COUNTRY REVIEWS: AFRICA

Analysis of feeds and fertilizers for sustainable aquaculture development in Cameroon

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SUMMARY

Aquaculture is an expanding activity in Cameroon. The availability of high quality fingerlings and feeds has been identified as the most important factors that constrain the development of the sector in Cameroon. The data and information presented here was obtained from the available literature and by interviewing key stakeholders in the sector.

Extensive and semi-intensive earthen pond fish farmings are the two most common aquaculture systems in Cameroon. Most small-scale rural fish farmers practice crib-based, compost aquaculture, without supplementary feeding. These cribs comprise around 10 percent of the pond water surface. A small-scale commercial sector is emerging in the peri-urban areas of Yaounde, Bafoussam and Bertoua. These farmers practise polyculture of Nile tilapia and African catfish in fertilized ponds using chicken manure and single feed ingredients such as wheat bran and cotton seed oilcake. More than 80 percent of the 800 tonne production in 2005 was derived from extensive and semi-intensive farming systems. In 2005, less than 200 tonnes of fish were produced using compounded feeds. There are three major and three smaller industrial animal feed manufacturers in Cameroon. Only one of the larger concerns produces aquafeeds. The total production capacity of animal feed manufacturers is estimated to be over 150 000 tonnes per year, though current production is less than 100 000 tonnes. In addition to the industrial sector, a farm-made livestock feeds sector is currently developing very rapidly in Cameroon, under common initiative groups that are less restricted by taxation policies. Most of the ingredients needed in classical animal compounded feed formulations are available on local markets. The prices of most feed ingredients have been relatively stable, except for maize and soybean products that are mostly imported.

To facilitate the development of the animal feed sector requires a renewed institutional and private sector focus. Its aims should be to provide information for the sustainable production of scarce ingredients such as maize, soybeans and fishmeal and facilitating the procurement of machinery for making and drying pellets using local technology. In particular, the public sector needs to accelerate the revision of import duties and taxes with respect to fuel, animal feed ingredients, fertilizers and machinery. In addition, researchers need to evaluate more of the locally available alternative feed ingredients and fertilizers and to provide farmers with a better comprehension of compost based aquaculture, which remains the most commonly used system.

1. INTRODUCTION

Aquaculture in Cameroon began in 1948. In comparison to other farming activities the sector is under developed. Fortunately, with the assistance of FAO and the WorldFish Center investor interest in the small-scale aquaculture sector is increasing. Seed and feed have been identified as key constraints for the development of the sector in the newly adopted strategic framework for aquaculture development in Cameroon (Moehl, Halwart and Brummett, 2005). As part of this strategy, the government will no longer set production goals, will endeavour to privatise all former public aquaculture stations, will facilitate development through generation and dissemination of technological and marketing information and focus on quality control of private sector seed and feed production. It should be noted that over 90 percent of fish producers in Cameroon are small, rural or peri-urban farmers who lack the resources to purchase costly feed ingredients. They rely mostly on nutrients derived from pond fertilization with organic materials of miscellaneous origins. In recent years the compound feed industry has shown tremendous growth, largely as a consequence of the rapidly expanding broiler chicken industry. Many of the ingredients used in the manufacture of chicken feed are also used for making fish pellets. Table 1 shows the contribution by livestock and fish to the protein requirement of Cameroon. The data show that fish, followed by beef are the two main protein sources for human consumption.

TABLE 1
Livestock and fish production in Cameroon (1998)

Sector	Population (thousand)	% contribution to national animal protein consumption
Cattle	4 846	25
Sheep	2 304	3
Goats	2 949	3
Pig	1 200	7
Poultry	31 000	8
Fish	*	54

*Total amount of fish consumed by Cameroonians was estimated in 2002 at 250 000 tonnes, of which 150 000 tonnes was from capture fisheries, 400 tonnes from aquaculture and the deficit (100 000 tonnes) imported.

Source: DSDSR (2002)

This review is based on secondary-sources of information and data derived from published papers and unpublished reports. Primary data and information were also collected from the field through consultations with professionals in the sector. The information used for this report is considered the most reliable and up-to date (mid December 2005) for Cameroon, even though some may differ from past available official data issued by the Department of Fisheries (MINEPIA), which is responsible for aquaculture development in the country.

2. GENERAL OVERVIEW OF AQUACULTURE PRACTICES AND FARMING SYSTEMS

2.1 Background

In 1952 the colonial administration built 22 aquaculture demonstration stations to strengthen the sector and by 1960 the number of private earthen fish ponds exceeded 10 000. Soon after independence in 1960 the extension effort collapsed and most ponds were abandoned. During the early 1970s a UNDP/FAO regional project increased the number of public aquaculture stations to 32. However, declining donor support and the transfer of aquaculture from the Forestry Department to the Livestock Department weakened the revival. Since 1980 there has been a revival in focussed donor support for aquaculture. The USAID common carp farming project in the Western Highlands (1980–1984, and PCV till 1998), the IDRC provided support for integrated fish cum pig and chicken farming from 1986 to 1990, the Belgian Cooperation Agency provided support for catfish seed production at the Foumban Research Station from 1990 to 1994, the French cooperation agency provided support for participatory aquaculture development in the Yaoundé region from 1994 to 1997, while DFID supported a participatory WorldFish Center project from 2000 to 2005.

The development of aquaculture in Cameroon since independence was therefore largely driven by donor support. Given the stop-start, top-down nature of support the evolution of the sector until the mid 1990s has been erratic. In 1995, after evaluating

TABLE 2
Aquaculture production (tonnes) in Cameroon (1990–2005)

Species	1990	2000	2003	2004	2005
Nile tilapia	80	180	250	350	450
North African catfish	6	120	180	230	300
Others	20	50	70	70	70
Total	**106**	**350**	**500**	**650**	**820**

Source: Author estimates, PNVRA, WorldFish Center, FAO Cameroon, CEPID and SEAPB (personal communication)

past experiences, the Cameroon Government promoted a more participatory approach such as those supported by the French Cooperation Agency and DFID. This has resulted in considerable changes in aquaculture practices, improved use of local knowledge and practical experience at the farm and village level. In addition, the revision of legislation regulating freedom of associations (1992) and increases in fish prices related to the devaluation of the CFA franc[1] in 1994 have created an environment favourable for sustainable aquaculture development. Population growth and the concomitant increase in the demand for animal protein have also contributed significantly to the rising fish price. As a consequence, many abandoned ponds have recently been rehabilitated and this has often been done without technical input from the extension services. This positive trend is facilitated by recent changes in policy and linked to the new market economy.

