JENRM, Vol. 4, No. 1, 1-7, 2017
Research Article

Production and use of farm-made fish feeds by small-scale pond fish farmers in Ghana

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Abstract
The increasing costs of commercial fish feeds have made it imperative for most small-scale pond fish farmers in Ghana to resort to the use of alternative feed types to feed cultured fish. Some fish farmers rotate commercial feeds with farm-made types. This study was carried out to investigate the production and use of farm-made fish feeds by small-scale pond fish farmers in five major pond fish farming Regions (Ashanti, Brong-Ahafo, Central, Volta and Western) in Ghana. Of the 147 farmers interviewed in all the five regions, 86 farmers used farm-made feeds of which 37 depended solely on farm-made feeds whilst 49 used both commercial and farm-made feeds. Farm-made feeds were produced using locally available ingredients and the most used ones were groundnut bran (92%), fish meal (90%), wheat bran (74%) and maize (60%). The farmers did not follow appropriate and standardized feed formulation protocol during farm-made fish feed production. Hence, farm-made fish feeds produced by all farmers interviewed were found not to be nutritionally balanced. There is need for small-scale pond fish farmers in Ghana to be trained in formulation and production of nutritionally balanced and cost-effective fish feeds so as to increase fish production through aquaculture in the country.

Keywords
Aquaculture, commercial and farm-made fish feeds, Ghana, locally available ingredients, small-scale fish farmers

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Contents

1. Introduction

Feed is known to be a major determinant of successful growth and intensification of aquaculture production. Low availability, poor quality and high costs of feeds is one of the most important factors inhibiting the development of commercial and non-commercial aquaculture in sub-Saharan Africa [1]. It is generally accepted that the highest recurring cost in aquaculture comes from feeds. Alone, feed accounts for about 60-80% of operational costs in intensive aquaculture [2]. With the increasing demand for food fish and the decline in capture fisheries production, aquaculture in Ghana is shifting from low density to high density culture, i.e. from traditional to semi-intensive or intensive culture. This consequently leads to an unprecedented rise in the demand for feeds more than that of fertilizers [3]. Aquaculture in Ghana started with the use of no feed, then the use of farm-made feeds to factory-made diets [3]. This demonstrates a real possibility of increasing production and reveals the potential importance of fish feeds in Ghana. Currently aquaculture feeds have been considered a major subsector of the feed milling industry [3]. From the economic point of view, feed cost appears to be one of the major constraints against the greater expansion of aquaculture in Ghana. Most small-scale fish farmers in Ghana use earthen ponds whilst others use cages, pens and raceway systems which are not commonly practised nationwide.

In terms of numbers, cages come after ponds. However, annual fish production is higher in cages than in ponds [4]. Tilapia production in Ghana is increasing, and over 80 percent of the production is derived from cage farms where imported commercial complete fish diets are utilized [5]. The high and rising costs of commercial tilapia diets have been one of the reasons why some small-scale pond fish farmers have resorted to the use of alternative feeds including agro and industrial by-products, kitchen and agricultural wastes as fish feeds. Some fish farmers rotate commercial feeds with kitchen and restaurant wastes or chicken by-products. Others replace tilapia feed with cheaper chicken or duck feed. This has affected the development and expansion of aquaculture enterprises in most African countries including Ghana, and this has contributed in no small way, to the low protein intake in many developing African countries [6]. The relatively slow aquaculture development in Ghana has been mainly attributed to a lack of nutritionally balanced, cost-effective feeds (especially for tilapia) using locally available, cheap and unconventional resources [7]. Local or sub-regional agricultural by-products could provide nutritionally sound and cost-effective feeds to support increased fish production in Ghana [7]. In order to increase and sustain aquaculture production in Ghana, there is the need to encourage use of the abundant locally available ingredients to develop low cost feeds and discourage import of very expensive formulated or extruded feed from foreign nations [7]. Thus, production of fish diets using locally available feed ingredients for small-scale fish farming in Ghana is the way forward to increase the profitability of the aquaculture industry and make its production more sustainable. However, factors such as competition with other large-scale demands such as the livestock sector and unpredictability in annual crop output must be taken into account in any plans for using plant by-products in fish feed formulations on a large scale [8]. This study was carried out to investigate the production and use of farm-made fish feeds by small-scale pond fish farmers in five major pond fish farming regions (Ashanti, Brong-Ahafo, Central, Volta and Western) in Ghana.

