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International Journal of Fisheries and Aquaculture

Full Length Research Paper

Comparative studies of bacteria load in fish species of commercial importance at the Aquaculture Unit and Lagoon Front of the University of Lagos

Olugbojo, Joseph A.[1]* and Ayoola, Simeon O.[2]

[1]Department of Biological Sciences, Bells University of Technology, Ota, Ogun State, Nigeria.
[2]Department of Marine Sciences, University of Lagos, Akoka, Lagos State, Nigeria.

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Bacteria diseases are widespread and can be of particular importance in fish farming. Bacteria exist as micro flora in water until certain environmental conditions such as poor water quality occur, which could impose a stress on fish, thereby making them vulnerable to infection, most especially by pathogenic bacteria. This study was carried out to assess and compare the bacteria diversities and population in *Clarias gariepinus, Sarotherodon melanotheron* and *Oreochromis niloticus,* in the three grow out ponds of the aquaculture unit of the Department of Marine Science and Lagoon Front of the University of Lagos. It also aims at determining their public health significance. The experiment was carried out between May-September 2013. Water samples were collected from the three grows out ponds in the Department of Marine Sciences and from Lagos lagoon Front of the University of Lagos. In each case, water samples were analysed for the possible indicator organisms of faecal and industrial pollutions such as *Escherichia coli, Staphylococcus aureus, Salmonella* spp*., feacal streptococcus, Vibrio* spp., and *Clostridium* spp. From the result obtained, all the bacteria listed above were first seen as common bacteria in all the samples of water analysed. Further studies (biochemical tests) also reveal bacteria such as Klebsiella spp., *Proteus* spp., *Enterobacter aerogenes, Citrobacter* spp*. and Pseudomonas aeroginosa.* Moreover, the same indicator bacteria seen in water samples were also detected in the different body parts (flesh, mouth, gill and gut) of each of the fish species analysed, both from the Departmental ponds and Lagoon front, except *Clostridium perfringes* (*C. welchii*), *Vibrio cholera and Salmonella typii* which were found in the gut of those fish species from the departmental ponds A-C and in the mouth, gill and gut of the fishes from lagoon front. The population of each of these bacteria was found to be highest in the gut region, followed by the gill, the mouth and least in the flesh. There was no significant difference in the population of each of the bacterial across pond water ($P>0.05$). Same is the case with each bacteria analysed across body parts of the fish species (skin, mouth, gill and gut) in the Departmental ponds, that is, no significant difference ($P>0.05$). But, when compared with the lagoon front (both for water and fish samples) the difference was highly significant ($P<0.05$). None of the population of the bacteria in the ponds exceeds the limit for human consumption. The bacteria load in the lagoon fish (skin, mouth, gill and gut) was higher than the recommended limit for human consumption. Therefore, they are not fit for consumption most especially samples from the mouth, gill and gut, except effective processing treatment is employed before consumption. Due policy should also be taken by the government to curtail the tradition of indiscriminate discharge of untreated effluent into the lagoon.

Key words: Bacteria load, *Clarias gariepinus, Sarotherodon melanotheron* and *Oreochromis niloticus,* Lagos lagoon.

INTRODUCTION

Fish is one of the cheapest sources of animal protein available all over the world for human consumption. Fish,

among all other important protein food stuff such as eggs, milk, meat, and other product constitute an excellent source of protein of high biological value, (Cleube, 2008). It was also observed that freshwater fish represent an important source of animal protein to human nutrition. However, the challenge due to pathogenic organisms especially bacteria has limited its effective production and availability.

Disease occurrence in aquatic animal production is beginning to show a significant impact on yield (Hudson, 1990). In a situation where there is low stocking densities, with low management practice characterized by traditional captured fisheries or extensively managed culture system, there was low yield levels (Sherman et al., 2000). In effect, the rate of disease occurrence was low. On the other hand, as aquaculture intensifies, necessitating fast movement of aquatic species in association with their pathogens, disease level has been triggered (Olufemi, 1998). The possible economic losses a fish farmer may suffer in the event of disease occurrence are mortality, growth reduction during and after an outbreak, treatment or prevention expenses, loss of investor's confidence. Loss or damage to brood stock may have major consequences on the genetic pool, increase in the time required for the fish to reach market weight-size and therefore postponement or loss of the opportunity to sell fish. Also, damage to wild population may result not only in the loss of a resource but also decrease biodiversity and a shift in the ecological balance (Cameron and Douglas, 2002). The good knowledge of fish disease agent is needed to prevent, cure, or minimise those negative effect.

