ISSN: 2347-5129
(ICV-Poland) Impact Value: 5.62
(GIF) Impact Factor: 0.352
IJFAS 2016; 4(3): 611-615

www.fisheriesjournal.com
Received: 28-03-2016
Accepted: 27-04-2016

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Proximate nutrient composition and cost of the selected potential fish feed ingredients in Lake Victoria basin, Uganda

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Abstract
Proximate analysis of ingredients provides reference database of the nutritional composition of the locally available ingredients that can be used in fish feed formulation. Proximate nutrient analysis was performed on seven locally mobilized ingredients from Uganda. The ingredients were analyzed for Moisture, Ash, Crude fat, Crude protein, Gross energy contents and matter basis using standard methods. Moisture content ranged from 8.05% in fish meal to 11.28% in chicken offal, ash content ranged from 4.21% in blood meal to 12.57% in fish meal, crude fat ranged from 1.44% in cattle blood meal to 7.66% in fish meal, crude protein ranged from 56.53% in chicken offal to 70.09% in blood meal while Gross energy ranged from 3673 Kcal/kg in fish meal to 4601 kcal/kg in chicken offal. The cost per kilogram protein ranged from Uganda shillings (Ugshs) 6.19 in chicken offal to Ugshs 7.1 in blood meal. The cost per kilogram energy varied from Ugshs 0.76 in chicken offal to Ugshs 1.38 in blood meal. In plant based ingredients, moisture content ranged from 5.44% in sun flower meal to 13.36% in bean seed meal, ash content ranged from 6.61% in soya bean meal to 10.39% in sun flower meal, crude fat ranged from 1.22% in bean seed meal to 16.37% in sun flower meal, crude protein ranged from 22.15% in cotton seed cake to 39.28% in soya bean meal whereas gross energy ranged from 2438.33 Kcal/kg in sun flower meal to 5025.00 Kcal/kg in cotton seed cake. The cost per kilogram protein ranged from Ugshs 4.33 in sun flower meal to 10.19 in bean seed meal and also the cost per energy ranged from Ugshs 0.22 in cotton seed cake to Ugshs 0.66 in bean seed meal. The results demonstrate that low cost per kilogram protein of the chicken offals make them better substitutes for fish meal and cattle blood meals that are not readily available and thus expensive fish meal. Similarly, the low cost per kilogram protein of sun flower and soya bean meal make them cost effective ingredients to use in feed formulation.

Keywords: Selected fish feed ingredients, proximate analysis, and Nutrient composition

1. Introduction

Uganda's total annual fish production is about 450,000 tones, 80% of which comes from capture fisheries and 20% from the aquaculture sector [1]. Between 2003-2005, there were about 20,000 ponds with an average surface area of 500m^2 but the number of fish farmers increased, with varying levels of establishment. Commercial hatcheries for catfish and tilapia fry production such as Kireka and Senya fish farms have reported decline in fish production due to lack of appropriate feeds. Industrial and more intensified fish culture is also being established largely through foreign direct investment or as joint ventures between local firms and foreign companies and the high demand in aquaculture has bolstered the shift to intensive fish farming systems in cage and tank fish farming. Intensive fish farming systems are highly productive and therefore, demand large volume of aquafeeds. Hence sufficient inventory of nutrient composition of the fish feed ingredients would quicken availability formulated feeds for improved aquaculture production.

Aquaculture has a great potential to improve food security in Uganda and the world, especially in the current state of declining capture fisheries potential as a result of the overfishing, environmental degradation and the introduction of the alien species which has been the major source of food fish for humans [1, 2]. This calls for the development of the aquaculture sector to reduce the pressure exerted on the natural fish stocks.

