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Research Application Summary

Small Scale Fish Farming in Liberia: Accessibility and biochemical profiling of local feed ingredients

Hinneh, M.K.,[1*] Liti, M. D.,[1] Matolla, G.[2] & Mawundu, S.[1]

[1]School of Environment and Fisheries, University of Eldoret, P. O. Box 1125-30100 Eldoret, Kenya
[2]School of Economics and Social Sciences, University of Eldoret, P. O. Box 1125-30100 Eldoret, Kenya
***Corresponding Author:** mandelahinneh@gmail.com

Abstract

Depletion of marine fish stocks and need for global food security have fueled rapid growth of aquaculture systems. The sector is considered one of the fastest growing, such that in a span of 15 years from the year 2000, it had grown from 41,724,569.75 metric tons to 106,004,183.75 metric tons which is a whopping 154% growth. Despite such growth record, Africa as a continent only contributes 2% to the global yield. The limited adoption of aquaculture in the continent and poor productivity particularly in sub-Saharan Africa (SSA) is underscored by several factors including; lack of poliy framework, weak supportive structures and infrastructures, inadequate management information and skills and poor quality feeds used by farmers. Therefore, this study was carried out to identify and map out the quality of the feeds adopted by Nile Tilapia farmers and their consequent on the yield in the six landlocked counties of Liberia: Bong, Lofa, Nimba, River Gee, Gbapolu, and Grande Gedeh. The study utilized multi-stage sampling, focus group discussions and feed sample collections which were subjected to nutrient proximate analysis. The findings indicate that gender plays a significant role in the management of the aquaculture systems and hence the whole farmed Nile Tilapia value chain. It was found that 82.6% of the ladies occupied the most labor demanding roles in production, however, 75.3% of the men owned the systems and dominated decision making regarding feed selection. Pond system of production has been adopted by 91% of the farmers. However, management practices employed did not provide conducive environment required for fish optimal production. Maize bran, wheat bran and soya cakes and other locally formulated feeds are the main feed sources used. The findings points out to inadequate feeding regimes practised by the farmers and poor management practices.

Keywords: Aquaculture, fish farming, Liberia, local feeds, Nile Tilapia

Résumé

L'épuisement des stocks de poissons marins et le besoin de sécurité alimentaire mondiale ont alimenté la croissance rapide des systèmes aquacoles. Le secteur est considéré comme l'un des plus dynamiques, de sorte qu'en 15 ans à partir de l'an 2000, il est passé de 41.724.569,75 tonnes métriques à 106.004.183,75 tonnes métriques, soit une croissance énorme de 154 %. Malgré un tel record de croissance, l'Afrique en tant que continent ne contribue que pour 2% au rendement mondial. L'adoption limitée de l'aquaculture sur le continent et la faible productivité, en particulier en Afrique subsaharienne (ASS), sont soulignées par plusieurs facteurs, notamment : le manque de cadre politique, les faibles structures et infrastructures de soutien, les informations et compétences de gestion inadéquates et les aliments de mauvaise qualité utilisés par les agriculteurs. Par conséquent, cette étude a été conduite pour identifier et cartographier la qualité

des aliments adoptés par les producteurs de tilapia du Nil et leurs conséquences sur le rendement dans les six comtés enclavés du Libéria: Bong, Lofa, Nimba, River Gee, Gbapolu et Grande Gedeh. L'étude a utilisé un échantillonnage à plusieurs étapes, des discussions de groupe et des collectes d'échantillons d'aliments qui ont été soumis à une analyse immédiate des éléments nutritifs. Les résultats indiquent que le genre joue un rôle important dans la gestion des systèmes aquacoles et donc de l'ensemble de la chaîne de valeur du tilapia du Nil d'élevage. Il a été constaté que 82,6 % des femmes occupaient les rôles les plus exigeants en matière de main-d'œuvre dans la production, cependant, 75,3 % des hommes possédaient les systèmes et dominaient la prise de décision concernant la sélection des aliments. Le système de production en étang a été adopté par 91% des agriculteurs. Cependant, les pratiques de gestion employées n'ont pas fourni l'environnement propice requis pour une production optimale de poisson. Le son de maïs, le son de blé et les tourteaux de soja et autres aliments formulés localement sont les principales sources d'alimentation utilisées. Les résultats soulignent les régimes alimentaires inadéquats pratiqués par les agriculteurs et les mauvaises pratiques de gestion.