Moreover, of all fish diseases, bacterial diseases are widespread, and can be of serious concern in fish farming. This has been responsible for heavy mortality in both wild and cultured fish (Hudson, 1990). Disease caused by bacteria are often chronic than acute and may also cause a high percentage of death which is highly induced by environmental stress (Olufemi, 1998).

Pathogens living in the fish depend on the type and abundance of microorganisms present in the water in which they live (Cahill, 1990, cited by Atlas and Bartha, 1998). Cahill also observed that the range of bacteria genera isolated from eggs, skin, gills, and intestine is related to the aquatic habitat of the fish and varies with factors such as salinity of the habitat and the bacteria load in the water. Bacteria recovered from the skin and gills may be transient rather than resident on the gill surface. Micro floral of fish intestine often appeared to vary with complexity of the fish digestive system (Cahill, 1990, cited by Atlas and Bartha, 1998). The bacteria genera present in the gut generally seem to be those from the environment or diet which can survive and multiply in the intestinal tract, although there is evidence for a distinct intestinal micro floral in some species (Cahill, 1990, cited by Atlas and Atlas and Bartha, 1998). Obligate anaerobes have also been recovered from Tilapia and carp intestine (Cahill, 1990, cited by Atlas and Bartha, 1998).

However, some of these micro-organisms are not pathogenic, but those that are pathogenic can cause serious damage to fish such as Aeromonas salmonicida which causes furunculosis of salmonids, carp erythrodarmatitis and gold fish ulcer diseases; and man when consumed infected fish. For instance, cholera caused by *Vibrio cholera*; *salmonellosis*, caused by gram negative rod, *Salmonella spp; shigellosis*, caused by *Shigella dysentariae*, *Shigella flexneri, Shigella boydii, and Shigella sonnei*; *tuberculosis,* caused by *Mycobacterium tuberculosis* and dysentery caused by *Escherichia coli* (Okafor, 1985; Austin and Austin, 2007).

The aim of this study is to assess and compare bacteria occurrence, diversity and population in fish organs (gill and gut) and body part (buccal cavity and flesh) of cultured *Clarias gariepinus, Oreochromis niloticus and Sarotherodon melanotheron* in an intensive fish production system at the Aquaculture Unit of the Department of Marine Sciences, and Lagoon Front of the University of Lagos, Lagos, Nigeria. It also aims at providing information on the morphometrics of these fish species.

MATERIALS AND METHODS

Study area and sample collection

The study areas are the Aquaculture Unit of the Department of Marine Sciences, and Lagoon Front of the University of Lagos.

Water and fish samples were collected from the three grow-out ponds of the Aquaculture Unit of the Department of Marine Science and from the Lagoon Front of the University of Lagos. All samples were collected aseptically using sterile sample bottles for water. Sterile dissecting instrument were also used to take samples from the flesh, mouth, gill and gut of the fishes' body for analysis.

Morphometrics

Morphometric parameters of the fish samples such as weight, standard length, head length, gill length and buccal depth were measured with the use of top loading balance for weights and graduated measuring ruler for lengths. This was done for all the samples of fish taken from each pond and lagoon, and their values were recorded in two decimal places.

Preparation of the serial dilutions

90 to 100 ml of distilled water was dispensed into conical flask as diluents for each sample and 9 ml of these diluents was dispensed into MacCartney bottles for serial dilutions. The diluents were

*Corresponding author. E-mail: josepgbojo2012@gmail.com

autoclaved at 121°C for 15 min. Nutrients agar was also autoclaved along with the diluents, and both were kept to cool.

Water samples

1 ml was aseptically taken from the raw water sample into 9 ml distilled water in the MacCartney bottle to give dilution 10^{-1}. Fivefold serial dilutions was made using sterile pipette (10^{-1} to 10^{-5} serial dilutions) while raw water sample remained 10°. However, further dilutions till 10^{-9} were made where required so as to allow easy colony counting.