2. Materials and Methods

2.1 Study Area and its Selection

Data on pond fish farmers per Region of Ghana for 2012 was obtained from the Fisheries Commission Head Office, Accra. The five predominant pond fish farming Regions (Brong Ahafo, Ashanti, Western, Central and Volta) in terms of number of farmers were selected. Surveys of fish feeds were conducted in the selected regions for a period of eight (8) months (December, 2013-July, 2014). The surveyed regions are shown in Fig. 1 below:

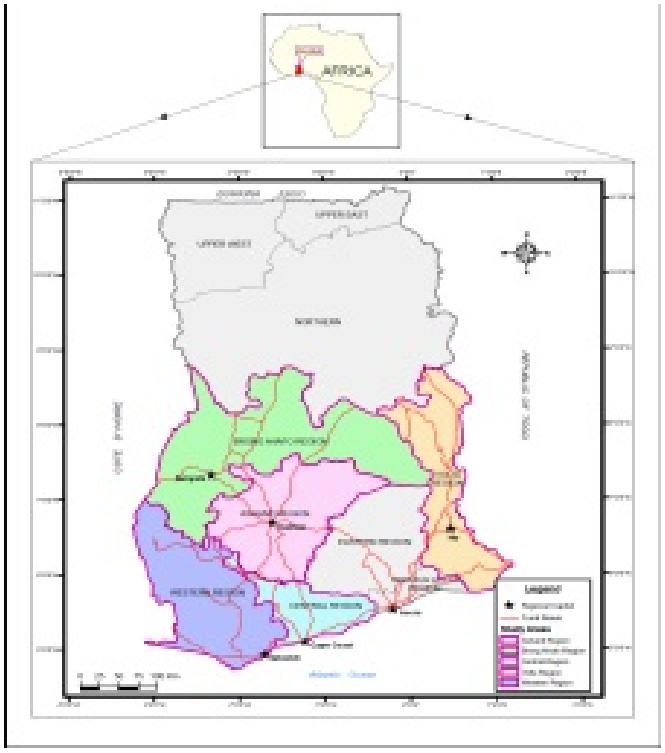

Figure 1. Map of Ghana showing the five regions where the survey of fish feeds were conducted

2.2 Survey of Fish Feed Production and Use

List of fish farmers in active production were obtained from the Regional Fisheries Offices in the five selected Regions. Standardized and structured interview guide was administered to gather data from fish farmers who were in active production. A total of One hundred and forty-seven (147) fish farmers were interviewed from all the five regions surveyed for in-depth data collection. Forty-four (44) farmers were interviewed in Brong-Ahafo, Thirty-eight (38) in Western, Twenty-seven (27) in Ashanti, Twenty (20) in Central and Eighteen (18) in the Volta. Interview with fish farmers were mainly conducted in their houses and/or farm sites. Interview with each farmer lasted at least an hour and was focused on fish farming practices, productivity, production constraints and fish feeds. In certain districts of some of the Regions, farmers were met in groups, and after the purpose for the survey and the objectives were explained to them, they were interviewed individually with the help of field assistants. Following the interview guide, farmers were posed questions and their responses were recorded. In cases where the interviewee did not understand English language, the assistance of interpreter was solicited. Further, visits were made to selected farms to observe farming practices.

To validate the information gathered from the interview, it was cross-checked with key informants. A key informant is someone with special knowledge on a par-

ticular topic. Key informants are expected to be able to answer questions about the knowledge and behaviour of others, and about the operations of the broader system [9]. These were regional fisheries directors, fisheries extension officers, aquaculture research scientists, fishmongers, commercial fish feed retailers, feed ingredient retailers and relevant food processors. Where data was found to be contradictory, additional assessments were carried out. A total of 31 key informants were interviewed in their offices, homes and/or at their workplaces. A check-list was created to indicate the production of farm-made fish feeds and ingredients used in the various Regions of the survey.