Mots clés : Aquaculture, pisciculture, Libéria, aliments locaux, Tilapia du Nil

Introduction

By 2015, fish and other aquatic products accounted for around 26% of animal protein consumption in the least developed countries, compared to 11% in the industrialized world (FAO, 2018). In Liberia, fish accounted for around 20% of animal protein consumption in 2016 (FAO, 2019). Fish intake per capita has however declined from around 15 kg in the pre-war period to around 6.0 kg in 2016 (FAO, 2019). Fish is a protein source in the diet of low-resource populations, but it has not been fully utilized in further development contributing to the increased food insecurity in developing countries (Kpadeh, 2012; Adeleke *et al.,* 2021).

Despite larger-scale investments in Egypt, Nigeria, Uganda, and Ghana generating huge quantities of fish, Africa's contribution to global aquaculture production remains low about 2.7 percent (Halwart, 2020). Egypt (1.7 percent) is the most productive country, followed by Nigeria (0.4 percent) (Cai *et al*., 2017; FAO, 2018). Despite abundant potential resources for fish farming development and previous government attempts to aid fish farmers, the majority of Sub-Saharan African countries (except for Nigeria) continue to report low fish farming production. Despite having been brought to the continent over five decades ago, Liberia's aquaculture sector is still very low-key (Kpadeh, 2012; Mansaray and Simpson, 2018). Limited credit availability to small scale farmers, the very low technical level of fish farmers, unavailability of local feed ingredients, lack of well-trained senior personnel, prohibitive transport costs, and lack of juvenile fish for pond re-stocking are factors contributing to Liberia's inability to use the aquaculture business productively (Mansaray and Simpson, 2018).

Commercial feeds are expensive and often out of reach for small-scale farmers; as a result, feed accounts for more than 60% to 70% of an agricultural operation's output expenditures (Edwards and Allan, 2004; Babalola, 2010). Periphyton-based cage systems (Huchette and Beveridge, 2002; Babalola, 2010), fertilization, and the use of aquatic plants, such as *Lemna* sp., green vegetables, rice bran, and other plant extracts as supplemental feed have all been examined as alternatives to high-cost commercial diets (Mzengereza *et al*., 2014).

For adequate growth in the shortest amount of time, fish require a high-quality, nutritionally

balanced food. As a result, low-cost local production of fish feed is critical for the development and sustainability of aquaculture in Africa, particularly in rural regions (Khan *et al*., 2011; Adéyèmi, 2020). A combination of low-cost diet and feed optimization strategies could give farmers a useful tool for lowering costs and reducing reliance on outside resources (Mzengereza *et al*., 2014).

Feedstuffs' nutritional value is determined not only by their chemical composition but also by the number of nutrients or energy that the fish can absorb and use (Khan *et al*., 2011). Affordable, high-quality feed will attract private investors and increase fish output. Several factors should be considered when evaluating components for usage in aquaculture (Adéyèmi *et al.,* 2020). The availability of the ingredient, as well as its accessibility and nutritious composition, are critical. Protein is the essential nutrient that cannot be compromised in the choice of ingredients for feed formulation and manufacturing, according to Bhilave *et al.* (2012).

The aim of this study was to determine the accessibility and the profiling of biochemical feed from local ingredients to improve nutritional quality, availability and cost-efficiency in small-scale aquaculture holders in Liberia. The aim is to provide information that can help in incorporating local ingredients in the production of formulated fish feed.

Material and Methods

Study area. The survey and collection of farmer feed samples will be conducted in the six landlocked counties which include; Bong, Lofa, Nimba, River Gee, Gbapolu, and Grande Gedeh. Geographically these counties are situated in the north, central, and southeastern parts of Liberia. The counties form the focus of this study because they are historically inaccessible to the right amount and quality of fish from the coastal regions and they are also the counties with significant aquaculture activities.

Figure 1. Map of Liberia indicating the six counties of study

Data collection. A survey of aquaculture activities in the six counties was conducted using a combination of two social data collection approaches; one on one interviews and focus group discussions (FGDs). The survey aimed to establish various types of feeds and ingredients that are used by the farmers in the six counties, determine the approximate economical returns of the Nile Tilapia production by farmers using different self-compounded feeds and determine their sources and formulation formulas. Baseline data on per capita production and income were collected. A cluster purposeful sampling methodology was used to obtain the fish farmers for the survey. In each county sampling was separately done for youths (18-35 years), and women and men engaged in the production node of the Nile Tilapia value chain. Focus groups discussions were also be conducted among different stakeholders and key informants. Four FGDs, constituting of women youths, men and extension officers were conducted separately in each county. The discussions used semi-structured fish production questions and each session consisted of 12 farmers, a language interpreter and the researcher. All the four FGDs in each county were video recorded for further content analysis. The resulting qualitative data were used to reinforce the qualitative data collected from one on one interviews.

