Nutritional Value of Fish Feed for Small-Scale Aquaculture Farmers in Bobasi Sub-County, Kisii County, Kenya

Abstract

A study was carried out to assess the nutritional value of fish feed used by small-scale aquaculture farmers in Bobasi Sub-County, Kisii County, Kenya between January and December 2019. Nine samples of fish feeds were collected randomly from fish farmers and commercial feed traders from the study area and their proximate analysis was carried out at the Kenya Marine Fisheries and Research Institute, Sangoro station, Kenya to assess their nutritional value. The results indicated that the crude protein (CP) content was in the range of 29 - 57.2 % & 14.7 - 15.2 %, ash 6.6 - 14.1% & 7.6 - 8.3%, lipid 2 - 11.2 % & 2.6 - 3.1%, fibre 0 - 5.6% & 4.2 - 10.3%, moisture 8.7 - 13.5% & 8.9 - 11.7% and nitrogen-free extract content 7.5 - 43.3% and 50 - 57.3% in commercial and farmer formulated feeds respectively. The results demonstrated that most commercial feeds had more protein content for fish growth compared to farmers' locally formulated feeds. They also showed that feeds that had lesser CP levels had more nitrogen-free extract content which would result in reduced growth rates and consequently affect the fish yields.

Keywords: fish feeds, proximate analysis, small-scale farmers, Kenya

1. Introduction

The world faces a growing population, compounded by climate change and food insecurity. This is expected to significantly increase the demand for animal protein (FAO, 2018). Aquaculture, the fastest growing food production sector globally (Omasaki et al., 2016; 2017;

FAO, 2020), offers a sustainable solution. Nile tilapia (*Oreochromis niloticus*) stands out for its fast growth, disease resistance, and high survival rate (Omasaki et al., 2017). However, to achieve its production increase, enhancing efficiency and environmental sustainability is paramount.

High-quality fish feed, formulated with the right ingredients, is crucial for both production and environmental impact. Feed costs account for a significant portion (40-50%) of aquaculture expenses (Craig & Helfrich, 2009; Omasaki et al., 2016; 2017). However, obtaining the right mix of nutrients in affordable feed price is a major challenge for small-scale farmers (Craig & Helfrich, 2009). Extensive research has been conducted to compare feed nutritional components of different feeds and their impact on fish productivity (Bhujel et al., 2001; Bureau et al., 2009; Mahmud et al., 2012; Muin et al., 2018; Mmanda et al., 2020). These studies highlight the importance of adequate protein content in fish feed for optimal growth and development.

Across Africa, knowledge of fish feeding and management techniques is limited (Shoko, 2011). While research explores alternative protein sources, most small-scale farmers struggle to afford commercially produced feed (Bureau et al., 2009, Munguti et al., 2014; Omasaki et al., 2017). This often leads to either using expensive commercially produced feeds or less nutritious locally formulated alternatives (Mmanda et al., 2020). However, a major challenge exists; commercially produced feeds, often with higher protein content, are too expensive for most resource-limited small-scale farmers (Bureau et al., 2009; Munguti et al., 2014; Mmanda et al., 2020). While research on cheaper protein alternatives is ongoing, these farmers are currently caught between using expensive commercially produced options or less nutritious locally formulated alternatives.

Despite government efforts, Kenyan aquaculture remains underdeveloped, contributing only to 2% of the country's fish production (Omasaki et al., 2016). Nile tilapia and African catfish farming in small-scale earthen ponds are the main fish species reared in Kenya (Omasaki et al., 2017). Availability, accessibility, and quality of fish feed are the major challenges (KMFRI, 2017; Musa et al., 2021). Distance makes access difficult, and the cost of low-quality feed is further inflated by a lack of skilled personnel in formulating affordable and environmentally friendly feeds.

This study aimed at assessing the nutritional value of fish feed used by small-scale aquaculture farmers in Bobasi Sub-County, Kisii County, Kenya. By assessing the current feed's nutritional value, we can identify shortcomings and flag the way for improvements in formulation or sourcing practices of the feeds. This can lead to improved productivity and overall success for these small scale farmers.