Despite the increasing global aquaculture production, production in Ugandan is still very low, averaging 95,000 tons in 2010 [1]. Among the reasons for the slow growth of the industry is short supply of good quality feeds in sufficient quantities for example Compost cribs and occasionally animal droppings are usually the main feed input in ponds. These, however, can only promote limited growth and further growth is restricted by insufficient nutrients from primary production, limited capital input and poor quality seeds. Further growth is only possible through provision of supplementary feed to sustain the increased demand for nutrients. Currently fish farmers use cereal bran, kitchen leftovers and green leaves as fish feed. This is because commercially formulated feeds are not constantly available in Uganda and the available feeds are not cost effective and beyond the reach of most fish farmers. Poor financial circumstances of the farmers within sub-Saharan Africa are one of the prime factors impeding aquaculture development [3]. Often feed is the most expensive operating cost item accounting for over 50% of costs in semi-intensive aquaculture [4]. and up to 70% in intensive aquaculture [5]. Lack of quality feed is such an issue that nutrition research should be given highest overall priority in the synthesis of national reviews and indicative action plans for sub-Saharan African aquaculture [6]. The lack of a reference database of the nutritional composition of the locally available ingredients continues to hinder the efforts of bridging the demand-supply gap of fish feeds in Uganda. An established reference database of ingredients therefore, will go a long way in stabilizing feed prices since this will be a tool that shall be utilized during feed formulation. In this study, the nutrient composition of seven ingredients was analyzed to make available the levels of moisture content, ash content, crude fat, crude protein and gross energy and their subsequent cost.

2.0 Materials and methods

2.1 Study area

The ingredients used in this study were collected from Lake Victoria Crescent Zone and the proximate analysis of the collected materials carried out at the Aquaculture Research and Development Centre (ARDC) - Kajjansi located 13km along Kampala Entebbe high way.

2.2 Fish feed ingredient identification and collection

Fish feed ingredients of the animal and plant origins were collected from different sources depending on its availability.

2.3 Fish feed ingredients of animal origin

2.3.1 Cattle Blood meal

Blood samples collected from city abattoir were boiled at 100°C for 45 minutes to evaporate water and sterilize the samples from pathogens. The resultant paste was then dried under a solar insulated drier for 15hrs before it was ground into powder using a portable electronic milling machine. The powder was further sieved through a 0.01µm plate and subjecting it to proximate analytical procedures in the laboratory.

2.3.2 Chicken offal

The chicken offal was purchased at Kajjansi market and was washed with the hands using tap water and then oven dried at 110°C for 2h and 30 min. The powder was further sieved through a 0.01µm plate and subjecting it to proximate analytical procedure as described [7]

2.3.3 Fish meal

Fish sample (Silver fish (*Rastrineobolla argente*a), locally known as (Mukene) was purchased from Kisenyi animal feed deport. Fish was then dried at 500 °C for 3h and 20min, the dried sample was grinded into fine powder using a hand milling machine and it turned into a solid product from which most of the water is removed and some or all of the oil is removed. The powder was further sieved through a 0.01µm plate and subjecting it to proximate analytical procedures in the laboratory.

2.4 Fish feed ingredients of plant origin

2.4.1 Bean seeds

The dried bean seeds were purchased from St. Balikudembe market-Kampala. They were soaked in water and then washed to remove the chemical (fungicide) which would affect the chemical composition of the ingredient. They were then dried under solar insulated drier for 15hour to evaporate the water. The dried sample was then ground using a hand milling machine into a fine powder. The powder was further sieved through a 0.01µm plate and subjecting it to proximate analytical procedure as described by [7]

2.4.2 Soya bean seeds

Soya bean seeds were purchased from St Balikudembe market-Kampala. The seeds were soaked in water to remove the fungicide which seller put. They were then dried thoroughly for 15hr to evaporate the water and then grinded into a fine powder using a hand milling machine and stored in sample bottles up to analysis.

2.4.3 Sunflower seeds

The seeds were purchased from St. Balikudembe market in Kampala. The seeds were dried thoroughly for one hour to evaporate the water and heated under controlled conditions for 15 minutes to deactivate the enzyme inhibitors and then grinded for thirty minutes into a fine powder and stored in sampling bottles awaiting chemical analysis.

2.4.4 Cotton seeds

These were also purchased from St. Balikudembe market-Kampala. The seeds were soaked in water to remove the chemical (fungicide) and then thoroughly dried for 1h and 25min to remove any moisture and then grinded for 30 min into a fine powder and stored in sampling bottles for analysis.

The ingredients above were preferred because of their availability in the region; they are nutritionally balanced for example fish meal has a high percentage of protein, limited competition with the livestock and some ingredients like cotton seed cake, blood meal assume to be cheap in the region.

2.5 Proximate nutrient analysis

The proximate analyses of moisture content, ash content, crude fat, crude protein, and gross energy were done in triplicates generally following [7] procedures.