Farmer compounded fish feed proximate nutrient analysis. For proximate composition, the moisture, crude protein, crude fat and ash were determined using standard procedures of the AOAC (2005). The following nutrients were analyzed for crude protein (CP), crude lipids (CL), ash, nitrogen-free extracts (NFE), and crude fibre (CF). Crude protein was estimated from Kjeldahl nitrogen, while crude lipid was quantified through the loss in weight after extraction of the sample with petroleum ether (40-60 °C). Ash content was determined by burning dry samples in a muffle furnace at 550 °C for four hours while Crude fibre was determined by alkaline/acid digestion, followed by ashing of the dry residue at 550 °C in a muffle furnace for four hours.

Collection of feed ingredients samples. For the study100 grams of feed ingredients samples were collected from five fish farmers within each of the six counties for proximate composition analysis. The samples were analyzed at the Ghana Standard Authority.

Data analysis. Qualitative data obtained from focus group discussions, were subjected to content analysis where the data were grouped, summarized and tabulated. On the other hand, interview data were cleaned, ordered and subjected to descriptive analysis, Chi-square independence test, ordinal regression and correlation at a 5% confidence interval using Statistical Package for Social Science (SPSS) version 23.

Result and Discussion

Demographics of respondents. The majority of the respondents from the sampling locations were above 35 years as indicated in Table 1. Chi analysis revealed that the sampling locations did not affect the age structure of respondents significantly (p-value = 0.246).

From the perspective of gender, majority of the respondents were females across the sampling locations. Chi-square analysis revealed that the sampling location affected the gender of respondents during the survey (p-value = 0.021) as shown in Table 2.

Table 1. Age of respondents

Location	Variable	N	%
Bong	Above 35	24	80
	Below 35	6	20
River Gee			
	Above 35	7	100
	Below 35	0	0
Grand Gedeh			
	Above 35	18	78.3
	Below 35	5	21.7
Nimba			
	Above 35	19	95
	Below 35	1	5
Lofa			
	Above 35	22	75.9
	Below 35	7	24.1
Gbapolu			
	Above 35	7	100
	Below 35	0	0

Table 2. Gender of respondents from the survey

		N	%
Bong			
	Female	24	80
	Male	6	20
River Gee			
	Female	7	100
	Male	0	0
Grand Gedeh	Female	12	52.2
	Male	11	47.8
Nimba			
	Female	18	90
	Male	2	10
Lofa			
	Female	23	79.3
	Male	6	20.7
Gbapolu			
	Female	4	57.1
	Male	3	42.9

Regarding education, most of the respondents ended their education at the secondary and primary level, with few attaining tertiary education status (Table 3). Chi-square analysis revealed that the sampling location played a significant role in the education status of respondents during the survey (p-value = 0.003) as shown in Table 3.

From Table 4, the mean years of engagement in small scale fish farming among the respondents ranged from 5.8 years to 11.9 years, but this varied significant across the sampling locations (p-value = < 0.001).

Table 3. Education status of respondents

County	Variable	N	%	df	p-value
Bong	Secondary	8	26.7	20	0.003
	Primary	10	33.3		
	None	9	10		
	Secondary/Vocational	3	0		
	University	0			
River Gee	Secondary	5	71		
	Primary	2	28.6		
	None	0	0		
	Secondary/Vocational	0	0		
	University	0	0		
Grand Gedeh	Secondary	6	26.1		
	Primary	11	47		
	None	6	26.1		
	Secondary/Vocational	0	0		
	University	0	0		
Lofa	Secondary	13	44.8		
	Primary	12	41.4		
	None	4	14		
	Secondary /Vocational	0	0		
	University	0	0		
Nimba	Secondary	2	10		
	Primary	10	50		
	None	1	5		
	Secondary/ Vocational	6	30		
	University	1	5		
Gbapolu	Secondary	4	4		
	Primary	3	3		
	None	0	0		
	Secondary/ Vocational	0	0		
	University	0	0		

Table 4. Work experience of respondents

Mean	SE	Minimum	Maximum	df	p-value
Bong	8.7586	0.373563.00	12.00	13	<0.001
River Gee	6.7143	0.808124.00	10.00		
Grand Gedeh	5.8261	0.443012.00	9.00		
Gbapolu	9.4286	1.770892.00	14.00		
Nimba	7.6500	0.608172.00	15.00		
Lofa	11.8621	0.339249.00	15.00		

