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Physical Characteristics of Indigofera-based Feed and Its Application on *Sinyonya carp*. (*Cyprinus carpio*)

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Abstract

The aquaculture industry faces significant challenges related to the availability and cost of feed ingredients because Feed allocation accounts for 70-80% of aquaculture production costs. Efforts to reduce feed costs can be made by seeking alternative feed ingredients such as local plants, agricultural waste, and other plant-based materials. Indigofera is a plant-based ingredient that has good nutritional content, making it a potential feed ingredient for fish. The use of plant-based materials like Indigofera can be a solution to reduce production costs and utilize abundant local resources. This study aims to examine the physical characteristics of Indigofera-based feed and its application in the cultivation of Sinyonya carp (*Cyprinus carpio*). The research was conducted using a completely randomized design with 5 treatments and 3 replications. The parameters observed were the physical tests of fish feed, including buoyancy, hardness, and disintegration rate, as well as the absolute growth, specific growth rate, and survival rate of Sinyonya carp. The results showed that the physical characteristics of Indigofera-based feed indicated good feed quality. There were no significant differences in the parameters of buoyancy, hardness, and disintegration rate of the fish feed. The application of Indigofera-based feed had a significant effect on the absolute growth and daily growth rate of Sinyonya carp but did not have a significant effect on their survival rate. Treatment D was the best treatment, showing the highest absolute growth and daily growth rate. Therefore, Indigofera-based feed supplementation can be used for the cultivation of Sinyonya carp.

Keywords: Physical Characteristics, Indigofera-based Feed, *Sinyonya carp*.

INTRODUCTION

The aquaculture industry plays a crucial role in meeting the global demand for fish products, but it faces significant challenges related to the availability and cost of feed ingredients. Feed allocation accounts for approximately 70-80% of total production costs, making it one of the largest expenses in aquaculture systems (Suprayudi, 2010). As the demand for fish increases, the need for more sustainable and cost-effective feed alternatives has become urgent. This issue is particularly relevant for small-scale and commercial aquaculture operations where optimizing feed efficiency can greatly impact economic viability. Plant-based ingredients, such as Indigofera, have emerged as promising alternatives to traditional fish meal, because of their nutritional content, abundance, and environmental benefits (Hossain *et al*., 2021).

Recent studies have explored the potential of plant-based feed ingredients to reduce production costs while utilizing locally available resources. Among these, Indigofera has gained attention due to its high protein content and favorable nutrient profile for fish. However, while many studies have focused on the chemical and nutritional aspects of plant-based feed, there has been limited research into the physical characteristics of such feeds,

which are critical to ensuring that the feed is utilized efficiently by the fish. The physical form of the feed—such as buoyancy, hardness, and disintegration rate—affects not only the ease with which the fish can consume the feed but also its water stability and overall feed intake (Murtidjo., 2001). The development of fish feeds with optimal physical properties can, therefore, enhance feed efficiency, leading to better growth performance and reduced feed wastage.

The primary research problem addressed in this study is the lack of data on the physical quality of Indigofera-based fish feed. While there is growing evidence of its nutritional benefits, little is known about how physical characteristics such as buoyancy, hardness, and disintegration rate impact the performance of fish, particularly in high-value species like Sinyonya carp (*Cyprinus carpio*). Understanding these physical properties is essential for optimizing feed application and improving overall fish health and growth. The general solution to this problem is to evaluate the physical characteristics of Indigofera-based feeds and assess their impact on the growth performance and survival of Sinyonya carp.

Previous studies have demonstrated that physical quality can significantly influence feed consumption and utilization in aquaculture. In particular, the buoyancy of feed affects its availability to different species, depending on whether the fish are surface feeders, mid-water feeders, or bottom feeders. Hardness and disintegration rate are also important because they determine how long the feed remains intact in water, preventing nutrient loss and improving water quality. Studies on other plant-based feeds have suggested that optimizing these physical properties can lead to better feed efficiency and growth performance in fish (Krisnan *et al*., 2009).

The objective of this study is to investigate the physical characteristics of Indigofera-based fish feed—specifically its buoyancy, hardness, and disintegration rate—and evaluate its effects on the absolute growth rate, specific growth rate, and survival rate of Sinyonya carp. the study wants to provide a comprehensive understanding of the suitability of Indigofera as a fish feed ingredient, both in terms of its physical properties and its impact on fish growth. This research will contribute to the ongoing efforts to develop cost-effective and environmentally sustainable feeds in aquaculture, offering a novel solution to reduce feed production costs while maintaining fish health and productivity. The scope of the study includes both the evaluation of feed quality and the subsequent application of the feed in a controlled aquaculture setting, where Sinyonya carp will be monitored for 45 days to assess their growth and survival.