2.3 Data Analyses

Data from interviews were coded and entered into a database system using Microsoft Excel software (2007 version). The data was then summarized using descriptive statistics. Results obtained based on the percentages of responses in addition to qualitative information gathered during the surveys were used to describe production and use of farm-made fish feeds in the five selected regions of Ghana.

3. RESULTS

3.1 Production and use of Farm-Made Fish Feeds by Fish Farmers in the Five Selected Regions

The results of the survey revealed that out of the 147 farmers interviewed, 138 used either commercial or farm-made feeds whilst others used both. Of this number, 86 farmers used farm-made feeds of which 37 depended solely on farm-made feeds whilst 49 used both commercial and farm-made feeds. Of the farmers in the various regions, the highest percentage (40.7%) production and use of farm-made feeds was observed in the Ashanti region whilst the least (7.9%) was in the Western region (Fig. 2).

Figure 2. Percentage of fish farmers who produced and used farm-made feeds in Ashanti, Brong-Ahafo, Central, Volta and Western Region of Ghana

The highest percentage (48.2%) use of both commercial and farm-made feeds was also in the Ashanti region whilst the least (20.4%) was in the Brong Ahafo region (Fig. 3).

The Region with the highest usage of commercial fish feeds among fish farmers was Western whilst the least was Ashanti. Of the 38 farmers interviewed in the Western Region, 21 of them representing about 55.3% used only commercial fish feeds whilst 3 representing about 11.1% of the 27 farmers in the Ashanti used only commercial fish feeds. Use of only commercial fish feeds was not observed in the Volta (Table 1).

The farm-made feeds were in the form of single ingredients, mixtures of two or more ingredients in a powdered form or compounded into dough. Whilst about 45.5% of farmers used the farm-made feeds as complete feeds,

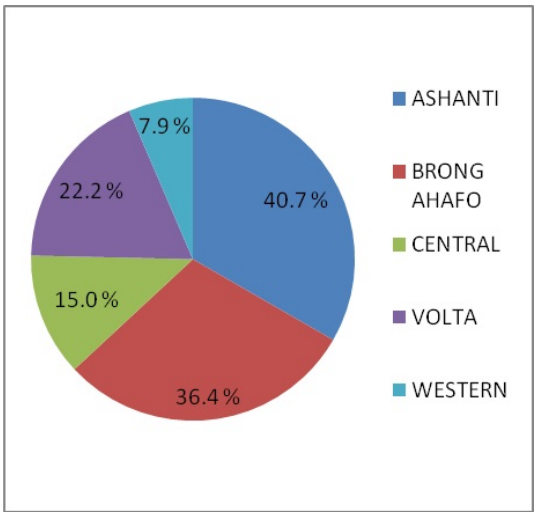

Figure 2. Percentage of fish farmers who produced and used farm-made feeds in Ashanti, Brong-Ahafo, Central, Volta and Western Region of Ghana

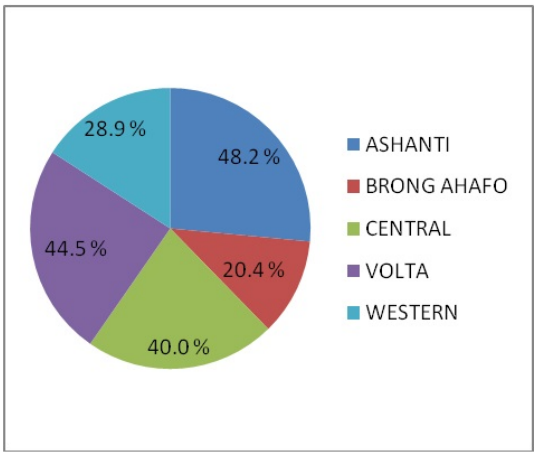

Figure 3. Percentage of fish farmers who used both farm-made and commercial fish feeds in Ashanti, Brong-Ahafo, Central, Volta and Western Region of Ghana

Table 1. Percentage of farmers using only farm-made and only commercial fish feeds in Ashanti, Brong-Ahafo, Central, Volta and Western Region of Ghana

	Feed Type	
Region	Only Commercial (%)	Only Farm-Made (%)
Ashanti	11.1	40.7
Brong-Ahafo	43.2	36.4
Central	45	15
Volta	0	22.2
Western	55.3	7.9

the rest used them to supplement the commercial ones. The latter group either used the farm-made and commercial feeds at different stages of the cultured fish or they mixed the two types of the feed in equal proportions to feed fish. The first group of farmers used the expensive commercial feeds as starter feed (i.e. to feed the fish at the fry/fingerling stage) whilst the farm-made feeds were used as finisher or grow-out feeds (i.e. from the juvenile/grower stage till the fish are ready for harvest)(Table 2).