Fish samples

Using a sterile dissecting tools, mortar and pestle, samples was taken from the fish (flesh, gill, mouth and gut). Each sample was pounded into pieces and properly mixed together. Each of these samples was added into 9 ml sterile distilled water in the MacCartney bottle and thoroughly mixed together to make a dilution 10^{-1}. Fivefold serial dilution was made using sterile pipette (10^{-1} to 10^{-5}). However further dilution till 10^{-9} was made and used where required so as to allow easy colony counting.

Inoculation into the solid medium

1 ml of inoculums was pipette into sterile Petri dishes. This was done in duplicates and also labelled sequentially. Using pour plate method, about 15 ml of sterilized molten Nutrient agar medium, cooled to about 45°C was poured into the inoculated Petri dishes within 15 min of original dilution. Both the sample dilution and agar medium were mixed thoroughly and uniformly, and allowed to gel. Some plates were also prepared as control to check on the sterility of the diluents, glasswares and agar medium. The possibility of air contamination was also assessed with the use of control plates. All poured Petri dishes were incubated in inverted position at 37°C for 24 h.

Using the same procedure described above for the total bacteria count with nutrient agar as a general purpose medium, the following list of indicator bacteria of fecal and industrial pollution were also isolated from the water and fish organs (flesh, mouth, gill and gut) using their respective selective medium: Coliform bacteria and *E. coli* were isolated with MacConkey agar, *Staphylococcus* spp were isolated with Mannitol salt agar, *Salmonella* spp and *Shigella* spp were isolated with *Salmonella Shigella* agar (SSA), *Vibrio* spp were isolated with thiosulphate citrate bile salt agar (TCBS), *Streptococcus fecalis* were isolated with blood agar whose 5% is horse blood and lastly, *Clostridium* spp were isolated with reinforced Clostridium agar (RCA).

Colonial and microscopic examination

From the isolated colonies, the colonial characteristics were first determined with the colony counter magnifying lens, which was also used to count the numbers of colony in each plate. Further clarification was then conducted with the use of a light microscope, especially morphological characteristics. The shape and arrangement, and some other characteristics of the colonies were examined and recorded. Also Gram's staining was carried out according to Fawole and Oso (1988).

Biochemical test

The following biochemical tests were carried out and used to further identify the bacteria isolated and also to identify any other bacteria that could be present.

Catalase test

A drop of 3% hydrogen peroxide was placed on the centre of a slide and sterile wire loop was used to pick small portion of the micro-organism to be identified from nutrient agar plate into the hydrogen peroxide for immediate gas bubble formation. Quick Gas bubble or foaming indicates positive result (Olutiola et al., 1991).

Coagulase test

A drop of physiological saline was placed on two separate slides. A colony of the test organism was emulsified in each of the drop to make suspension. A drop of plasma was then added and mixed gently with the suspension. Clumping (due to coagulation) of the organisms in 10 s when viewed under the microscope indicate positive result (Olutiola et al., 1991). This was done for the plate suspected to be *Staphylococcus aureus.*

Motility test

A loopful of growth was inoculated into peptone water broth and incubated overnight. A wet preparation from the peptone water culture was prepared and examined under a microscope at x40 objective lens. Dating movement of the organism indicate a positive result (Olutiola et al., 1991).

Citrate utilization test

A slant of a citrate agar was aseptically inoculated with the organisms to be identified using a sterile wire loop. The inoculated citrate agar slant was incubated at 37°C for 24 h and observes the colour change daily for up to 4 days. Blue colouration indicate positive test (Olutiola et al*.,* 1991).

Indole reaction test

The micro-organisms to be identified were inoculated into tryptone broth for 48 h at 37°C, 5 drops of Kovac's reagent was then added. A deep red colour indicates positive result (Olutiola et al*.,* 1991).

Sugar fermentation test

Peptone water (7.5 g) was weight and diluted to 500 ml with distilled water after which few pinch of phenol red was added. 9 ml of broth was distributed into test tubes with Durham tubes inverted into each tube. The tubes were sterilized at 121°C (at 15 pounds pressure) for 15 min. 1% (w/v) aqueous solution of Glucose, Sucrose, Lactose, and Mannitol were prepared separately and sterilised. 1 ml of 1% of sugar solution was added aseptically using sterile pipette into each of the test tube containing 9 ml broth. The test organisms were inoculated into each set of test tubes. Uninnoculated test tubes serve as control. Incubation was done at 35°C for 5 days. A change in the initial colour of the solution indicates acid production, and gas in the inverted Durham tubes indicates gas production. The colour change is from red to yellow (Olutiola et al., 1991).