2.2 Major cultured species and production figures

An analysis of available data from the National Research and Extension Program, WorldFish Center, FAO Special Program for Food Security and the Department of Fisheries revealed that by the end of 2004 there were approximately 4 000 farmers with 7 000 ponds (>50 percent new or rebuilt since 1995) with an average size of 350 m². Total fish production from earthen ponds was estimated at 600 tonnes, of which more than 90 percent was produced by small-scale farmers. Nile tilapia (*Oreochromis niloticus*) was the most commonly farmed species, followed by North African catfish (*Clarias gariepinus*). The most common practice is polyculture of Nile tilapia with *Clarias gariepinus* where possible, or with other locally available species such as African bonytongue, *Heterotis niloticus* (local name: kanga), snakehead, *Parachanna obscura* (local name: viper fish), banded jewel fish *Hemichromis fasciatus* (local name: panther fish), common carp (*Cyprinus carpio*) or barbs, *Barbus* spp. (local name: gougeon) (Pouomogne, 2005). Fingerlings of the other species listed above are obtained mostly from the wild.

2.3 Aquaculture practices (size of installations, profitability, farming systems)

Aquaculture in Cameroon is dominated by the use of small ponds with an average size of 350 m² and indirect feeding through compost cribs loaded with organic material (mainly grass and weeds) and kitchen refuse. On average, the compost cribs comprise 10 percent of pond surface area. Average production is around 1 900 kg/ha/year (Pouomogne, field work findings 2004). The most progressive farmers (about 15 percent of the total) who are concentrated mainly around Yaoundé (the capital city), use additional organic fertilizers (dry chicken droppings from commercial chicken farms) or compounded low cost pellets (presently available from IRAD and WorldFish Center pilot feed manufacturing plants). The recent on-farm participatory approaches by the WorldFish Center and FAO have shown that production can be increased to around 9 000 kg/ha/year. A small number of commercial producers (FoodFishCorp and EPA) have attained production levels of 15 tonnes/ha/year. Well managed farms with more than 0.5 ha of water were found to be generally profitable. A recent WorldFish Center study involving a dozen farms around Yaoundé showed that sustainable profits are possible (up to 40 percent internal rate of return), particularly where fish farming was integrated with chickens or pigs (Pouomogne, 2003). However, a recent economic

[1] Cameroon local currency; average value in 2005 US$1.00 = CFAF530

TABLE 3
Differences in structural and price parameters between rural and peri-urban harvest markets in southern Cameroon (n= 84 farms)

	Type of harvest market		
Variable	Peri-urban	Rural	One-tail T-test
Number of buyers in market	25.4 ± 8.96	8.3 ± 7.32	0.0004
Average quantity per sale (kg)	4.1 ± 3.47	2.4 ± 0.76	0.1660
Total quantity marketed per harvest (kg)	89.9 ± 48.7	28.2 ± 23.5	0.0127
Total quantity given as gifts (kg)	55.7 ± 41.2	11.4 ± 9.3	0.0458
Total quantity consumed by household (kg)	50.3 ± 89.6	8.3 ± 6.8	0.3020
Catfish price (CFAF/kg)	2 583 ± 376	1 636 ± 354	0.0000
Tilapia price (CFAF/kg)	1 833 ± 408	1 054 ± 258	0.0000
Mean price all species (CFAF/kg)	1 908 ± 570	1 290 ± 386	0.0053

Source: Brummett (2005)

analysis showed that at the current price of CFAF100 for one 5 g catfish fingerling, most small-scale rural farmers are losing money, although they would be profitable at a unit fingerling price of CFAF50. Hence there is a need to reduce the production cost of catfish fingerlings. Table 3 summarizes some socio-economic variables of the recently ended WorldFish Center project.

2.4 Aquaculture development policy in Cameroon and future prospects

Compared to other farming activities, aquaculture in Cameroon remains under developed. To address this inadequacy a strategic framework was developed to accelerate the development of the sub-sector. Facilitated by the FAO and WorldFish Center, the framework was approved at the end of 2002 and provides the foundation for the development of a strategic aquaculture plan (Moehl, Halwart and Brummett, 2005). The framework fits within the Development Plan for the rural sector and the poverty alleviation strategic plan currently implemented by the government (DSRP, 2000; DSDSR, 2002).

The strategic framework defines the respective roles of the public and the private sectors and relevant key points are highlighted below:

- The role of government will be largely restricted to the provision and dissemination of information and will be geared towards control of production and market chain activities to reduce hindrances linked to the interaction of various actors in the field and will cease to participate in any direct production activities. The private sector (including commercial and non-commercial producers, investors, NGOs (Non Governmental Organizations), banks, development agencies) will be directly responsible for the development of the sub-sector. Under these conditions, a sharp reduction of current government infrastructure will occur, which in turn provides opportunities for the private sector (e.g. aquaculture stations). Moreover, the framework recognises that previous interest in aquaculture was driven largely by misdirected assistance, inappropriate information and promotion of the activity in unsuitable environments and was therefore mainly artificial. Henceforth, the development of the sector will be driven by market forces. Scarce government resources can then be mobilised to focus on promoting aquaculture in identified high potential zones, using "mobile mixed teams", including senior researchers and multidisciplinary extension technicians. The proposed new dispensation will compel producers to work together through fish farmers' associations and to facilitate information flow within and between associations, their members, and the market.
- The availability of good quality fish seed has historically been a major constraint to aquaculture development. Within the new strategic framework, government will retain the responsibility of progressive training and will aim to provide private fingerlings producers with up-to-date information on seed production

and hatchery management. Moreover, the public service, through its own infrastructure or specialised NGOs acting for the government will be responsible to develop and maintain brood stock to ensure a regular supply of certified and improved genetic material to private fingerling producers.