2. Materials and methods

2.1. Study area

The study took place in Bobasi Sub-county region of Kisii County, Kenya. The region is found in an area of altitude between 1500 - 1800m above sea level and between latitude 0 30‘and 1 0‘South and longitude 34 38‘and 35 0‘East and experiences heavy rainfall of about 1922 mm and an average temperature of 19.6 C.

2.2. Sample collection

Nine samples of fish feeds were collected randomly from fish farmers and commercial feed dealers from the study area. These feeds were grouped into two categories: starter feeds and grower feeds. Farmers provided four locally formulated feeds: two starter feeds (C and D) and two grower feeds (H and I) while commercial dealers provided five feeds: two starter feeds (A and B) and three growers feeds (E, F, and G). Triplicate 100g samples were then collected from each of the 9 samples, making a total of 29 samples. The samples were then stored using airtight 150g plastic containers and their proximate analysis carried out at the Kenya Marine and Fisheries Research Institute, Sangoro station, Kenya. The following methods were used to analyse the different aspects of the fish feeds collected:

Crude protein

Crude protein (CP) was determined using the Kjeldahl method which constitutes of three steps: digestion, distillation, and titration (Saha et al., 2012), and the CP (%) was determined as:

$$\text{Nitrogen Content (\%)} = 100\left(\frac{A \times B \times 0.014}{C(g)}\right) \qquad \textit{Equation 1}$$

Where A is the hydrochloric acid used in titration (ml), B is the normality of standard acid, C is the weight of the sample (g) and CP (%) is nitrogen in sample × 6.25.

Determination of ash content

Ash content was determined by measuring the inorganic residue left after either ignition or complete oxidation of organic matter in the fish feed samples (Ismail, 2017). Triplicate samples of 2 gm feeds were placed in pre-weighed porcelain dishes and charred on a hotplate for 1 hour, thereafter transferred and pounded to ash in a muffle furnace at 600^{0}C for 6 hours. The samples were transferred to a desiccator and allowed to cool to room temperature before weighing. The percentage of ash was determined as:

$$\text{Ash Content (\%)} = 100\left(\frac{A-B}{C}\right) \qquad \textit{Equation 2}$$

Where A is the weight of the crucible with ash sample (g), B is the weight of the empty crucible (g) and C is the weight of the sample (g).

Crude Lipid determination

Crude lipid was determined using the Soxhlet extraction method (Słomińska et al., 2012). The % ether extract was estimated as follows:

$$\text{Crude Lipid Content (\%)} = 100\left(\frac{B-A}{C}\right)$$ *Equation 3*

Where A is the weight of a clean dry flask (g), B is the weight of a flask with fat (g) and C is the weight of the sample used (g).

Crude fibre determination

The crude fibre was determined as the fraction remaining after digestion with standard solutions of sulphuric acid and sodium hydroxide. The crude fibre was determined as follows:

$$\text{Crude Fiber Content (\%)} = 100\left(\frac{A-B}{C}\right)$$ *Equation 4*

Where A is the weight of crucible with dry residue (g), B is the weight of crucible with ash residue (g) and C is the weight of the sample (g).

Determination of nitrogen-free extracts (NFE)

The Nitrogen-free content was calculated as indicated below:

$$\text{Nitrogen-free extract (\%)} = 100 - (A + B + C + D + E)$$ *Equation 5*

Where A is the moisture content (%), B is the CP content (%), C is the crude lipid content (%), D is the crude fibre content (%) and E is the ash content (%).

The collected samples included both processed and unprocessed fish feeds that are commonly used by the fish farmers in the Sub- County.

3. Results

3.1. Proximate analysis of the fish feeds

The CP content of the fish feeds used by farmers ranged from 14.7 - 57.2% with a mean of 30.32 ± 16.08 standard deviation (Table 1). Feed H had the lowest CP content (14.7%), while feed A had the highest CP content (57.2%). Generally, feeds from the farmers had lower CP content compared to those supplied by the commercial dealers. The ash content in the feeds formulated by fish farmers ranged from 6.6 - 14.1% with a mean of 9.30 ± 2.69. Unlike the CP content, the feeds with the lowest (E) and highest (C) crude ash content were all from the commercial dealers.