Table 2. Types of fish feeds used in feeding various stages of fish by small-scale pond fish farmers

Fish Size	Feed Type
Fry	Commercial
Fingerlings	Commercial
Juvenile	Farm-made
Grower	Farm-made

About 98.9% of the farmers did not take into consideration the nutritional values of the ingredients used in preparing their feeds, neither did they consider the nutritional requirements of the fish being cultured. Generally, most of the farmers did not know how to formulate fish feed. They therefore, did not apply fixed ratios of the ingredients they used in preparing their feeds. In almost all situations, the ingredients were not weighed but measured by volume using varying sizes of both plastic and metallic containers. The ratio of ingredients used varied for each production batch depending on the season, availability and affordability of ingredients.

3.2 Fish Feed Ingredients used in Farm-Made Fish Feeds Production by Fish Farmers in the Selected Regions

A list of feed ingredients and supplements/additives observed being used by small-scale pond fish farmers in the production of farm-made fish feeds in Ashanti, Brong Ahafo, Central, Volta and Western Regions and their prices are presented in Table 3. In all, 33 ingredients and 5 supplements/additives were being used to feed fish and in farm-made fish feed production in all the five Regions surveyed. Most of the ingredients were being utilized in at least three of the Regions, except a few that were unique to one or two regions. Fish meal (miscellaneous), Maize (Zea mays), Rice (Oryza sativa) bran and Wheat (Triticum aestivum) bran were being used in all the five regions. The percentage of farmers using each ingredient ranged between 33 to 82%, 4 to 64%, 7 to 63% and 33 to 82% for fish meal, maize, rice bran and wheat bran respectively (Table 4). The highest use of fish meal was in the Central whilst its least use was in the Volta. The highest use of maize was in the Western whilst its least use was in the Brong-Ahafo. The highest use of rice bran was in the Ashanti whilst its least use was in the Western. The highest use of wheat bran was in the Central whilst its least use was in the Ashanti. Bean (Phaseolus vulgaris) leaves, Birds (dead poultry), Brewery waste, Cassava (Manihot esculenta) leaves, Coconut (Cocos nucifera) paste, Cotton (Gossypium spp) seed cake, Millet (Urochloa ramose), Palm fruit fibre, Pito mash (made from millet), Sweat potato (Ipomoea batatas) leaves, Poultry offal and Rice (Oryza sativa) were being used in only one region. The most used plant source ingredient in farm-made fish feed production was groundnut bran (92%), followed by wheat bran (74%) whilst the most used animal source ingredient was fish meal (90%)(Table 5).

In general, most of the ingredients were cultivated by the farmers themselves as most of them grow crops aside from fish farming. However, a section of them obtained most of the ingredients they used from food processors and feed ingredient retailers. There were both inter- and intra-regional differences in the price per kilogramme of all the ingredients. Ingredients whose unit cost is indicated by GHS 0.00 could be sourced off farm or the household at no cost.

Table 3. List of utilized fish feed ingredients and their price range per unit weight (GHS kg-1) in Ashanti, Brong Ahafo, Central, Volta and Western Region of Ghana