- Outreach (extension services) in Cameroon, as elsewhere in sub Saharan Africa, remains a major debacle in aquaculture development. Lessons learnt from the past emphasize the effectiveness of specialized technicians providing on-farm support and supervision or through on-farm participatory research. However, the cost of this approach is prohibitive and unsustainable. By contrast, repetitive failures have been registered with generalist extension services providing advice in the field of aquaculture. A compromise should thus be sought, with *inter alia*, the idea of "mobile mixed teams" evoked earlier, or the establishment of technical assistance contracts with specialised NGO partners on the basis of objectively verifiable indicators. In high potential and prioritised zones (e.g. peri-urban areas of large cities such as Yaounde or Douala), government should explore the opportunity of providing high level technical assistance to suitable and specifically identified private producers. In return for this support such commercial producers would be required to lend support to non-commercial farmers.

To ensure the success of the initiatives a multi-disciplinary committee comprised of representatives of major stakeholders is needed to monitor development and revise the strategy on an iterative basis as and when necessary. For some recurrent issues, such as high level education and training, new outreach paradigms or specific regulatory aspects (e.g. fish handling practise, introduction of alien species, pond effluent management, etc), multilateral partners may be needed to better tackle the issues at the regional or sub-regional level rather than at the national level. In addition, the framework tackles some specific questions, including the future of public aquaculture stations. It is suggested that most of these stations be sold or leased to the private sector on the basis of existing laws and procedures on the sale or lease of public property. One or more stations, preferably those in high potential zones, should be maintained by the State for training, research and genetic management of brood stock.

3. REVIEW AND ANALYSIS OF AQUACULTURE FEEDS AND FEEDING

Compounded balanced diets are used only marginally by Cameroonian fish farmers. More than 90 percent of fish producers in Cameroon know nothing about compounded fish pellets. They depend mostly on on-farm resources such as vegetable matter, animal manure and household wastes for pond inputs. Some farmers provide supplementary feed in the form of agro-industrial by-products such as cereal bran, where affordable.

3.1 Fertilizers, feed ingredients and feeds

3.1.1 Seasonal availability, cost, accessibility, nutritional composition

a. Fertilizers and on-farm aquafeeds

The materials described below are used as pond inputs to stimulate natural water productivity. They are normally dumped into the compost crib or are spread over the water surface. Depending on the level of integrated farm activities and the scale of operation most of these materials are available on the farm. These commodities are farm by-products and are free of charge for most small-scale farmers.

Manure (chicken, pig, rabbit, goat, sheep, cattle)

More than 40 million land animals are reared in Cameroon per annum (DSDSR, 2002). Manure production from this standing stock has been estimated to exceed 30 million tonnes per year. This manure is available all year round and is used mostly for vegetable production and for natural fertilization of extensive pastures. These materials are well suited as fish pond fertilization inputs, with dry manure: fish conversion rates varying

from 4–6 for chicken litter to more than 10 for cattle manure. This variation is related to the C:N ratio of the manure, estimated at about 10:1 and 25:1 for chicken and cattle manure, respectively (ODA, 1986, cited by Pouomogne, 1994).

Laos grass and "marguerite"
Laos grass (*Chromolaena odorata) and* "marguerite" (*Tithonia diversifolia, Leucanthemum vulgare*) are available all year round. Both grasses were tested as compost crib input in small ponds (Yossa, 2003) and are now commonly used in most rural fish ponds. The chemical composition on a dry matter basis is as follows: N= 3.2 percent, P = 0.19 percent, K= 2.3 percent, Ca = 1.1 percent, and Mg = 0.55 percent for *Chromolaena odorata*; N= 3.17 percent, P =0.2 percent, K = 3.22 percent, Ca = 3.5 percent, and Mg = 0.41 percent for *Tithonia diversifolia* (Pouomogne *et al.,* 2005).

*Elephant or napier grass (*Pennisetum purpureum*)*
Napier grass is commonly used by fish farmers, both as compost input and as feed for herbivorous species. A certain degree of competition exists for this material as it is also used as a feed for ruminants and pigs. It grows mostly in fertile wet lands. Availability is restricted to the rainy season, from April to October. *P. purpureun* contains 6 percent crude protein (dry matter basis) and 9 percent ash (Pouomogne, 1994).

*Water lily (*Nymphaea *sp), papyrus (*Cyperus *sp) and water hyacinth (*Eichhornia crassipes*)*
These aquatic weeds are available all year round and also occur in many ponds where they have been voluntarily introduced by the farmer to mistakenly "provide shelter to fish". Unfortunately, and as could have been expected, the plants have covered the entire water surface and pond bottom. No formal composting trials have been undertaken to test these materials as pond inputs. Chemical composition of these materials show lower nutritional content compared to Napier grass (New, Tacon and Csavas, 1994).

Cacao husk, coffee pulp
These by-products are available mainly during the harvesting season from November to February. Total availability in 2000 was estimated at 300 000 and 75 000 tonnes, respectively. Both are used as compost crib inputs and in the dry form can also be used at a 20 percent inclusion rate in tilapia and catfish pellets (Pouomogne, Takam and Pouomogne, 1997; Mvouti, 2001).

Cassava pearls and soaking residues
Cassava is one of the staple foods most commonly consumed by rural farmers within the forest areas of Cameroon. Annual production is estimated at 2 million tonnes (DSDSR, 2002). Before consumption the entire tuber is soaked for 2 to 7 days to facilitate pealing and to decrease the cyanidic toxin component of the tuber. The soaking is commonly performed in fish ponds or nearby small streams. The fertilizing material consists of the abandoned "pearls" and the white juice that is diluted in the water during the soaking process. The recommended application rate for pond fertilization is 10 tonnes cassava soaked per ha per week (Pouomogne, 1994). The nutritional composition of cassava is presented in Table 4.

Other on-farm by-products used as feed or fertilizers
Other on-farm by-products that are used for pond fertilization or as feed include palm oil pressure extraction molasses, sugar cane molasses, bean envelopes, over ripe fruit (papaya, guava, avocado), kitchen wastes, dead animals (mostly chickens and

pigs), slaughtered animal viscera, miscellaneous forest fruits and termites. All the above are commonly used on an *ad hoc* basis, though precise application rates have not been determined. The availability of these materials is regular and farmers are now demanding reliable scientific information for greater efficiency. Kitchen refuse appears the most readily available commodity with which to load compost cribs. An average of 1.2 tonnes/household/year is produced in the western Cameroon highlands (Pouomogne, Brummett and Gatchouko, 2004, *unpublished data*). The chemical composition of some of the materials are presented in Table 4.