Oxidase test

A drop of a freshly prepared oxidase reagent was added onto a strip of filter paper. A little of the test organism was rubbed into it.

Table 1. Bacteria isolated from pond A to C and lagoon water.

Types of bacteria	Pond A	Pond B	Pond C	ULF
Salmonella typi	ND[1]	ND[1]	ND[1]	DE[1]
Shigella spp	DE	DE	DE	DE
Escherichial coli	DE	DE	DE	DE
Streptococcus fecalis	DE	DE	DE	DE
Vibrio cholera	ND[1]	ND[1]	ND[1]	DE[1]
Clostridium perfringes	ND[1]	ND[1]	ND[1]	DE[1]
Enterobacter aerogene	DE	DE	DE	DE
Proteus spp	DE	DE	DE	DE
Klebsiella spp	DE	DE	DE	DE
Pseudomonas Aeroginosa	DE	DE	DE	DE

DE – Detected; N.D – Not detected; ND[1] – Not detected but other strains/spp were seen; DE[1] – Detected along with other strains/spp; ULF- UNILAG lagoon front.

Colour changes into deep-blue in 5 s indicate positive test while non colouration indicate negative test.

Test for the production of hydrogen sulphite and Indole using Sulphite Indole Motility medium (SIM medium)

15 g of SIM agar was suspended in 500 ml of distilled water (30 g in 1 L). It was brought to boil to dissolve completely. It was mixed well and distributed into test tubes and tacked with cotton wool and aluminium foil. It was then sterilized by autoclaving at 121°C for 15 min and allowed to set/solidified. With the use of a straight wire/inoculating needle, the organism was inoculated into the SIM medium and incubated at 37°C. After 24 h, sulphite production (Blackening of the medium) was noticed. Also when 1 ml of Kovac's reagent was added, a red colouring of the surface layers within 10 min indicates the presence of indole (Cheesbrough, 1984).

Statistical analysis

The results of bacteria isolates (populations) and morphometrics were subjected to a one-way analysis of variance (ANOVA). The significant level was $p<0.05$.

RESULTS

Bacteria isolated from water and fish samples

The organisms (bacteria) found in all the water samples analysed in Ponds A-C at the Aquaculture Unit of the Marine Science Department and the Lagoon Front of the University of Lagos are presented in Table 1. It shows the presence of the following indicator organisms of faecal, industrial and other sources of pollution such as *S. aureus, Salmonella* spp*, Shigella spp, faecal streptococcus, Clostridium spp, E. coli and Vibrio spp*. Morphological and biochemical examination also revealed other organisms such as *Klebsiella spp, Proteus spp, Citrobacter spp, Enterobacter aerogenes and P. aeruginosa.*

It was observed that the same types of bacteria isolated from the ponds were also found in the Lagoon, except *Clostridium perfringes, V. cholera* and *Salmonella typhi.*

Tables 2 and 3 also show the bacteria found in the flesh, mouth (Buccal cavity), gill and gut of each of the three species of fish analysed, both in the Departmental pond and lagoon front. The same type of bacteria were found in all the organs that were analysed both in the Departmental pond and lagoon front except *C. perfringes*, *V. cholera and S. typhi* which were seen in the lagoon fish species (mouth, gill and gut only), and guts of the fishes from the Department. The result of these bacteria load shows a marked difference ($P<0.05$) between the population of organisms found in the departmental ponds (A to C) and those found in the UNILAG Lagoon front.

The results of the bacterial population in the fish organs from the pond in comparison with that obtained from lagoon front species are shown in Table 7 to 10. The result of the population of bacteria in the buccal cavity (mouth) of *C. gariepinus, O. niloticus* and *S. melanotheron* harvested from the UNILAG lagoon front as compared with those from the departmental pond were shown in Table 7. The result show a significant ($P<0.05$) difference between the population of bacteria in the *C. gariepinus* harvested from the lagoon front when compared with those in the ponds. Similar trend was also observed in *O. niloticus* and *S. melanotheron* harvested in the ponds and UNILAG lagoon front. The situation was the same with the flesh, mouth, gill and gut of all the three fish species harvested from UNILAG lagoon front when compared with those in the Departmental ponds. There was a marked difference ($P<0.05$) between the populations of bacteria in the pond fish organs when compared with those from UNILAG lagoon front (Table 8 to 10).