Region	Ashanti	Brong-Ahafo	Central	Volta	Western	Cost per kg (GHS)
Ingredients						
Bean (*Phaseolus vulgaris*) husks		✓		✓		0.00
Beans (*Phaseolus vulgaris*)			✓	✓		3.00 – 4.67
Bean (*Phaseolus vulgaris*) leaves				✓		0
Birds (dead poultry)	✓					0
Brewery waste			✓			0
Cassava (*Manihot esculenta*)		✓		✓		0.90 – 1.25
Cassava (*Manihot esculenta*) flour	✓	✓	✓	✓	✓	0.50 – 0.85
Cassava (*Manihot esculenta*) leaves		✓				0
Coconut (*Cocos nucifera*) paste			✓			2.05 – 2.25
Cocoyam (*Caladium spp*) leaves		✓		✓	✓	0
*Common salt (*Sodium chloride*)		✓		✓		1.00 – 1.80
Copra cake	✓		✓			0.44 – 0.85
Cotton (*Gossypium spp*) seed cake	✓					0.90 – 1.00
Cow (*Bos Taurus*) blood meal	✓	✓		✓		0.40 – 0.80
Fish meal	✓	✓	✓	✓		1.20 – 5.00
Groundnut (*Arachis hypogaea*)		✓			✓	3.80 – 4.43
Groundnut (*Arachis hypogaea*) bran					✓	0.09 – 0.40
Groundnut (*Arachis hypogaea*) cake	✓		✓			1.00 – 1.44
Kitchen wastes						0
*Lysine	✓					7
Maize (*Zea mays*)	✓	✓	✓	✓	✓	0.54 – 1.00
Maize (*Zea mays*) bran	✓	✓	✓		✓	0.10 – 0.50
Maize (*Zea mays*) gluten/meal				✓		0.53 – 0.90
**Methionine*	✓					13
Millet (*Urochloa ramose*)				✓		1.22 – 1.40
**Oyster shells*	✓	✓				0.14 – 0.40
Palm fruit fibre				✓		0.40 – 0.80
Palm kernel cake		✓	✓	✓	✓	0.01 – 0.08
Palm oil (*Elaeis guineensis*)	✓	✓			✓	3.00 – 4.40
'Pito' mash		✓				0.20 – 0.30
Potato (*Ipomoea batatas*) leaves				✓		0
Poultry offal	✓					0.83 – 1.25
*Premix (minerals and vitamins)	✓	✓	✓		✓	6.00 – 6.50
Rice (*Oryza sativa*)					✓	4.80 – 5.50
Rice (*Oryza sativa*) bran	✓	✓	✓	✓	✓	0.22 – 0.46
Soya bean (*Glycine max*)			✓	✓	✓	1.80 – 2.90
Soya bean (*Glycine max*) meal/cake	✓	✓	✓		✓	1.00 – 1.60
Wheat (*Triticum aestivum*) bran	✓	✓	✓	✓	✓	0.44 – 0.65

*Supplement/additive. Average exchange rate of the Ghana cedis (GHS) to the USA dollar (USD) in 2014 was: GHS 2.45 = 1.00 USD

Table 4. Percentage of fish farmers who used the various fish ingredients in Ashanti, Brong Ahafo, Central, Volta and Western Region of Ghana

Ingredients					
	Ashanti	Brong-Ahafo	Central	Volta	Western
Bean (*Phaseolus vulgaris*) husk		4		8	
Bean (Phaseolus vulgaris)			18	8	
Bean (*Phaseolus vulgaris*) leaves				8	
Birds (dead poultry)	8				
Brewery waste			18		
Cassava (*Manihot esculenta*)		20		33	
Cassava (*Manihot esculenta*) flour	8	4	18		29
Cassava (*Manihot esculenta*) leaves		8			
Coconut (*Cocos nucifera*) paste			36		
Cocoyam (*Caladium spp*) leaves		24		25	29
*Common salt (*Sodium chloride*)		4		17	
Copra cake	25		18		
Cotton (*Gossypium spp*) seed meal	17				
Cow (*Bos Taurus*) blood meal	8	4		25	
Fish meal	50	44	82	33	57
Groundnut (*Arachis hypogaea*)		4			7
Groundnut (*Arachis hypogaea*) bran	71	60	18		79
Groundnut (*Arachis hypogaea*) cake	8		9		
Kitchen wastes			18	67	
*Lysine	8				
Maize (*Zea mays*)	33	4	36	58	64
Maize (*Zea mays*) bran	29	40	9		7
Maize (*Zea mays*) gluten/meal		32		17	
*Methionine	8				
Millet (*Urochloa ramose*)				17	
*Oyster shells	4	12			
Palm fruit fibre				8	
Palm kernel cake		25	55	42	43
Palm oil (*Elaeis quineensis*)	8				36
'Pito' mash		20			
Potato (*Ipomoea batatas*) leaves				8	
Poultry offal	17				
*Premix (minerals and vitamins)	8	4	18		14
Rice (*Oryza sativa*)					7
Rice (*Oryza sativa*) bran	63	8	18	25	7
Soya bean (*Glycine max*)			36	17	7
Soya bean (*Glycine max*) meal/cake	17	4	36		36
Wheat (*Triticum aestivum*) bran	33	48	82	42	36

*Supplement/additive

Table 5. Percentage of small-scale pond fish farmers using various feed ingredients in farm-made fish feed production in Ghana.