TABLE 4
Proximate composition (% dry matter basis) and availability of common pond input materials in Cameroon (2005)

Material	Crude protein	Ash	P	Ca	Peak availability
Laos grass (*Chromolaena odorata*)	26	-	0.2	1.1	Everywhere, all year
Marigold/marguerite(*Tithonia diversifolia*)	23	-	0.2	3.5	Nearby roads, all year
Elephant or Napier grass (*Pennisetum purpureum*)	6	17	-	-	Wet and fertile soils, all year
Cassava peelings	7	-	0.1	0.2	Household, all year (Feb–May)
Bean peels	30	-	0.4	0.1	Farm plots, Nov–Feb
Leucaena (whole)	24	7	-	-	Farm plots, all year
Mimosa (*Mimosa pudica*) leaves	30	5	-	-	Farm plots, all year
Groundnut leaves	16	19	-	-	Farm plots, July–Sept
Sweet potato leaves	15	-	0.3	0.4	Farm plots, Nov–Feb
Cassava leaves	27	10	-	-	Farm plots, all year
Taro leaves	17	-	0.2	0.6	Farm plots, all year
Macabo leaves	16	-	12.0	-	Farm plots, all year
Water lily/nenuphar (*Nymphaea sp*)	-	-	-	-	Marsh areas, all year
Water hyacinth	15	-	0.5	0.9	Marsh areas, all year
Papyrus	10	-	-	-	Marsh areas, all year
Ripe avocado fruit	12	-	0.3	0.1	Households, farm plots (March–June)
Ripe guava fruit	11	-	0.2	0.1	Farm plots, all year
Guava leave	9	-	0.1	2.2	Farm plots, all year
Ripe banana peels	10	-	0.2	0.3	Households, farm plots
Ripe banana fruit	7	-	0.1	0.1	Households, farm plots
Papaya fruit	6	-	0.1	0.3	Households, farm plots
Papaya seeds and pulp	27	-	0.4	0.5	Households, farm plots
Papaya peels	18	-	0.2	0.3	Households, farm plots
Ground nut peels	5	2	-	-	Households, farm plots (Jul–Sept)
Kitchen wastes	20	1	-	-	Household, all year
Wild mango (whole)	4	-	0.1	0.3	Household, March–May
Miscellaneous forest fruits	6	-	-	-	All year, Aug–Nov, Southern Cameroon
Palm oil pressure extraction molasses	12	-	-	-	All year
Sugar cane molasses	2	3	-	-	Industrial firm, Bandjock, all year
Dead animals	50	-	-	-	Households and farm plots, all year
Slaughterhouse wastes	52	-	-	-	All year (festivals)
Cow rumen content	60–70	14	-	-	All year (festival)
Termites	-	-	-	-	All year
Snails	61	9.1	-	-	All year
Pig manure	-	-	-	-	Households, southern Cameroon
Cow manure	9	40	-	-	Household and pastures,
Goat/sheep manure	-	-	-	-	Nationwide, all year
Rabbit manure	-	-	-	-	Households, all year
Fresh chicken manure	27	35	-	-	Households

Most of these materials are available free of charge. The main constrains when available are related to collection and transportation cost.

Source: Hauber (2005)

Wood ash and inorganic fertilizers
Wood ash from kitchen fires is occasionally also used for pond fertilization. Inorganic fertilizers are not commonly used in Cameroon small-holder ponds and this is mainly due to the high price of the commodity. In some commercial farms NPK (20:10:10) is the most commonly used fertilizer at an application rate of 50 kg/ha/month to enhance phytoplankton start up, followed by organic fertilization and supplemental feeding.

b. Feed ingredients
The materials discussed in this section are produced by agro-industrial plants. They are used either as single feeds or are compounded with others and fed to fish in the form of dough or pellets, but mostly as dry meal. Feed conversion ratios in semi-intensive pond culture are generally below 8:1 for most of these by-products. Prices fluctuate widely according to supply and government taxes. All of these feed materials are subject to transportation constraints such as bad roads, high transport costs, police harassment and corruption.

Wheat bran
This is a by-product of the wheat flour milling industry. All wheat used in Cameroon is imported. An estimated 30 000 tonnes of wheat bran was produced in 2004. There is a high demand for this relatively low cost commodity, particularly by pig farmers. Given its current price (CFAF60/kg) and the favourable crude protein and gross energy contents (11–16 percent and 18.0 kJ/g respectively), the use of wheat bran as a fish feed has been widely promoted and is now used by most small-scale commercial farmers, alongside with dry chicken layer droppings.

Rice bran
Rice bran production in Cameroon has decreased over the last 15 years. National production in 1990 was estimated at 25 000 tonnes (Fomunyam *et al*., 1990), while current production is less than 10 000 tonnes. Rice bran is used in fish farming in the same way as wheat bran.

Maize
Current national production is estimated at 1.2 million tonnes and there is high user competition for the commodity. The price varies from FCFA75/kg immediately after harvesting in mid July to more than CFAF210/kg in May of the following year. National production does not meet the demand and annually more than 20 000 tonnes are imported. Maize is also used in the manufacture of compound fish diets.

Cotton oil seed cake
The main producer of this ingredient is Sodecoton, a newly privatized firm based in the Northern part of Cameroon. Production in 2004 was estimated at 60 000 tonnes. Its high protein content (49 percent) and relatively low price of CFAF125/kg (2.3 times lower than soybeans) makes it a preferred fish feed ingredient (see formulations in Table 6). Because of the high gossypol content a maximum inclusion rate of 30 percent in compounded fish feeds is recommended (Pouomogne, 1994). Price fluctuations for cotton oilseed cake are negligible.