2.5.1 Moisture content

Moisture content was determined by oven drying the sample at 100 °C to 105 °C for 12 to 24 hours after weighing the sample into a tarred (previously weighed) pan/crucible.

$$\%\text{moisture content} = \text{Final weight of the sample} / \text{Initial weight of the sample} \times 100$$

2.5.2 Ash content

Five grams of the sample was weighed accurately in a crucible which was dried and tarred. The crucible was then placed in drying oven at 100 ºC for 24 hours. The sample was then transferred to cool muffle furnace and the temperatures increased step wise to 550 ºC. The temperature was maintained for eight hours until a white ash was obtained. The crucible was removed from a desiccator and weighed soon after cooling.

$$\%\text{ Ash content} = \text{weight of ash} / \text{Initial weight of the sample} \times 100$$

3.5.3 Crude fat
Five grams of the duplicate sample was weighed in a fine form in to thimble. The thimble and content was placed in to 50 ml of extracting solvent in beakers, this was assembled in the soxhlet system. The sample contained in the thimble was extracted in the extracting solvent, by boiling at 100-109 ºC for 25 minutes and the rinsed for 45 minutes. At the end, the beakers were transferred into the oven and water soluble material evaporated for 45 minutes at 100 ºC. The beakers were removed from the oven, cooled in desiccator to room temperature and beakers were with fat extracted.

$$\% \text{ Crude Fat} = \text{weight of fat extracted/Initial weight of the sample} \times 100$$

2.5.4 Crude Protein
This was determined by the Kjeldahl nitrogen multiplied by 100/16 or 6.25 as developed by Johan Kjeldahl in 1883.

2.5.5 Gross energy
Five grams of the ground samples were weighed and then ignited with pure Oxygen in the Oxygen bomb calorimeter. The temperature inside the bomb calorimeter before burning the sample was determined and the sample temperature after burning was determined also and the gross energy of the sample calculated. With the two temperatures (before igniting and after igniting, the gross energy was determined.

Gross energy (Kcal/kg) (DM) = (C x ΔT- QF)/ (Mp x DM of AD) Where C is the warmth capacity of the calorimeter (J/k); ΔT is the measured temperature rise; QF is the sum of all foreign energies (wire and fibre, (J)); Mp is the weight of the sample (g) and DM of AD is the percentage of dry matter in the air-dried sample.

2.6 Calculating the cost per kilogram of a unit protein
The cost per kilogram of the feed was recorded after the purchase time and the amount of the protein of each ingredient determined, Amount of the protein=percentage crude protein of the ingredient × One kilogram of the ingredient (g)

$$\text{Cost per kg protein} = \text{Cost of the ingredient (Ugshs)} / \text{Amount of protein in an ingredient (g)}$$

2.7 Calculating the cost per kilogram of energy of an ingredient
The cost per kilogram of the feed was recorded after the purchase time and the amount of the energy of each ingredient determined as shown below,

Amount of the energy = Gross energy of the ingredient (Kcal/kg) × One kilogram of the ingredient (g) (ref)

$$\text{Cost per kg protein} = \text{Cost of the ingredient (Ugshs)} / \text{Amount of protein in an ingredient (g)}$$

3.0 Results and discussion
3.1 Proximate analysis of Animal based ingredient
Blood meal had the highest crude protein content of 70.09 % followed by fish meal (63.96%), chicken offal (56.53%) as indicated in Table 1. The crude protein content of blood meal obtained from the study (70.09%) was higher than that of cattle blood meal (65.20%) [8]. The difference in the crude protein composition is due to differences in cattle species to which blood was collected, poor handling procedures and the processing techniques used which finally affects its nutrient composition. The value obtained for chicken offal (55.87%) was comparable to the chicken offal value (54.82%) [9].

The ash content of the feed ingredients ranged from 4.21% in blood meal to 12.57% in fish meal. The high ash content of fish meal is attributed to the contamination with sand and other inorganic particles due to inadequate drying methods [10].