Colonial, morphological and biochemical characteristics of bacteria diversity in ponds and lagoon front

Table 4 shows the colonial, morphological, and biochemical characteristics of various bacteria found in

Table 2. Bacteria isolated from the three species of fish in Pond A-C.

Types of bacteria	Pond A				Pond B				Pond C			
	FL	MT	GL	GT	FL	MT	GL	GT	FL	MT	GL	GT
Salmonella typi	ND[1]	ND[1]	ND[1]	DE	ND[1]	ND[1]	ND[1]	DE	ND[1]	ND[1]	ND[1]	DE
Shigella spp	DE	DE	DE	DE	DE	DE	DE	DE	DE	DE	DE	DE
E. coli	DE	DE	DE	DE	DE	DE	DE	DE	DE	DE	DE	DE
Streptococcus fecalis	DE	DE	DE	DE	DE	DE	DE	DE	DE	DE	DE	DE
Vibrio cholera	ND[1]	ND[1]	ND[1]	DE	ND[1]	ND[1]	ND[1]	DE	ND[1]	ND[1]	ND[1]	DE
Clostridium perfringes	ND[1]	ND[1]	ND[1]	DE	ND[1]	ND[1]	ND[1]	DE	ND[1]	ND[1]	ND[1]	DE
Enterobacter aerogene	DE	DE	DE	DE	DE	DE	DE	DE	DE	DE	DE	DE
Proteus spp	DE	DE	DE	DE	DE	DE	DE	DE	DE	DE	DE	DE
Klebsiella spp	DE	DE	DE	DE	DE	DE	DE	DE	DE	DE	DE	DE
Pseudomonas aeroginosa	DE	DE	DE	DE	DE	DE	DE	DE	DE	DE	DE	DE

DE – Detected; N.D –Not detected; ND[1] – Not detected but other strains were seen; DE[1] – Detected along with other strains/spp; FL- Flesh; MT - Mouth; GL- Gilll; GT- Gut.

Table 3. Bacteria isolated from the three species of fish from the lagoon front.

Types of bacteria	ULF Fish A				ULF Fish B				ULF Fish C			
	FL	MT	GL	GT	FL	MT	GL	GT	FL	MT	GL	GT
Salmonella typi	ND[1]	DE	DE	DE	ND[1]	DE	DE	DE	ND[1]	DE	DE	DE
Shigella spp	DE	DE	DE	DE	DE	DE	DE	DE	DE	DE	DE	DE
E. coli	DE	DE	DE	DE	DE	DE	DE	DE	DE	DE	DE	DE
Streptococcus fecalis	DE	DE	DE	DE	DE	DE	DE	DE	DE	DE	DE	DE
Vibrio cholera	ND[1]	DE	DE	DE	ND[1]	DE	DE	DE	ND[1]	DE	DE	DE
Clostridium perfringes (C. welchii)	ND[1]	DE	DE	DE	ND[1]	DE	DE	DE	ND[1]	DE	DE	DE
Enterobacter aerogeneS	DE	DE	DE	DE	DE	DE	DE	DE	DE	DE	DE	DE
Proteus spp	DE	DE	DE	DE	DE	DE	DE	DE	DE	DE	DE	DE
Klebsiella spp	DE	DE	DE	DE	DE	DE	DE	DE	DE	DE	DE	DE
Pseudomonas eroginosa	DE	DE	DE	DE	DE	DE	DE	DE	DE	DE	DE	DE

DE – Detected; N.D – Not detected; ND[1] – Not detected but other strains/spp were seen; DE[1] – Detected along with other strains/spp; FL - Flesh; MT – Mouth; GL- Gilll; GT- Gut.

ponds and lagoon front (both in water and fish samples). It shows their edges, colour, elevations, shape and arrangement. This table also shows various identification procedures, tests and techniques by which several of these bacteria species were identified. It was also used to determine the presence of pathogenic bacteria. Some of this test includes: gram's staining, catalase test, coagulase test, citrate utilization test, sugar fermentation test, oxidase test, indole, motility and test for sulphite production (as outlined on the table).

