatullah University, Bhopal in 2 m × 2 m × 1.5 m rectangular pools for 90 days with five replicas with one control. Proximate analysis of ingredients was performed according to A.O.A.C, (1990). *Chela* sp. for the preparation of the fish meal, dried prawns, de-oiled mustard cake, de-oiled ground nut cake, and peas were procured from the local market. For proximate analysis, empty pea shells were used and washed well. All the feed ingredients were properly dried in a hot air oven before turning to powder form with the help of a mixer grinder. All the ingredients were weighed by 100 g on an electronic weighing balance. Crude protein estimation was done according to the Lowry's method. Total carbohydrate estimation was done by the anthrone method. Total fat estimation was done by the solvent extraction method. For this, 2 g of pre-dried sample (W_1) were exposed to soxhlation with 150 ml of n-hexane and heated at 80 °C in a water bath for 6 hours to obtain fat content in a bottom flask, further kept in a hot air oven to remove residual n-hexane and water at 100 °C for 30 minutes. The weight of the pre-dried bottom flask (W_2) was already taken, then the weight of the flask with the sample (fat) extracted was taken as WS. The fat content was calculated as:

$$\textit{Crude fat \%} = W2 - W1 \div WS \times 100$$

The crude fibre content was estimated by boiling in both acid and basic solutions. For this, 0.128 M H_2SO_4 was used as an acid solution, 3.5 ml of H_2SO_4 solution was diluted in 500 ml of distilled water and 2 g of the sample were boiled on a hot plate stirrer for 30 minutes and filtered with a cotton cloth. After that, the filtrate was boiled in 200 ml of a NaOH basic solution (0.313 M) and filtered again. The filtrate was collected in a crucible and further kept in a hot air oven at 100 °C for 2 hours to remove water content. After that the weight of the crucible (W1) was taken. After that filtrate was subjected to incineration by keeping the crucible in a muffle furnace at 550 °C for 4 h and further cooled in a desiccator for 10 minutes and the weight of the crucible along with incinerated filtrate (ash) was taken as W2. The crude fibre content in the sample was calculated as:

$$\textit{Crude fibre \%} = W1 - W2 \div WS \times 100$$

Formulation of feed was done using the Pearson square method by considering the determined protein content of the ingredients, which were properly proportioned and calculated before mixing. Feed ingredients were properly mixed, cooked well and pelleted with the help of a hand pelletizer. Feed was administered at 8 % of the body weight of fish thrice a day. Fish growth parameters were studied in terms of body length and body weight during the initial stocking day to the harvesting after the culture period of 90 days. The growth was calculated according to the following formulae:

$$TLG = \textit{Final body length (cm)} - \textit{Initial total body lenght (cm)} \div \textit{Initial total body length (cm)} \times 100$$

$$SGR = \textit{Ln (Weight after harvesting in g)} - \textit{Ln (Weight during stocking in g)} \times 100 \div \textit{culture days(90)}$$

$$FCR = \textit{Feed given (g)} \div \textit{Weight gain (g)}$$

During the culture period water quality assessment was properly done according to the standard method of APHA (2005). Water temperature, pH, dissolved oxygen, total alkalinity and ammonia were checked after 4 days.

Data analysis

The data are presented as the mean with standard deviation and calculated using a one-way ANOVA; Tukey post-hoc HSD (beta) for pairwise comparisons for growth analysis and water quality assessment at $P < 0.05$ significance level was undertaken.