Fish species farmed. From Figure 2, although all the respondents were engaged in tilapia farming, majority of the respondents reared Nile tilapia with a few engaged in Silver tilapia farming. The species cultured by the respondents vary significantly across the sampling location (p-value 0.001). The high rate of tilapia farming among fish farmers in Liberia may be attributed to the short period of maturation exhibited by Tilapia species as well as the availability of ingredients for the formulation of local feeds (FAO, 2021; Martínez-Cordero *et al*., 2021). Furthermore, tilapia species do not require any special feeds as they can feed on a wide range of feeds, making their culturing highly preferred by most of the respondents (Cassell *et al*., 1992; Alemayehu *et al*., 2018).

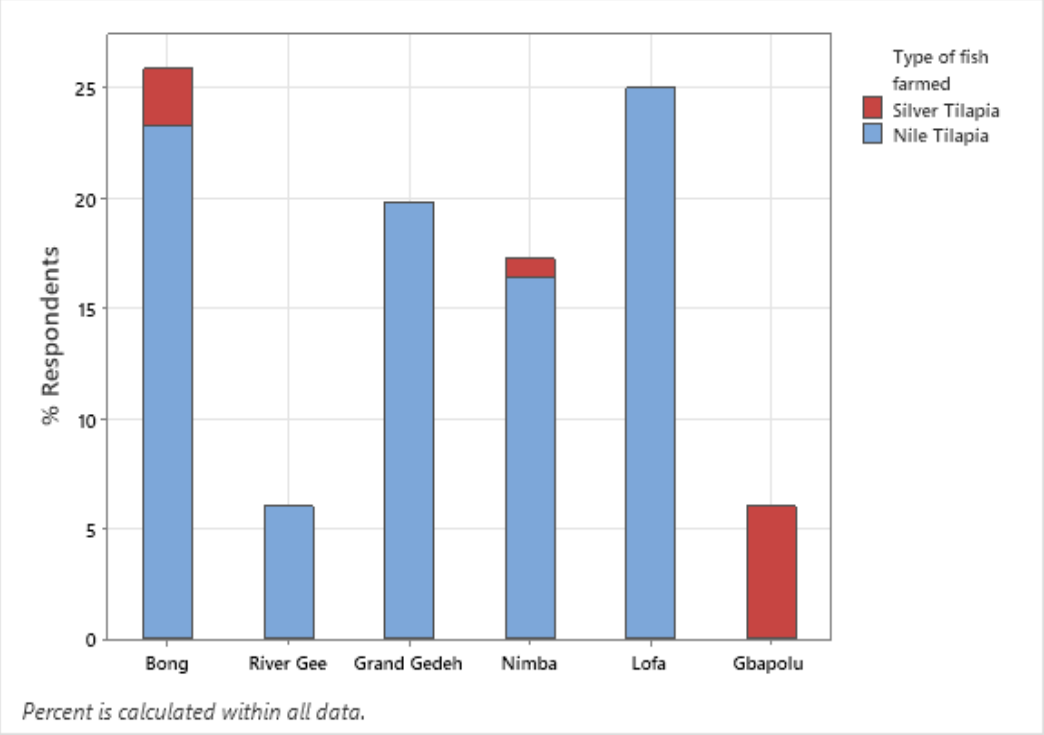

Figure 2. Fish species farmed by respondents

The main feed used by fish farmers across the sampling locations was local feeds because the ingredients needed to prepare these local feeds are readily available (Mmanda *et al.,* 2020). Local feeds to rear tilapia species by farmers within the sampling areas are mostly sourced from local markets, local feed vendors or other fish farmers. The low interest in the application of commercial feeds could be attributed to accessibility, high cost as well as the educational level of the fish farmers (Chowdhury, 2007; El-Sayed, 2013a). For instance, the absence of a local manufacturing plant for commercial feeds could make accessibility of such feeds very difficult for fish farmers, especially those that are into subsistence farming (Soko and Kang'ombe, 2010; El-Sayed, 2013b). Further, the high cost of commercial fish feeds could lead to low patronage by fish farmers as this can raise the expenditure for the culture of the species. Again, having low educational status may have the propensity of fish farmers going in for local feeds which do not involve high-rate literacy in its usage (Obiero *et al.,* 2019; Brugere *et al.,* 2020; Mensah *et al.,* 2021).