Among the enteric gram negative rods, organisms such as: *E. coli, Klebsiella spp, Enterobacter spp, Citrobacter spp,* are lactose fermenters, giving a positive reaction to lactose by producing acid and gas while their non lactose fermenter counterparts such as *Salmonella, Shigella*, *Proteus* gave a negative reaction to lactose and some other sugars, except glucose (and mannitol for *S. typhi*) fermentation but without gas production (Table 4). Other species of *salmonella* were seen to ferment mannitol and glucose with gas production.

The two sets of organisms discussed above are members of a family known as *Enterobacteriaceae* and they are all oxidase negative, that is, they do not produce a deep purple or blue colouration during oxidase test (Table 4). *P. aeroginosa* and *Vibrio spp* are oxidase positive (as shown in the Table 4) and do not belong to this family. They do not react positively to lactose test. Tests such as oxidase, citrate utilization, catalase and some colonial characteristics like colour, elevation, shape and edges will be sufficient and thus were used to identify them.

Moreover, gram positive cocci and rods are also identified and outlined in Table 4, for instance, Cocci such as *staphylococcus* is catalase positive while *Streptococcus* (e.g *faecal streptococcus*) is catalase negative (Table 4). Catalase test was used to differentiate staphylococcus from streptococcus spp, while coagulase test was used to differentiate *S. aureus* from other *Staphylococcus species*.

Table 4. Colonial, morphological and biochemical characteristics of various bacteria isolated from ponds A to C in the Aquaculture unit of the Department of Marine Science and Lagoon front of the University of Lagos.

Edge	Colour	Elevation	Shape and arrangement	Gram stain	Catalase	Coagulase	Oxidase	Citrase utilization	Glucose	Lactose	Sucrose	Mannitol	SIM medium			Probable organisms (Bacteria)
													H_2S	Indole	Motility	
Regular.	Colourless with black centre	Raised -	Short Rod	-	+	-	-	-	A	-	-	A	+	-	+	*Salmonela typi*
Regular	Colourless with black centre	-	Short rods	-	+	-	-	+	AG	-	-	AG	+	-	+	*Other Salmonella spp*
Irregular	Yellow	Raised	Cocci in cluster	+	+	+	NR	NR	A	A	A	A	-	-	-	*Staphilicoccus aureus*
Undulated	Red	Flat	Rod in singles	-	+	-	-	+	AG	AG	AG	AG	-	+	+	*Escherichial coli*
Regular	Colourless	convex	Rod	-	+	-	-	-	A	-	-	-	-	-	-	*Shigella spp*
Regular	Yellow	Raised	Curved rod	-	+	-	+	+	A	-	A	A	-	+	+	*Vibrio cholera*
Regular	Green	Raised	Curved rod	-	+	-	+	+	A	-	-	A	-	+	+	Other *Vibrio spp*
Irregular	Cream	Raised	Rod in chain	+	-	+	NR	NR	A	A	-	AG	-	-	-	*Clostridium perfringes (Welchii)*
Irregular	Cream	Raised	Rod in chain	+	-	+	NR	NR	A	-	-	AG	-	-	+	*Clostridium spp*
Irregular	Red	Raised	Cocci in short chain	+	-	-	NR	NR	AG	AG	AG	AG	NR	NR	-	*Feacal streptococcus*
Undulated	Cream	Slightly raised	Rod in pairs and singles	-	-	+	-	+	AG	AG	AG	AG	-	-	-	*Klebsiella spp*
Undulated	Cream	Flat	Rod	-	+	-	-	+	A	-	-	-	+	-	+	*Proteus mirabilis*
Serrated	Cream pink	Raised	Rod	-	+	-	-	+	AG	AG	AG	AG	-	-	+	*Enterobacter aerogenes*
Regular	Red	Raised	Rod	-	+	-	-	+	AG	AG	-	AG	+	-	+	*Citrobacter spp*
Irregular	Blue green	Raised	Rod	-	+	-	+	+	A	-	-	-	-	-	+	*Pseudomonas aeruginosa*

SIM- Sulphite, Indole and motility test medium, H2S- Hydrogen sulphite, NR-Not Required, AG- Acid and Gas production, A-acid production.