Table 1: Proximate nutrient composition of the animal based feed ingredients on dry matter basis

Feed Ingredient	Moisture content (%)	Ash Content (%)	Crude fat (%)	Crude protein (%)	Gross energy (kcal/kg)
Blood meal	9.63 ± 0.04	4.21 ± 0.26	1.44 ± 0.16	70.09 ± 0.25	4017 ± 4.73
Chicken Offal	11.28 ± 0.31	11.28 ± 0.31	2.58 ± 0.19	56.53 ± 0.33	4601 ± 9.02
Fish meal	8.05 ± 0.20	8.05 ± 0.20	7.66 ± 0.16	63.96 ± 0.80	3673 ± 5.29

3.1.2 Cost per kilogram unit protein
Generally, blood meal has a high cost per kilogram crude protein followed by fish meal and then chicken offal (Figure 1). The high cost of fish meal is attributed to the scarcity of silver fish because its supply is hampered by dwindling fisheries landings (due to over fishing, pollution), bad weather (El Niño) and increased demand from the fast expanding animal feed industry [11]. The high cost per kilogram of blood meal can be attributed to the competition among users as people also use it as food and for their petty animals.

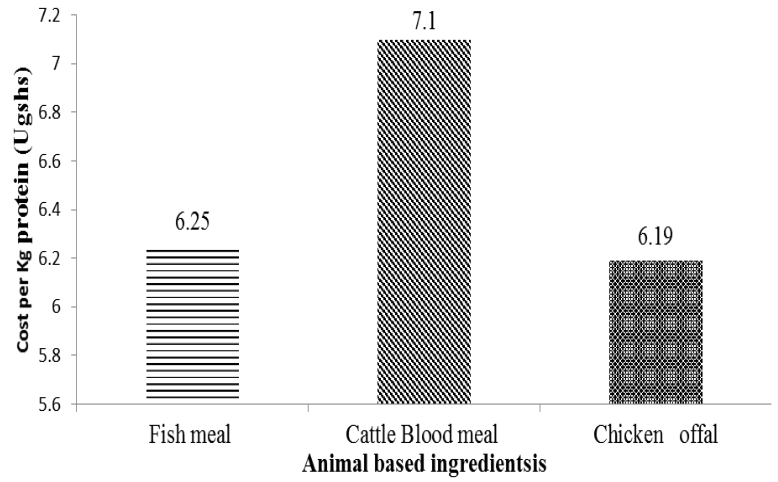

Fig 1: Estimated cost per kilogram of Crude protein for animal based ingredients

4.1.3 Cost per kilogram of the energy

Blood meal had the highest cost per kilogram energy value followed by fish meal and then chicken offal (Figure 2). The high cost per kilogram energy value of the blood meal and the fish meal is due to high demand and competition with other manufacturers like the poultry feed manufacturers within and outside Uganda. The scarcity of the fish meal in the capture fisheries makes the ingredient (fish meal) costly because many people need it but it is insufficient to satisfy the demand.

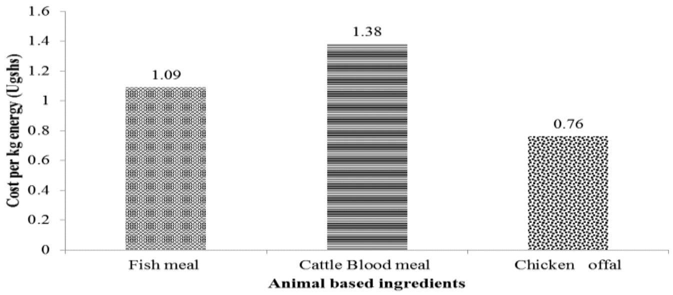

Fig 2: Estimated cost of the energy per kilogram of the animal based ingredients

3.2 Proximate analysis Plant based ingredients

The results of this study showed that soya bean meal had the highest crude protein (39.28%) followed by Sun flower meal (30.05%), bean seed meal (23.53%) whereas cotton seed cake had the least crude protein content of (22.15%) (Table 2). The value obtained for soya bean meal (39.28%) was comparable with the soya bean meal value (40.1%) [12]. Cotton seed cake had a lower protein content (22.15%) compared to cotton seed cake value (38.9%) [13].

Generally, the differences in the values could have been brought about by the varieties of the species, stages in the harvest and also the storage conditions of the ingredients. Sunflower meal had the highest crude fat content of (16.37%) followed by Soya bean meal (15.15%), Cotton seed cake (6.72%) whereas Bean seed meal had the lowest value of 1.22 %. Cotton seed cake had a low crude fat content (6.72%) compared to the crude fat content (12.50%) of cotton seed cake [14]**.** The reason for this variation can be due to the different species of cotton or the ripening stage at which they were harvested.