From Figure 3, the radar graph revealed that majority of the respondents across the sapling locations rated the rearing of Tilapia (either Nile or Silver) as good with a few ratings as excellent and average. The sampling locations did not influence the ratings for tilapia rearing by respondents (p-value = 0.639). This observation could be due to the fact that tilapia are hardy fish species that can withstand harsh environmental conditions (Authman *et al*., 2012). Furthermore, the farming of Tilapia species does not entail high technical know-how, making its farming among individuals relatively easy (Peña-Mendoza *et al*., 2005).

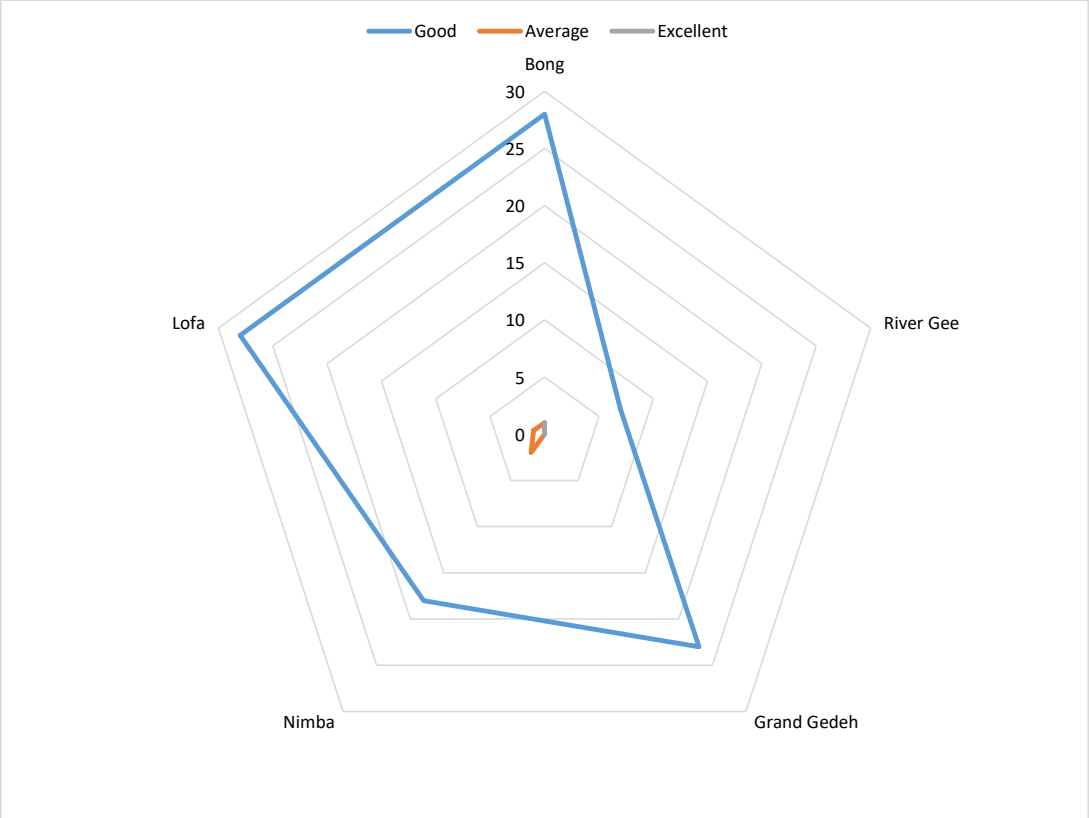

Figure 3. Radar graph showing the ratings for Tilapia farming across the sampling locations

Challenges faced by small scale fishermen. One major challenged regarding the use of locally manufactured feed is that most fish farmers have little or no knowledge on the biochemical composition of the local ingredient used (Mensah *et al.,* 2021). Such deficiency in knowledge could have severe ramifications on the growth performance of Tilapia species reared (El-Sayed, 2013a,b; White, 2013). Not having knowledge of the biochemical composition of the local feeds could be attributed to probably the absence of enough funds to carry out test on the composition at an accredited laboratory and the absence of extension services by fisheries experts to the farmers (Mansaray and Simpson, 2018).

The studies conducted by Kpandeh (2012) and Mansaray and Simpson (2018) also outlined other challenges faced by the aquaculture sector in Liberia that include; limited credit availability to small scale farmers, the very low technical level of fish farmers, unavailability of local feed ingredients, lack of well-trained senior personnel, prohibitive transport costs, and lack of juvenile fish for pond re-stocking rendering Liberia's inability to use the aquaculture business productively.

The study concludes that while aquaculture sector is important to Liberian population and also to other landlocked countries, policy intervention including provision of relevant supportive systems is needed.

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