RESULTS AND DISCUSSION

There are several studies regarding the use of agricultural waste in the feedstuffs of animals to mitigate vegetable waste. Utilization of vegetable and fruit waste as the components of feeds of livestock, for the production of fish and poultry could be a better innovative approach to mitigate waste (Wadhwa and Bakshi, 2013) that comprises cauliflower, cabbage leaves, pea pods, tomato pomace, corn husk, banana, apricot and lettuce waste (Wadhwa *et al.*, 2006; Wadhwa and Bakshi, 2013). Because of the use of vegetable and fruit waste as resources of feed components in feedstuffs, this study was carried out to use dried pea shells in the feed of common carp for 90 days. Pea shells can be directly used as a functional food or can be used as an additive in foodstuff due to their good nutritional value (Kumari and Deka, 2021; Hanan *et al.*, 2020; Lu *et al.*, 2019). Protein plays an important role in terms of growth and other physiological activities (Abbasi *et al.*, 2018) and it is very important to estimate the crude protein content of feed ingredients before incorpo-rating them into feedstuff. The crude protein content of pea shells estimated was 18 to 20 % (Wadhwa *et al.*, 2017), 14.2 % (Mejri *et al.*, 2019), 14.88 % (Meenakshi, 2015) and 19.80 % (Upasana, Deepa Vinay; 2018), which nearly correlates with our study, as crude protein was estimated as 15.45 %. Proximal analysis of empty pea shell and other feed ingredients and experimental feed is depicted in Tables 1 and 2 and the amount of ingredients used for the preparation of different experimental feed is depicted in Table 3.

The use of vegetable waste in fish culture is also studied well. Dried carrot was used as a natural source of β-carotene in the feed of Koi carp (Kaur *et al.*, 2016). The utilization of sweet potato peels, banana peels, and papaya seeds was used in feed to access their impact on the growth performance of fish (Kaur and Shah, 2017). The combination of 5 % vegetable waste and 5 % fruit waste has caused high net weight gain as compared to control in *Catla catla* (Sachan *et al.*, 2016). As well in *Pangasius* sp. 5 % fruit waste in feed gained high net weight gain as compared to control in *Catla catla* (Yadav *et al.*, 2016). The partial replacement of fish meal with a mixture of vegetable protein in feed of juvenile catfish (*Clarias gariepinus*) had a positive impact on the growth (Nyina-Wamwiza *et al.*, 2010). However, several studies reported no significant impact of vegetable waste on growth per-formance as compared to control. In one of the studies, potato peels incorporated in the feed of *Oreochromis niloticus* did not cause any significant impact on SGR and FCR of fish, as compared to control

Table 1. Proximate analysis of feed ingredients

Ingredients	Proximate Analysis of Feed Ingredients (%)				
	Crude Protein (%)	Carbohydrate (%)	Fat (%)	Crude Fibre (%)	Ash (%)
Fish Meal (*Chela* Sp.)	37.67	55.04	6.75	0.05	2.02
Ground Nut Cake (de-oiled)	21.03	50.41	7.11	17.95	9.90
Mustard Cake (de-oiled)	3.016	41.82	6.92	11.95	10.07
Prawn Meal	13.29	46.45	7.13	0.04	1.07
Pea Shell	15.45	86.10	0.51	46.95	9.01

Table 2. Proximate analysis of the experimental feed with respect to different experimental groups

Experimental Groups	Proximate Analysis of Feed			
	Crude Protein (%)	Carbohydrate (%)	Crude Fibre (%)	Ash (%)
Control	27	35.34	12	5.75
T1	26	35.67	12.19	5.99
T2	26.20	36.02	12.44	6.22
T3	26.68	35.22	12.78	6.56

Table 3. Experimental feed and the amount of feed ingredients used with respect to different treatments groups and control

Ingredients	Quantity of Feed Ingredients Used and Different Treatments (T)			
	Basal Feed (Control)	T1	T2	T3
Fish Meal	44.98 %	29.98 %	37.48 %	44.98 %
Ground Nut Cake (de-oiled)	44.98 %	44.98 %	37.48 %	32.06 %
Prawn Meal	4.96 %	4.96 %	4.96 %	4.96 %
Mustard Cake (de-oiled)	2.08 %	2.08 %	2.08 %	-
Pea Shell Powder	-	15 %	15 %	15 %
Vitamin Mineral Mix	1 %	1 %	1 %	1 %
Binder Gelatin	2 %	2 %	2 %	2 %

Table 4. Water quality analysis during the culture period of 90 days

	Water Quality			
Water Temperature	24.03 ± 0.14	24.00 ± 0.73	24.31 ± 0.38	24.51 ± 0.37
Ph	7.40 ± 0.17	7.41 ± 0.20	7.44 ± 0.28	7.66 ± 0.22
Dissolved Oxygen	8.02 ± 0.60	8.02 ± 0.40	8.04 ± 0.14	8.02 ± 0.39
Total Alkalinity	164.93 ± 0.73	164.50 ± 1.03	164.40 ± 0.52	164.11 ± 0.63
Total Ammonia	0.0422 ± 0.01	0.0424 ± 0.01	0.0432 ± 0.02	0.0392 ± 0.01

Data are presented as the mean ± standard deviation.
The data are not significant at $P < 0.05$ and < 0.01 significance levels.