The moisture content for the experimental feed ingredients ranged from 5.43% in sun flower meal to 13.36% in bean seed meal. The high moisture content in the bean seed can be attributed to the drying rate of the seeds, stage at which the plant is harvested and also the storage conditions and the time the seeds spent in the store the moisture content of the feed ingredients is also affected by processing method and collection time of the ingredient.

The ash content of the feed ingredients ranged from 6.61% in soya bean meal to 10.39% in sun flower meal**.** The high ash content of sun flower meal can be attributed to processing techniques like direct sun drying on the bare ground which exposes the ingredient to contaminants like sand [15].

Table 2: Proximate nutrient composition of plant based fish feed ingredients on dry matter basis

Feed Ingredient	**Moisture content (%)**	**Ash Content (%)**	Crude fat (%)	Crude protein (%)	Gross energy (kcal/kg)
Bean seed meal	13.36 ± 0.39	8.87 ± 0.07	1.22 ± 0.09	23.53 ± 0.49	3617 ± 4.04
Cotton seed cake	8.52 ± 0.26	7.87 ± 0.18	6.72 ± 0.15	22.15 ± 0.35	5025 ± 5.73
Sun flower meal	5.44 ± 0.50	10.39 ± 0.17	16.37 ± 0.47	30.05 ± 0.79	2438.33± 5.95
Soya bean meal	8.77 ± 0.17	6.61 ± 0.09	16.37 ± 0.47	39.28 ± 0.98	4355 ± 4.00

3.2.2 Cost per kilogram of the unit crude protein

Bean seed meal had the highest cost per kilogram crude protein followed by Soya bean meal, Cotton seed cake and Sunflower with the least cost per kilogram crude protein (Figure 2). The high cost per kilogram protein of bean seed meal and sunflower meal is attributed to the high cost of the bean seeds and sunflower because of primarily being used as human food; it faces competition with people when it needs to be used in feed formulation. Soya bean meal faces competition with other users like poultry feeds, livestock feeds and piggery thus the cost per kilogram crude protein is also high.

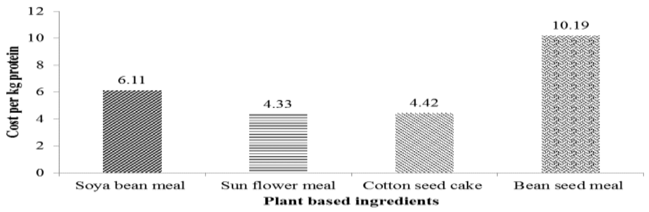

Fig 3: Estimated cost per kilogram of crude protein for plant based ingredients

3.2.3 Cost per kilogram energy of plant based ingredients

Bean seed meal had the highest cost per energy value followed by sunflower, soya bean meal and cotton seed cake with the least cost per kilogram of the energy value (Figure 4). The multiple uses of bean seed meal, soya bean meal and sunflower meal make them expensive as they are used as source of food for people and as ingredients to make animal feeds.

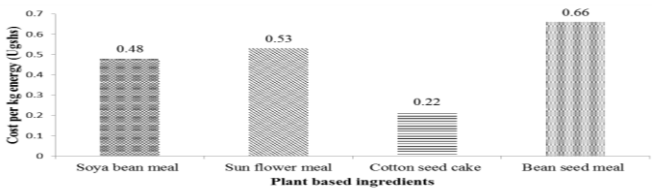

Fig 4: Estimated cost per kilogram of the energy of plant based ingredients

4. Conclusion

Aquaculture technologies in Uganda are increasing especially in the lake Victoria Basin. Furthermore, there exist chances for increasing aquaculture production through best management practices and other innovations. The ever increasing fish demand in Uganda through aquaculture will be met through the use of locally produced fish feed that will increase aquaculture production and make it attractive to all and the majority of poor people living in Uganda. Locally produced feed using locally available ingredients will reduce the cost of production and hence, cheaper fish to meet the protein needs of the population. Again, there is the need to further train fish farmers on how to formulate and produce nutritionally balanced high quality fish feed and government's policy to regulate the prices of the feed ingredients so that the feeds cannot be expensive in the long run.

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