Table 1: The proximate analysis results of fish feeds in Bobasi Sub-County, Kenya

Feed components Tested	***Fish Feeds***								
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Crude Protein (%)	57.2	55.2	14.9	26.7	29	29.1	30.9	14.7	15.2
Ash Content (%)	13.6	14.1	7.8	7.6	6.6	8.8	9.2	8.3	7.7
Lipid content (%)	11.2	9.7	2.8	2.6	2	4.5	4.5	2.8	3.1
Fibre Content (%)	0	0	7.3	4.2	3.2	5.6	5.2	10.3	6.9
Moisture Content (%)	9.3	13.5	9.9	8.9	10.2	8.7	8.6	11.7	9.9
Nitrogen Free Extract (%)	8.7	7.5	57.3	50	49	43.3	41.6	52.2	57.2

[a]A & B are the starter feeds from commercial dealers in the study area; C & D are the starter feeds from the fish farmers; E, F & G are grower fish feeds from commercial fish farmers; H & I, are grower fish feeds from the fish farmers.

Feeds provided by commercial dealers had generally higher ash content than the feeds from farmers. The crude lipid content in the feeds formulated by fish farmers ranged from 2 - 11.2% with a mean of 4.80 ±3.33. The feeds with the lowest (Feed E) and highest (Feed A) crude lipid content were also from the commercial dealers. The fibre content in the feeds formulated by fish farmers ranged from 0 - 10.3% with a mean of 4.74 ± 3.37. Unlike all the other feeds, feed A and B, had 0% fibre content. Feed H, had the highest level of fibre content. Generally, feeds made by farmers had higher levels of fibre content (4.2 - 10.3%) than those provided by commercial dealers (0% - 5.6%).

The nitrogen-free extract content of the feeds provided by both commercial dealers and farmers ranged from 7.5% - 57.3%, with a mean of 40.76 ± 19.27. The moisture content of feeds provided by both commercial dealers and farmers ranged from 8.6 - 13.5%, with a mean of 10.8 ± 1.06.

4. Discussion

4.1. Proximate analysis results of the fish feeds

Crude protein content

The results from this study indicate that the feeds formulated by farmers had very little CP content compared to commercial feeds. The fish CP content required percentage for optimal growth for larvae is between 45-50%, 35-40% for fry and 28-30% for fingerlings (Hasan & New, 2013). Studies have shown that the use of fish feeds with higher or lower CP than the recommended content negatively impacts aquaculture production by adversely affecting the overall food conversion rates (FCR) of the farm. Low protein levels lead to heightened FCR, which subsequently leads to reduced growth rates and fish size thus translating to losses. Feeding fish with excess CP has adverse implications on the Protein Efficiency Ratio (PER), the Protein Growth Rate (PGR), and Protein Productive Value (PPV) in fish. For instance, excessive CP content leads to lowered PER and PPV in any given fish size, affects water quality and finally the production cost. Protein in fish feeds is the most expensive ingredient thus having fish feeds that have more than the required CP levels would increase feed costs (Ahmad et al., 2004; Craig & Helfrich, 2009). In this study, the low CP levels in the locally formulated feeds could be attributed to the high cost of purchasing the raw materials coupled together with the high number of unskilled personnel who engage in the feed formulations. On the other hand, commercial feeds have high levels of CP content thus subsequently making these feeds very expensive.

Crude ash content

The recommended crude ash content for fish feeds ranges from 7%- 12% (Chapman & Miles, 2020). The feeds that exceeded the recommended ash content levels in this study were (A, B), all from commercial dealers. Feed E from the commercial dealers was also below the recommended range. The crude ash contents of all the feeds formulated by farmers were within the recommended range. Ash content represents the mineral component of the fish feed and is solely responsible for the supplementary minerals including potassium, phosphorus, copper, and zinc made available to fish. High levels of ash content alongside the fibre content in fish could result in issues of digestibility which would lead to poor growth in fish. The levels of ash content being as recommended or below isn't as alarming compared to other elements of the feeds since fish can acquire the said minerals from natural food present in the water as most farmers in the region practised semi-intensive aquaculture.