Groundnut oil cake
Groundnut oilseed cake is another substitute of soybean oilcake in compounded fish feed. It has a similar protein content to soybean oil cake. Current production fluctuates significantly. When available on local markets, it constitutes a good substitute for soybean or cotton seed oilcakes. The price in 2005 of CFAF150–200/kg was lower than for cotton and soybean oilseed cake. Storage of groundnut oilseed cake is problematic.

Compounded feed containing this ingredient is easily contaminated by aflatoxins that can result in high fish mortalities.

Palm kernel cake
This residue of palm kernel oil extraction is one of the cheapest commodities that can be used in compounded fish feeds (CFAF40/kg). About 20 000 tonnes were produced in 2004. The strong smell limits its consumption by most animals and hence the use of the product is minimal. In fish farming, the highest inclusion rate in compounded diets is 10 percent (Pouomogne, Nana and Pouomegne, 1998; Jauncey, 1998).

Soybean oilseed cake
This is the main ingredient used as a protein source in animal feeds in Cameroon. National production of soybean cake is low (<1 000 tonnes in 2004). In 2004, an additional 14 000 tonnes were imported to meet the demand. It is available all year round at a price of just over CFAF300/kg.

Brewery waste
More than 30 000 tonnes of brewery waste is produced annually by the lager breweries. Proximate analysis reveals crude protein = 27 percent, crude lipid = 8 percent, crude fibre = 21 percent, ash = 4 percent and energy = 21.5 kJ/g (Pouomogne, Nana and Pouomegne, 1998). The material is mostly used fresh (75 percent moisture content) as pig and cattle feed and as a pond compost input. It is also used dried and milled in compounded diet for ruminants (cattle, goats, sheep and horses) and in fish feed. At a 20 percent inclusion rate, it also serves as a binder in meat-mincer made fish pellets.

Dry chicken layer droppings
National production in 2004 was estimated at 5 million tonnes. There is a very high demand for chicken manure by peri-urban horticulture and fish farming. It is incorporated in fish pellets (20 percent) and is available all year round, at a price of CFAF60/kg.

Animal meals and additives (oil, minerals, appetizers, binders)
The local fishmeal is mostly derived from milled dry wastes from smoked tilapia, catfish and clupeids (*Sardinella sp* and *Ethmalosa sp*). Fishmeal used by the animal feed industry is imported. In 2005 some 1 000 tonnes were imported and 5 000 tonnes were produced locally. Feed additives, including certain essential amino acids, fatty acids, vitamins, minerals and appetizers, are available on the market as a premix, which is imported for inclusion into chicken feeds.

Other miscellaneous ingredients (coffee bean pulp, cacao husk, Laos grass Chromolaena odorata*, avocado)*
Investigations at IRAD have shown that most of the above ingredients can be incorporated at an inclusion rate of around 20 percent without any significant effect on growth of Nile tilapia in semi-intensive pond culture. Estimated availability of cacao husks and coffee pulp in Cameroon in 2000 was 300 000 and 75 000 tonnes, respectively. Recent investigations have shown that avocado could be incorporated at a level of 10 percent on a dry weight basis into the Standard CP31 diet (see later) for *Clarias gariepinus*. Similarly, a 10 percent inclusion of dry and milled Laos grass in the compounded standard pellet had no significant negative effect on growth and survival of Nile tilapia. Through on-going research the standard pelleted fish feed in Cameroon (CP31 formulation) is continually undergoing least costing changes.

TABLE 5
Protein content, availability and price of major fish feed ingredients in Cameroon (2005)

Ingredient	Crude protein (% dry matter)	Quantity (tonnes/year)	Average price (CFAF/kg)	Peak availability
Crayfish meal	60–76	*	700	Market, all year
Fishmeal (white)	59–66	6 000	600	Feed retailers, all year
Cattle meat meal	50–58	*	600	Sodepa, all year
Blood meal	82–87	*	700	Idem
Concentrate /premix	22	1 000	1 000	Import, retailers
Bone meal (dry powder)	*	*	175	Feed retailers
Groundnut cake	32–40	*	250	Idem, Sodecoton Garoua, CHOCOCAM-Douala
Soybean oil cake	45–49	15 000	360	Import, retailers
Cotton oil seed cake	48–50	70 000	160	Sodecoton, retailers
Brewery waste	18–26	30 000	15	Lager Beer Breweries, nationwide
Wheat bran	12–17	30 -000	50	STC Wheatflour factories Foumbot, Sodeblé Ngaoundere, retailers
Rice bran	8–11	10 000	50	Semry, Soderim, retailers
Maize	8–12	1 200 000	140	Maiscam Ngaoundéré, markets, retailers
Millet (sorghum)	8–12	400 000	150	Idem, Northern Cameroon
Palm kernel oil cake	10–16	20 -000	40	CDC, SOCAPALM, retailers
Cocoa husk	14	300 000	*	Farms plot southern Cameroon (Nov–Feb)
Coffee pulp	11	75 -000	*	Idem, Western highland Cameroon
Dry layer droppings (industrial)	22–28	5 000 000	50	SPC and EPA stores, Nationwide, all year

* Data not available; CHOCOCAM = Chocolaterie de Cameroun; CDC = Cameroon Development Corporation; SOCAPALM = Société Camerounaise des Palmeraies; SPC = Société Camerounaise des Provenderies; EPA = Elevage Promotion Afrique

Source: Hauber (2005) and author estimates

c. Compounded pellets

Four compounded fish diets are currently available in Cameroon. These include a dry mix (usually made by mixing 2 or 3 ingredients), a compound diet made by extrusion through a meat mincer and sun drying the pellets, a commercially available extruded pellet (made by a single manufacturer) and a flake diet made for ornamental fish farming. Most of the feeds contain around 30 percent crude protein, all from plant origin except for the commercially extruded diet, which contains fishmeal. With the development of low-cost formulations using up to 30 percent of non-conventional ingredients, such as cocoa husks and dry chicken manure, the cost price of these pellets vary from CFAF170–250/kg. The retail price varies from CFAF225–500/kg according to demand. The total quantity of pellets used in 2004 was estimated at 100 tonnes. Demand is however increasing and the estimate for 2005 exceeded 300 tonnes. The main aquafeed producer was FoodFishCorp (extruded pellets), while IRAD and most small-scale commercial peri-urban fish farmers produced CP31 and CP45 pellets by alternative means (Pouomogne, Nana and Pouomegne, 1998; Mbongo and Yossa, 2004). Information on the availability, price and crude protein content of the most commonly available fertilizers and feed ingredients are presented in Table 5.