METHOD

This research was conducted over 45 days, from May to July 2024, at the Aquaculture Laboratory, Fisheries Science Study Program, Faculty of Agriculture, Universitas Sultan Ageng Tirtayasa, Indonesia

Tools and Materials

The equipment used in this study included research containers in the form of aquariums, a heater, top filters, an analytical balance, a pellet machine, 3 mm mesh sieves, an oven, a pH meter, a DO meter, and a thermometer. The materials used were fish feed, anesthetic, raw materials for making feed, and Indigofera leaf meal.

Experimental Method

The study was designed using an experimental method in the form of a completely randomized design (CRD), consisting of five treatments and three replications. The treatments of the five Indigofera zollingeriana levels were as follows:

TDI 0: 0% Indigofera content (control);

TDI 25: 25% Indigofera content;

TDI 50: 50% Indigofera content;

TDI 75: 75% Indigofera content;

TDI 100: 100% Indigofera content.

Feed Preparation

The test feed used was a formulated feed with iso-protein content (±30%). The process began by weighing the raw materials according to the formulation of each treatment. The ingredients were mixed gradually, starting with the smallest amounts and proceeding to the largest, ensuring a uniform or homogeneous mixture. The raw materials were then ground and passed through a pellet machine with a 3 mm mesh sieve. The pellets were heated in an oven at 50°C for 8 hours.

Physical Test of Fish Feed

Physical test (feed resistance in water and feed buoyancy). The Disintegration rate in water is calculated based on the length of time the feed is destroyed after being put into the water. The hardness calculated by dropping a weight on the pipe that was filled with feed and then counting a pellet that broken and still good while the buoyancy of the feed is done by dropping the pellet into the water in a container (20cm high) followed by counting the time for the feed to touch the water until it sinks (Handajani & Widodo 2010).

Container Preparation and Fish Maintenance

The containers used in this study were 15 aquariums, each measuring 60 × 40 × 40 cm^3. The tops of the aquariums were covered with black plastic to prevent stress in the test fish. Before being given the test feed for each treatment, the fish were acclimated for approximately 7 days. After acclimatization, the fish were weighed and measured for length as baseline data. They were then placed into the maintenance containers, each holding 48 L of water, with a stocking density of 1 fish per 2 liters. Each aquarium contained 10 Sinyonya carp.

Sinyonya carp with an initial weight of around 3.5-5.5 g were obtained from the Bukit Sinyonya cultivation facility. Before being raised for 45 days, the fish underwent a 3-day acclimatization period. During acclimatization, the fish were kept in a holding pond with a 24-hour aeration system. After the 3-day acclimatization, the fish were transferred to 15 maintenance aquariums, each measuring 60 × 40 × 40 cm^3. Each aquarium housed 10 Sinyonya carp. The test feed was provided three times daily at 08:00, 12:00, and 17:00 WIB, in quantities sufficient to meet the fish's satiation needs. Every 15 days during the maintenance period, sampling was conducted to measure the fish's length and weight gain. Before sampling, the fish were fasted and anesthetized to facilitate data collection and minimize stress. The water quality in the maintenance tanks was kept at optimal conditions for Sinyonya carp culture using a heater and top filter. Water quality indicators monitored during the rearing period included temperature, pH, and dissolved oxygen. Throughout the maintenance period, water quality was closely monitored to ensure it remained within acceptable ranges for Sinyonya carp cultivation.

Data Collection

After 45 days, the fish were fasted for 24 hours before data collection. The data collected included absolute weight, specific growth rate, feed conversion ratio, fish survival rate.

Data Analysis

The collected data will be presented in tables and graphs and analyzed using analysis of variance (ANOVA) with a 95% confidence interval. If significant differences are found between treatments ($P<0.05$), further analysis will be conducted using Duncan's post hoc test, with SPSS Ver. 22 software.

RESULTS AND DISCUSSION

According to table 1, The analysis of the physical characteristics of Indigofera-based feed formulations (TDI 0, TDI 25, TDI 50, TDI 75, and TDI 100) showed no significant differences across the tested parameters of buoyancy, hardness, and disintegration rate.

Buoyancy results were consistent across all formulations, with values ranging from 435.66 to 448.31 minutes, indicating stable floating properties regardless of the Indigofera concentration. Similarly, hardness percentages remained comparable, with all treatments recording values between 83.66% and 86%, showing that Indigofera inclusion did not impact feed pellet hardness. The disintegration rate, which measures feed stability in water, also showed no significant variation, with times ranging from 20.33 to 22.33 minutes. These findings suggest that Indigofera can be incorporated at varying levels in fish feed without negatively affecting the physical quality of the pellets, maintaining their structural integrity and floating time .

The findings of this study are consistent with previous research on the physical quality of plant-based fish feeds. Similar studies, such as those by have demonstrated that alternative protein sources like Indigofera can be incorporated into aquafeeds without significantly altering key physical properties such as buoyancy, hardness, and disintegration rate. For instance, Wu *et al.* (2021) found that the inclusion of plant proteins and animal protein at various levels did not significantly affect feed pellet hardness or buoyancy, aligning with the results observed in this study.