Ingredient	Percentage of users
Bean (Phaseolus vulgaris) leaves	1
Palm fruit fibre	1
Potato (Ipomoea batatas) leaves	1
Birds (dead poultry)	2
*Lysine	2
*Methionine	2
Palm oil (Elaeis quineensis)	2
Bean (Phaseolus vulgaris) husk	3
Cotton (Gossypium spp) seed cake	3
Millet (Urochloa ramose)	3
Rice (Oryza sativa)	3
Brewery waste	5
Cassava (Manihot esculenta) leaves	5
'Pito' mash	5
*Common salt (Sodium chloride)	6
Groundnut (Arachis hypogaea)	6
Poultry offal	6
Groundnut (Arachis hypogaea) cake	7
*Oyster shells	7
Bean (Phaseolus vulgaris)	8
Coconut (Cocos nucifera) paste	8
Cow (Bos Taurus) blood meal	10
Copra cake	13
*Premix (minerals and vitamins)	15
Soya bean (Glycine max)	15
Cassava (Manihot esculenta)	17
Kitchen wastes	19
Maize (Zea mays) gluten/meal	20
Cassava (Manihot esculenta) flour	22
Cocoyam (Caladium spp) leaves	31
Soya bean (Glycine max) meal/cake	33
Maize (Zea mays) bran	36
Rice (Oryza sativa) bran	38
Palm kernel cake	47
Maize (Zea mays)	60
Wheat (Triticum aestivum) bran	74
Fish meal	90
Groundnut (Arachis hypogaea) bran	92

*Supplement/additive

4. Discussion

The largest number of producers and users of farm-made fish feeds found in the Ashanti appeared to have a fair knowledge in fish feed preparation which most of them claimed they acquired through expert training and on the job experience. However, the producers did not follow standard feed formulation protocol in producing balanced diets that meet the nutritional requirements of the cultured fish. The practice of using both commercial and farm-made diets was intended to reduce cost of fish production whilst mixing of equal portions of the diets was to improve upon the quality of the prepared farm-made feeds.

Farmers who used the farm-made feeds throughout the culture period as commonly practised in the Ashanti Region could not afford the commercial ones. As most times the farm-made feeds were not nutritionally balanced, the fish they are fed with could take longer period to reach the harvestable size. Most of the farm-made feeds consisted of ingredients that were not combined in a specified proportion. Some were raw agricultural wastage that was directly fed to the cultured fish. This could impact on water quality negatively and affect fish growth. Most farmers who produced farm-made feeds are often unaware of the nutrient requirements of their farmed species, particularly dietary protein and energy levels and how they change during the production cycle [5];[10]. Formulations are often based on past experience (what the farmers themselves have found to work), feed ingredient availability and cost, advice from other farmers, feed ingredient suppliers and occasionally, Fisheries Extension Officers.

The results of the present survey suggest that more (63.3%) of the small-scale pond fish farmers were producing and using farm-made feeds than those (37.7%) using commercial ones only. The higher usage of farm-made feeds by farmers could be attributed to the continuous increase in the prices of the commercial fish feeds, making the latter increasingly unaffordable. The nutrient composition of the ingredient sources was not a consideration in terms of formulation [5]. The inclusion levels of an ingredient were based on its availability. Hence, ingredients such as wheat bran and maize which to a large extent are available throughout the year were widely used by most farmers at high inclusion levels whilst fishmeal which is the most expensive ingredient was used sparingly in most cases.