3.1.2 Feeding / fertilization practices (feeding rates, pellet size, feeding frequency)

As indicated earlier, aquaculture in Cameroon is primarily based on a fertilization system using a compost crib built inside the pond. The crib is filled with miscellaneous inputs that are available on the farm. The typical rural/subsistence based farm pond crib is a bamboo frame comprising approximately 10 percent of the water surface area. Prior to stocking the pond, the crib is loaded with weeds and grass and available

animal manure. There after, all available household food wastes are dumped into the crib, the contents of which is then turned and mixed biweekly. In this system, fish depend entirely on natural productivity of the water body. Nile tilapia are stocked at an unknown density (usually the left overs of the preceding rearing cycle), and secondary fish species (*Clarias sp.* and/or *Parachanna obscura*) are added when possible to control the tilapia population.

The follow-up to the above scenario is where the farmer aims to commercialize the enterprise. The system is essentially the same as above except that there is a greater degree of controlled management and an improved feeding/fertilization regimen. In such cases stocking density of Nile tilapia is usually 1 to 2 per m² plus an equivalent density of *Clarias gariepinus*, *Heterotis niloticus* or *Parachanna obscura,* and farmers are prepared to use scarce animal manure as a pond input rather than for vegetable growing and regularly apply supplementary feeds such as cassava, cocoyam, banana leaves, chopped up dead farm animals, over-ripe fruit and household food leftovers. The feed application rates are not standardized and essentially depend on the availability of the materials.

In close proximity to the main cities of Yaounde and Bafoussam, where farmers have easier access to pond inputs, the second system has evolved further. Peri-urban fish farmers feed their fish directly and no longer rely purely on natural productivity. However, presently the price of feed ingredients is still more important than the nutritional balance of the feed. Among other options, farmers feed their fish with fresh or sun dried brewery waste and wheat bran and water fertility is enhanced mainly by the application of animal manure. Water quality is monitored by way of crude Secchi disks and manure is applied as and when necessary. Some of the peri-urban farmers have livestock pens above their ponds to enhance primary production (Pouomogne, 1994). Pen stocking densities are at a rate of 1 pig (>25 kg weight) or 50 chickens (>3 weeks old) per 100 m² water surface.

There are only a few commercial farms where ponds are not fertilized and fish are fed entirely on a balanced diet. Stocking density of fish in intensive systems is higher (up to 3 Nile tilapia + 3 *Clarias gariepinus* + 1 *Heterotis niloticus* per m²), and ponds are intensively managed. Floating feeding frames are commonly used and the fish are fed according to prescribed feeding tables depending on mean fish weight. The use and practicality of demand feeders is currently being tested by IRAD.

3.2 On farm feed management strategies and pond management techniques

3.2.1 Pond management techniques

Ponds in Cameroon are mostly of the derivation type (receiving water through a feeder canal or pipe). This technology and a minimum water depth of 1.2 m and surface area of 200 m², has led to higher fish yields and the increased demand and price of fish has led to pond rehabilitation in many areas. However, the level of management and production depends largely on the means and motivation of the farmer.

a. In rural subsistence based aquaculture the farmer uses left over small fish from the previous rearing cycle. Tilapia are raised either in mono or in poly-culture with a “police fish”. The preferred “police fish” is African catfish, which is stocked at a ratio of 1 predator per 4 m². Alternatively indigenous wild species, captured from the surrounding streams, are used and these include native catfish (*Clarias jaensis*), viper fish, panther fish, kanga, gougeon, etc (see corresponding scientific names in the earlier section). Fish are fed with available on-farm materials, including cassava, cocoyam, banana leaves, kitchen refuse, termites, etc. Each pond contains a compost crib and production hardly reaches 3 tonnes/ha/year.
b. In small-scale commercial aquaculture, single feed ingredients are used to feed the fish along with pond fertilization and often integrated with chickens or pigs

reared above the pond water. Pond preparation is performed using quick lime (10 to 30 kg per 100 m² water surface, depending on the nature of the pond bottom and on the farmers understanding of technical recommendations). Normal stocking density is 1 to 2 tilapias plus 1 catfish per m², plus some other fish species at a lower density. Higher production levels have been recorded when the number of species in the pond is increased and the pond is adequately fertilized and fed.

c. Compounded pellets and extruded feeds are commonly used in peri-urban, medium or large commercial farms. Stocking densities are higher at up to 7 fish per m². Strict feeding protocols are maintained, fish are sampled every two months and feed is adjusted accordingly. Production levels of between 9 to 17 tonnes/ha/year have been recorded in some of these systems.

3.2.2 Feed formulation, processing and storage

a. Formulation

Farm made supplemental feed formulations are diverse. Most small-scale commercial farmers use single ingredients to feed fish, based on affordability and seasonal availability. Wheat and rice bran are the two most common single feeds, while farmers around the oil factories use cotton oilseed cake. Other single ingredient feeds for tilapia and catfish polyculture include brewery waste, dry chicken droppings, rotten maize, beans or kitchen leftovers. More innovative farmers use a combination of mixed ingredients either in a dry or a moist form. The available formulated feeds (see Table 6) are used by the more advanced commercial farmers, while the larger companies use formulations as recommended in the international literature (Jauncey, 1998; Guillaume *et al.*, 1999).

b. Processing

The common feed processing practice by small-scale, peri-urban fish farmers consists of sun drying the wet ingredients, milling the dried ingredients in a disk or hammer mills, sieving, mixing and then extruding the mixture through a mincer (2 or 5 mm diameter) after moistening with 30 percent water. The pellets are then sun dried and packaged into 50 kg bags. Sun drying is not possible during the rainy season (i.e. from

TABLE 6
Feed formulations developed in Cameroon for Nile tilapia in polyculture with African catfish and other species