The advantage of the current research lies in the use of Indigofera, which offers a sustainable, plant-based alternative to conventional protein sources without compromising the physical quality of the feed. The non-significant differences in the buoyancy, hardness, and disintegration rate across all Indigofera concentrations suggest that it can be integrated into aquaculture diets without negatively impacting feed performance. This consistency in physical properties, regardless of Indigofera concentration, contrasts with some other plant-based feeds that may degrade more quickly in water or become overly hard. This supports the potential for Indigofera-based feeds to be a viable option in commercial carp farming.

Table 1. Effects of Different Concentration of Indigofera on Physical Quality of Pelleted Feed

Parameter	TDI (0)	TDI (25)	TDI (50)	TDI (75)	TDI (100)
Bouancy (minute)	439.3±9.29[a]	435.66±7.2[a]	437.66±10.69[a]	448.31±7.24[a]	445±13[a]
Hardness (%)	84.66±1.53[a]	86±2.65[a]	85±4.00[a]	84±2.00[a]	83.66±2.08[a]
Disintegration rate (minute)	20.33±0.58[a]	21.33±2.08[a]	22.33±2.31[a]	20.66±2.08[a]	22±2.65[a]

The effect of Indigofera-based feed on the growth performance of Sinyonya carp (*Cyprinus carpio*) was evident in the results for absolute growth rate and specific growth rate (SGR). Among the different treatments, TDI 75 (75% Indigofera) showed a significant increase in both growth parameters compared to other formulations. The absolute growth rate

for TDI 75 was 4.04 ± 0.48 g, which was significantly higher than the other treatments, such as TDI 0 (3.15 ± 0.30 g) and TDI 25 (2.94 ± 0.13 g). Similarly, the specific growth rate for TDI 75 was 0.090 ± 0.01%, significantly outperforming the other groups, which had SGR values ranging from 0.065% to 0.073%.

Table 2. Effects of Different Concentration of Indigofera on Growth Parameters of *Sinyonya carp*.

Parameters	Treatment				
	TDI (0)	TDI (25)	TDI (50)	TDI (75)	TDI (100)
Absolute growth rate (g)	3.15±0.30[a]	2.94±0.13[a]	3.27±0.14[a]	4.04±0.48[b]	3.29±0.06[a]
SGR(%)	0.07±0.07[a]	0.065±0.03[a]	0.073±0.03[a]	0.090±0.01[b]	0.073±0.01[b]
SR (%)	93.3±5.77[a]	96.66±3,08[a]	96.66±3,08[a]	100 ±0.00a	96.66 5.77a

Despite these positive growth trends, the survival rate (SR) across all treatments showed no significant differences, with all values ranging from 93.3% to 100%, indicating that the varying levels of Indigofera did not negatively impact the survival of Sinyonya carp. This suggests that while the TDI 75 formulation was optimal for promoting growth, all formulations were equally effective in supporting fish survival .

The results of this study align with prior research on the use of plant-based feeds in aquaculture. Studies such as Rai *et al*. (2021) have shown dietary wheat gluten meal, when optimally balanced, can promote growth in shrimp (*Litopenaeus vannamei*). The significant improvement in the absolute growth rate and specific growth rate (SGR) observed with the TDI 75 formulation mirrors findings from similar studies, where partial replacement of fishmeal with plant-based ingredients improved growth performance due to the adequate provision of essential nutrients, particularly proteins and amino acids. For instance, research by Xu *et al*. (2022) demonstrated that inclusion of a moderate coton seed into feed fish can show similar growth rate compared with fish that feed with fish meal, but high concentrations of cotton seed can decrease the growth rate of shrimp (*Litopenaeus vannamei*) .

However, the non-significant difference in survival rate across all Indigofera treatments is consistent with literature that suggests plant-based proteins do not negatively impact fish health or mortality, as long as the feed is nutritionally balanced. Other studies also point out that high fiber content in certain plant ingredients may reduce feed palatability or digestibility at higher concentrations, but this effect was not observed in this study, indicating that Indigofera-based feeds can support both growth and survival when appropriately formulated.

CONCLUSION

The results of this study demonstrate that Indigofera-based feed has a significant effect on the growth performance of Sinyonya carp (*Cyprinus carpio*). Among the various treatments, the TDI 75 formulation, containing 75% Indigofera, showed the highest increase in both absolute growth rate and specific growth rate, outperforming other formulations. This indicates that incorporating Indigofera at this level provides an optimal balance of nutrients that promotes growth in Sinyonya carp. However, no significant differences were observed in the survival rate across all treatments, suggesting that Indigofera-based feed does not negatively impact fish mortality when used as a protein source.

The physical qualities of the feed, including buoyancy, hardness, and disintegration rate, were consistent across different Indigofera concentrations, confirming that increasing levels of Indigofera do not compromise the feed's physical integrity. These findings support the potential of Indigofera as a sustainable alternative protein source in aquaculture feeds. Further research is recommended to refine the formulation and explore the long-term effects on fish health and productivity, as well as its application in other aquaculture species.

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