Prepared farm-made feeds were not of specified crude protein contents and these were fed to the cultured fish from the fingerling to the grow-out stage. Most of the farm-made feeds surveyed were fed to the cultured fish in powdered forms without being extruded or pelletized whilst some were fed to the fish in wet dough forms. This

was mainly due to the fact that all the farmers interviewed during the surveys claimed they had neither extruders nor pellitizers. The use of locally-made mincers as pellitizers by some farmers as observed by [5] was not recorded during the present study. Both feed ingredients and supplements/additives were being used to produce fish diets by some small-scale pond fish farmers in all the regions (Ashanti, Brong-Ahafo, Central, Volta and Western) surveyed. The ingredients surveyed in the present study were mainly agricultural crops and by-products and most were available in most parts of the country throughout the year. This could be due to the fact that Ghana is mainly an agro-based country, and these findings agreed with those of [11]. Agro-industrial by-products observed in the current study have potential use in fish feeds based on their nutritional compositions, total annual production, seasonal availability as well as their prices [8]. Some of the ingredients used by fish farmers as fish feed or in fish diet production were cultivated by the farmers themselves as most of them practised integrated culture systems. This may ensure reliable source of ingredient supply as well as reduced cost of fish feed production.

The availability of the ingredients and feed supplements/additives surveyed in the present study in the various Regions, also reflected in the cost per kilogramme of the various ingredients. In regions where particular ingredients were localized, such ingredients were cheaper than regions where they were least available. This suggests that it would be cheaper to produce a kilogramme of fish diet in a region where the ingredients used are localized and less expensive than in others where such ingredients are not readily available and hence could be more expensive.

Availability and price are key determinants for an ingredient to be used [12]. For availability, volume, time of availability, (e.g. is it available every day or week or is it only available during one season each year), source (e.g. is it available everywhere or only in a particular city or region) and accessibility (i.e. supply chain mechanism) are all important determinants. Ingredient pricing is obviously critical, and factors that drive price change have to be considered. Weather (especially droughts) affects supply and price of grains and other agricultural products as in the changing pattern for the demand of ingredients for other purposes [12].

In the present survey, the costs of fish meal in all the 5 regions were generally higher in comparison with that of other ingredients. This was consistent with observations made by [11] that the costs of feed ingredients of animal origin were generally high and unlikely to be economically viable for semi-intensive culture of O. niloticus and C. gariepinus when their percentage inclusion in the diet formulations is over 25%. The high price of fish meal in Ghana has created a situation which warrants a thorough evaluation and improved use of alternative protein sources, especially locally available plant by-products in fish feed formulations at farm and commercial levels to boost fish production especially in small-scale farms [8]. Although most of the ingredients have a high potential for inclusion in fish diets due to their nutritional compositions and lack of competition as human food, they may still suffer the limitation of competition as such ingredients are utilized in poultry and livestock feed producing industries.

During the survey, ingredients such as bean (Phaseolus vulgaris) husks and leaves, dead poultry, brewery waste, cassava (Manihot esculenta) leaves, kitchen wastes and potato (Solanum tuberosum) leaves were sourced by fish farmers at no cost. These ingredients would attract cost and may become unaffordable when their demand and use in farm-made fish diets increase. The inter- and intra- regional differences in the unit costs of most of the ingredients used suggest that there will be remarkable differences in the cost of a kilogramme of farm-made fish diet production from region to region using the same ingredients. Hence, it will be more cost-effective to produce and use farm-made fish feeds in some regions than others using the same ingredients.

5. Conclusion

Small-scale pond fish farmers in the country are increasingly using farm-made fish feeds in feeding cultured fish. About 59% of farmers interviewed in all the five regions used farm-made feeds of which about 43% depended solely on farm-made feeds whilst about 57% used both commercial and farm-made feeds. Farm-made feeds were produced using locally available ingredients and their inclusion levels varied based on affordability. Research should be conducted to assess the cost effectiveness and growth performance of the farm-made and the commercial feeds. For fish farmers to produce good quality farm-made fish feeds, the farmers should be trained regularly in how to formulate and produce nutritionally balanced high quality fish feeds.

6. Acknowledgement

The authors wish to express their heart-felt sincere appreciation to all the Fisheries Extension Officers in all the Regions where the surveys were carried out for their assistance in reaching the farmers for data collection. Many thanks to all the fish farmers and other related groups and individuals who gave their priceless attention and time to volunteer the necessary information that made this study a success.

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