Table 5. Growth parameters from the day of stocking to harvesting day after 90 days with gain in SGR and FCR were accessed

	Stocking			
	Control	T1	T2	T3
Mean Weight (G)	2.71 ± 0.53	2.63 ± 0.43	2.64 ± 0.07	2.53 ± 0.41
Mean Length (cm)	4.34 ± 0.30	4.30 ± 0.31	4.26 ± 0.32	4.24 ± 0.33
Harvesting (after 90 days)				
Mean Weight (G)	11.84 ± 0.09^{a}	10.89 ± 0.11^{d}	11.05 ± 0.11^{c}	11.17 ± 0.08^{b}
Mean Length (cm)	10.58 ± 0.65^{ab}	9.58 ± 0.53^{d}	9.84 ± 0.52^{cd}	10.33 ± 0.27^{bc}
Survival (%)	98	98	98	98
Gain				
Sgr	1.08 ± 0.02^{a}	1.01 ± 0.03^{d}	1.03 ± 0.03^{cd}	1.04 ± 0.01^{bdc}
Fcr	1.01 ± 0.01^{d}	1.10 ± 0.01^{a}	1.09 ± 0.01^{b}	1.07 ± 0.01^{c}

The data are represented as the mean ± standard deviation. The data are significant at $P < 0.05$ level using Tukey post-hoc HSD (beta) test provided pairwise comparison within ANOVA data. Different letters mean significant differences, while with no superscript are not significantly different.

(El-Nadi *et al.*, 2017). The 25 % inclusion of sweet potato (*Ipomoea batatas*) peels caused the least daily weight gain, low SGR in *Oreochromis niloticus* as compared to control (Omoregie *et al.*, 2009). However in our study, 15 % inclusion of pea shells into feed with partial replacement with fish meal, ground nut cake and full replacement with mustard cake was accessed as different treatments, as depicted in Table 3. It was observed that partial replacement of pea shell with ground nut cake and full replacement of mustard cake yielded better weight gain, SGR and FCR, as compared to partial replacement with the fish meal, as depicted in Table 5. During the culture period, water quality was properly monitored and maintained to dissolved oxygen content, total alkalinity, water temperature, total ammonia and pH (APHA, 2005), as depicted in Table 4. The culture conditions were appropriate with a 98 % survivability rate.

CONCLUSION

Pea shell inclusion into fish feed did not cause significant impact on the specific growth rate in three treatments, as it remained lower compared to control. Also, the feed conversion ratio was higher in groups where fish meal was partially replaced with pea shell. Pea shell inclusion into feed can be an innovative approach towards reducing vegetable waste and the cost of feed. Pea shells can be used as a replacement for plant-based protein sources. According to our study, pea shell inclusion was not a better option to partially replace fish meal but can successfully be used to replace plant-based protein sources. There is a lack of research using pea shells as a feed ingredient in fish diets, which needs further study in this field.

ACKNOWLEDGEMENT

The authors are thankful to the Head of the Department of Applied Aquaculture department, Barkatullah university for his consistent guidance for carrying out the research.

AUTHOR CONTRIBUTIONS

Conceptualization: Gagandeep, K., Rekha, S.
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Investigation: Gagandeep, K., Rekha, S., Vipin, V.
Writing-original draft preparation: Gagandeep, K.
Writing-review and editing: Gagandeep, K.
Project administration: Gagandeep, K., Rekha, S.

All authors have read and agreed to the published version of the manuscript.

INFORMED CONSENT STATEMENT

Not applicable.

DATA AVAILABILITY STATEMENT

The data presented in this study are available on request from the corresponding author.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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