Crude lipid content

The recommended crude lipid content for fish feeds ranges from 6% -15% (Chapman & Miles, 2020). In this study, the crude lipid content of feeds made by farmers was below the recommended range. The only feeds with crude lipid content falling within the recommended range for fish were A and B. Both starter feeds were obtained from commercial dealers, hence most of the feeds (3) which did not meet the recommended levels were from commercial dealers. Extremely low polyunsaturated fats (PUFA) levels in fish feeds could not only result in the dwindling of the fish's health but also the nutrition value. Extremely high levels of lipids in the diet could result in more fat in the fish which would affect the value of the fish generally. Dietary lipid levels also affect the muscle and liver strength in fish (Kim et al., 2012). The low amounts of lipids in the fish feeds in this study could be attributed to the source of lipids in this case plant. Plant sources might have significantly lowered omega 3 and omega 6 fatty acids thus resulting in lower lipid levels in the formulated diets. The use of integrated fish farming could be a solution in ensuring that the fish get more PUFA's since the product provides for the use of variant sources of dietary inputs and thus could be an alternative for low-level fish farmers (Nederlof et al., 2019).

Fibre content

In this study, all the feeds made by farmers (C, Hand I) had fibre content higher than the recommended range of 3% -5% (Chapman & Miles, 2020). The only feeds with fibre content falling within the recommended range for fish were a starter feed made by farmers (D) and a commercial grower feed (E). Hence all except Feed E provided by commercial dealers had fibre content outside the recommended range required for aquaculture. Too high fibre level may reduce the apparent digestibility of dry matter, weight gain, specific growth rate, whole body lipid, protein and the efficiency ratio of other nutrients.

Nitrogen free extract

In Table 1 above, starter feeds (A and B) had a Nitrogen Free Extract (NFE) that was way below the required range of 20 - 45%. All the farmers' feeds had an NFE of above the range. Feed D provided by commercial dealers had a NFE falling outside the range while feed E and F provided by the dealers had an NFE within the range. High levels of NFE in fish feeds is not recommended, fish use only 20% of carbohydrates (NFE) provided in their diet (Craig & Helfrich, 2009). This is because fish do not efficiently utilise carbohydrates as mammals do, thus the excess carbohydrates are stored up as glycogen in the fish's body. High levels of NFE in fish feeds would therefore result in decreased specific growth rates and higher FCR.

Moisture content

Fish feeds usually have a moisture content of 8% - 10% (Terpstra, 2015) hence the moisture content of fish feeds made by farmers approximately fell within this range, while the moisture content of feed B provided by the commercial dealers fell outside the range. In conclusion, the moisture content of almost all the feeds except one fell within the recommended range.

5. Conclusion and Recommendations

Most of the fish feeds tested indicated that fish feeds accessible to farmers in the region were not of the recommended quality. Most feeds formulated by commercial dealers had a relatively higher amount of crude protein. This could have a huge implication: first on the feed price due to high price of protein which would lead farmers into making relatively lower profits if any, and secondly a threat to the water quality in the culture areas due to accumulation of crude protein. Feeds formulated by farmers were found to have low levels of crude protein and very high levels of nitrogen-free extract and this would impact on the size and quality of fish produced in the region. This is indicative of a gap in extension services on matters fish feeds in the area. The need for farmer training on fish feed formulation and selection is evident since some of the farmers had shown initiative to formulate their fish feeds. Thus training farmers on the recommended quantities of each element would go a long way in ensuring that the said farmers have access to the sought-after fish feeds.

The utilization of low-quality feeds and poor feeding practices in the Sub-county adversely affect the output of the aquaculture sector. Availability of quality feeds at more affordable prices or presentation and capacity building on feed alternatives such as the use of sweet potato tubers would help in improving aquaculture output and thus improving the yield and output of farmers.

The socio-economic effects of accessing fish feeds in the area are also factors that should be considered. Farmers who opt to buy feed incur expenses in travelling; the distance travelled translates to time spent not to mention the risks associated with traveling. These aspects increase production and pose travel-related risks to the fish farmers.

The establishment of a fish feed manufacturing centre within each ward would play a critical role in ensuring that fish feeds were accessible to farmers as there is an already present market for fish feeds in the region. Capacity building in fish feed formulation is also crucial in the area as it will see to the impartment of relevant technical know-how to fish farmers in the region. A survey to determine the number of extension officers trained on fish feeds in the country would also aid in accessing the skill gap and ensuring that targeted training is carried out. The fish farmers' know-how of fish feeds and feeding of fish should also be re-evaluated.

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