Ingredients	Grower, IRAD CP31 (fertilized ponds)	Grower tilapia 2 (intensive system formula)	Starter, IRAD CP45 (tilapia or *Clarias* below 10 g)
Fishmeal	-	20	55
Soybean meal	13	15	5
Cotton seed meal	15	15	5
Groundnut meal	12	5	4
Brewery waste	10	15	10
Rice or wheat bran	20	15	2
Cocoa husk or coffee pulp	10	-	-
Layer droppings meal	15	-	-
Corn meal	-	8	3
Bone meal	1	-	4
Palm oil	2	2	5
Premix*	2	5	5
Proximate analysis			
Crude protein	28.5	34.5	43.3
Fat	8	9	11
Gross energy (kJ/g)	?	19.2	20.4

*Contains: 50% Met-Lys-Thr-efa-vitamins mix, 25% appetizer (crayfish), and 25% binder (wheat flour)

Source: IRAD and private feed company

April to November in southern Cameroon). At a moisture content above 10 percent pellets become mouldy and unsafe after a few days. An air drying system is currently being tested to address this problem (see Figure 16, Hecht, this volume), because electric, oil or wood dryers are too expensive for small manufacturers. An air dryer of this type with a 100 kg drying capacity costs CFAF100 000. An electric dryer of the same capacity costs 5 to 8 times more. FoodFishCorp produces pellets with an industrial extruder with a capacity of 100 tonnes per month. The ornamental fish feed manufactured in Cameroon is formulated and contains an antioxidant, which plays a key role in the stability of the feed both for nutritive value and for long term storage. After preparing the moist formulation, the mixture is spread in a thin layer, hand pressed using wooden rollers and ultimately pressed between two electrically heated metallic sheets under a precise temperature, pressure and time protocol.

c. Storage

Dried and packed pellets are stored in aerated halls and must be used within four months following manufacture. Formulations containing more than 15 percent groundnut oilseed cake have to be used within two months after packaging.

3.2.3 Feed / fertilizer efficiency and labour cost

Conversion efficiencies for tilapia in polyculture using currently available inputs for crib based systems in rural fish ponds are estimated to range from 8 to 30:1. Most often, labour does not constitute a limiting factor except during the staple crop farming season. Commercial fish farmers who use supplemental feeds show efficiencies 4 to 10 time higher than their rural counterparts. Food conversion ratios of 1.5 to 6:1 have been recorded.

3.3 The development of the aquafeed industry, with special reference to Nile tilapia and African catfish

Aquafeed production in Cameroon remains insignificant and has by no means reached its full potential. Data presented in this section refers mainly to the chicken and pig feed industries.

3.3.1 Overview

The compounded animal feed industry is dominated by the production of chicken feed (70 percent), followed by pig (20 percent) and rabbit feeds. There are three major feed producers (Sodecoton, Société des Provenderies du Cameroun (SPC), Elevage Promotion Afrique (EPA) and several smaller concerns (Complexe Avicole de Mvogt Betsi (CAMB), SABEL, Ets Nkam and GICABAF). In the past SPC and EPA produced about 20 000 tonnes annually (Table 8), however since 2004 both companies have decreased their annual production and now mainly produce feeds for their in-house requirements only.

Soybean oilseed cake is the most important imported feed ingredient (average consumption during the past five years was 11 000 tonnes per annum). The major importers belong to the Chicken Market Chain Syndicate in Cameroon (SIFAC) and these have joined the recent established association for the Defense of Consumer Rights (ACDIC) to fight against subsidised frozen chicken imports from the European Union by the government. All major players oppose the current regulations controlling the animal feed industry. New regulations are under discussion, including the duty free importation of milling equipment and raw materials such as fishmeal, soybean meal, concentrates and other premixes, a five-year tax holiday for new feed millers entering the industry and a code of investment encouraging foreign companies to participate in the Cameroonian animal feed industry (see Moehl, Halwart and Brummett, 2005; MINEPIA, 2005).

TABLE 7
Local and imported animal feed ingredients in Cameroon from 2001 to 2005 (tonnes)

Ingredient	2001	2002	2003	2004	2005*	Origin	Availability**
Soybean oil cake	8 968	12 472	10 824	13 648	7 033	Import	Adequate
Cottonseed oil cake	47 601	50 544	49 119	58 354	63 625	SODECTON	Adequate
Maize "gritz"	8 811	12 022	11 098	10 988	9 067	Import	Poor
Veterinary drugs	126	149	111	124	95	Import	Adequate
Premix	?	1 094	601	22		Import	Adequate
Miscellaneous	4 576	5 724	4 320	4 073	4 011	Import	Excellent

* From January to October 2005
**Precise data on prices were not provided in the reference document.
Source: Groupement Professionnel des acconiers (2005); Sodecoton (pers. comm.)

TABLE 8
Compounded animal feed production in Cameroon

Firm	2000	2001	2002	2003	2004	Capacity tonnes/year	Observations
FishFoodCorp	0	0	0	0	40	1 000	New firm
Sodecoton	28 286	47 601	50 544	49 119	48 354	30 000	Developing
SPC	19 200	18 500	19 000	14 000	18 800	50 000	Strategic changes
EPA	20 600	21 500	14 400	10 800	2 000	25 000	Declining
Ets Nkam	1 900	2 000	2 150	1 800	2 400	5 000	Increasing
CAMB	2 -000	2 500	3 000	3 750	4 000	20 000	Increasing
SIPREK	-	-	-	-	-	15 000	Increasing
SIFAB	-	-	-	-	1 450	12 000	New firm
Total	**71 986**	**92 101**	**87 669**	**79 449**	**75 594**	**131 000**	

Source: Feed company representatives (pers. comm.)

3.3.2 Current feed ingredient imports, exports and taxes

An average of 27 700 tonnes of raw animal feed ingredients were imported annually during the past five years (Table 7).

3.3.3 Total production capacity of compounded animal feeds

The total capacity of the currently active animal feed mills in Cameroon exceeds 100 000 tonnes per annum. However, less than 35 percent of this capacity is currently employed (Table 8).

FishFood Corp focuses on the production of extruded fish pellets, while the other producers manufacture cattle feed concentrate, chicken feed, pig and rabbit and other miscellaneous feeds. Chicken and pig feeds comprise 70 and 20–25 percent of the total feed production, respectively. Major feed producers are committed to technical inspections by larger customers to ensure quality, sustainability and efficiency. This guarantee by the producers is important as many customers are ready to purchase the feeds at higher prices if they have a say and are ensured of quality feeds.

3.3.4 Industrially manufactured versus farm-made aquafeeds

The industrial animal feed manufacturers are facing fierce competition from smaller feed producers. This is mainly a consequence of taxes that favour Common Initiative Groups (GICs) over large corporations. This has provided the impetus for the rapid growth and expansion of smaller feed producers, who only use locally available ingredients. This sector is currently booming at the expense of the larger feed producers, some of which are now forced to limit their production for own use. Moreover, most small-scale commercial fish farmers prefer using the IRAD CP31 pellets made by small-scale producers rather than the extruded products made by FishFoodCorp, despite the fact that the feeds are similarly priced. The preference for the IRAD CP31 feed is mainly a consequence of availability and producers providing a follow-up customer care service.

TABLE 9
Quantity (tonnes) and price (CFAF/kg) of feed ingredients distributed for farm-made animal feeds by the importer ADER from 2003 to 2005

Ingredients		2003	2004	2005	Average
Soybean oil cake	Quantity	6 500	4 820	4 500	5 275
	Price	270	320	250	280
Fishmeal	Quantity	200	184	70	151
	Price	400	433	400	411
Premix	Quantity	65	74	65	68
	Price	1 500	1 440	1 280	1 410

Source: ADER company representative (pers. comm.)

3.4 Problems and constraints

Small-scale commercial aquaculture is developing in Cameroon. However, the majority of farmers remain poor and many cannot afford the shift to a more intensive production system using supplemental feeds. Aquaculture will only be able to play its role in poverty alleviation in the short-term if the compost based traditional system is better understood and optimised. Current problems and constraints in the manufacture and use of aquafeeds in Cameroon can be listed as follow:

- The sustainability of the current demand for aquafeeds is questionable. Most of the demand is derived through subsidized facilitation and from smaller private beginners. Users of formulated aquafeeds are excited by the results obtained but most lack the finances and the necessary business acumen to make fish farming profitable.
- Although data exists on the nutritional value of many alternate ingredients, most locally available materials remain to be appraised, both in terms of palatability and digestibility.
- The tropical climate (high temperature and humidity) negatively affects the quality of ingredients and compounded feeds during storage. For instance, infestation of maize or beans by grain driller insects or oilseed cakes by *Aspergillus* is prevalent throughout Cameroon.
- Funding for research and development in aquaculture is limited and inadequate. When data are available, extension services remain inadequate to diffuse the information reliably to motivated farmers.
- Government taxation policies are disabling the animal feed manufacturing sector. Policies are currently under revision.
- Feed formulation and processing technologies developed in Europe are not always appropriate and research needs to be undertaken to make better use of locally available ingredients such as bloodmeal, fishmeal, soybean meal and binders.
- Aquafeed manufacturing equipment, particularly pelleting machines, are not available locally. Mills and mixers are relatively easily adapted by most local electro-mechanical artisans (Figure 1) but trials with most pelleting system have been disappointing.
- The key constraints are macro-economic policy and climate (devaluation of the currency, the cycles of heavy international debt, corruption, etc) which keep most of sub-Saharan African farmers in an acute state of poverty.
- Lack of expertise in aquaculture technologies. Given the current state of aquaculture in Cameroon it is our opinion that more effort should be focused on the development of semi-intensive pond fertilization based aquaculture, which is more accessible to most Cameroonian farmers. However, this does not mean that the aquaculture feed industry should be neglected.

FIGURE 1
Adapted equipment for the production of fish pellets in Foumban, Cameroon

4. RESOURCE AVAILABILITY AND THE EXPANSION OF THE AQUACULTURE INDUSTRY

4.1 Projected growth

Since 1992, aquaculture has registered a significant growth (Table 2). Many abandoned ponds have been rehabilitated and the work undertaken by various institutions has led to improved aquaculture practices. As already mentioned, most farmers remain relatively poor. However, positive examples of fish farmers who have successfully begun to practice supplemental feeding and who have increased production from 1–3 tonnes to >9 tonnes/ha/year are pushing an increasing number of non-commercial farmers to switch to commercial fish farming. This will generate a continuous increase in aquaculture production. While the larger commercial producers will no doubt increase fish production in Cameroon, we think that the most interesting future prospects will come from small-scale commercial farmers in the peri-urban areas. The most promising of these farmers should be identified and strongly encouraged to participate with development partner organizations. In short, the business is still under construction and in the absence of any commitment from development partners to keep working for some more years to come, it would be unwise to make any projections. The current fact is that for the past 15 years aquaculture in Cameroon has registered a 10 percent yearly growth rate.

5. RECOMMENDATION AND SUGGESTED POLICY GUIDELINES

Semi-intensive and extensive earthen pond-based farming is the prevailing aquaculture system in Cameroon. It has remained a rural subsistence activity up to the mid 1990s. Since then, many changes in living conditions alongside the devaluation of the currency in 1994 have created positive conditions resulting in a revitalization of aquaculture and the mergence of a strong small-scale market orientated aquaculture sector. Development over the last 15 years has been most rapid in peri-urban areas, where there is a greater demand for fish and easier and affordable access to inputs and efficient technical expertise.

The animal feed manufacturing industry has been operating for more than 10 years and produces mainly chicken feed. Most feed ingredients are readily available and prices have remained relatively stable, except for maize and soybeans that are mostly imported. There is a need for government to facilitate the production of maize and soybeans in Cameroon. Whereas most equipment for small-scale animal feed manufactures can be locally sourced at affordable prices, pellet presses and dryers still need to be improved. Government taxation policies constitute a serious hindrance to the development of the sector and the current new legislation under revision is eagerly awaited by animal feed manufacturers. Further scientific work remains to be done on the following: evaluation of alternative locally available feed ingredients and fertilizers; improved performance of pellet drying devices during the rainy season; better storage protocols for aquafeeds; improving the water stability of farm-made pellets and a better comprehension of the natural feed contribution to fish growth within compost based aquaculture systems; Cameroonian farmers need to be educated to optimize natural plus exogenous feed regimens. Moreover, there is need for continued farmer-scientist based partnerships to improve fish breeding and production (Brummett, 2005).

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