Gram positive rods such as *C. perfringes* was also identified and other *Clostridium* genera which could not be identified to species level were also seen. *C. perfringes* was identified and singled out from other members of *Clostridium* by its lack of motility and its negative reaction to Lactose fermentation test.

V. cholera was also differentiated from other *Vibrio spp* identified in the TCBS plate (Thiosulphate citrate-bile salt sucrose agar plate) by its ability to ferment sucrose and its characteristic yellow colony on TCBS agar plate.

S. typhi was also identified among other *Salmonella spp* seen on the agar plate by its ability to ferment mannitol and glucose but without gas production whereas other species of *salmonella* do ferment glucose and mannitol with the release of gas.

Morphometric parameters

The result of the morphometric parameter revealed that there is no significant difference in the standard length of *O. niloticus* in pond B, *S. melano*theron in pond C and *O. niloticus* in Lagoon front (Table 5).

For the head length, there is no significant difference between *S. melanotheron* in pond C, *O.*

Table 5. Result of the morphometric parameter (Mean±SD).

Parameter	Pond A	Pond B	Pond C	ULF A	ULF B	ULF C
Weight (g)	276.72±3.91^{d}	33.04±2.15^{a}	46.08±2.15^{b}	376.72±3.91^{e}	48.15±3.65^{b}	54.19±2.43^{c}
Standard Length (cm)	31.35±0.98^{d}	9.85±0.17^{a}	11.30±0.35^{a}	30.52±3.56^{d}	10.60±0.69^{a}	13.75±0.87^{b}
Head Length (cm)	9.55±0.06^{c}	2.95±0.06^{a}	4.05±0.06^{b}	9.24±1.45^{c}	3.95±0.17^{b}	3.35±0.17^{b}
Gill length (cm)	8.33±1.27^{b}	2.42±0.14^{a}	2.85±0.06^{a}	8.30±1.27^{b}	2.88±0.03^{a}	2.35±0.17^{a}
Buccal Depth(cm)	7.25±0.29^{b}	1.75±0.29^{a}	2.35±0.11^{a}	6.68±1.07^{b}	2.30±0.23^{a}	1.78±0.14^{a}

ULF- UNILAG Lagoon front; A - *Clarias gariepinus;* B - *Oreochromis niloticus;* C - *Sarotherodon melanotheron.*

Table 6. Bacteria load in ponds and lagoon (cfu/ml±SD) × 10^{5}.

Types of organisms	Pond A	Pond B	Pond C	UNILAG lagoon front
TCC	0.52±0.02^{b}	0.39±0.01^{a}	0.36±0.01^{a}	90.63±0.04^{c}
Total plate count	5.90±0.14^{c}	5.55±0.07^{b}	3.85±0.07^{a}	958.00±0.02^{d}
Staphylococcus aureus	0.09±0.01^{a}	0.07±0.01^{a}	0.05±0.01^{a}	14.10±0.14^{b}
Escherichia coli	0.05±0.01^{a}	0.03±0.01^{a}	0.02±0.01^{a}	48.03±0.04^{b}
Faecal streptococcus	0.07±0.12^{a}	0.03±0.09^{a}	0.09±0.08^{a}	24.75±0.07^{b}
Salmonella spp	0.09±0.01^{a}	0.05±0.01^{a}	0.05±0.01^{a}	29.40±0.14^{b}
Shigella spp	0.04±0.01^{a}	0.02±0.01^{a}	0.04±0.01^{a}	59.45±0.21^{b}
Vibrio spp	0.06±0.02^{a}	0.05±0.01^{a}	0.40±0.00^{a}	50.63±0.24^{b}
Clostridium spp	0.01±0.01^{a}	0.02±0.03^{a}	0.02±0.01^{a}	28.35±0.12^{b}

Mean±S.D with superscript of the same alphabet either 'a' or 'b' shows no significant difference (P>0.05); Mean ± S.D. with superscript of different alphabet e.g 'ab' 'b' 'c' 'd' or 'e' shows that there was significant difference (P<0.05). ULFA- lagoon front fish A (*Clarias gariepinus*); ULFB- lagoon front fish B (*Oreochromis niloticus*); ULFC-lagoon front fish C (*Sarotherodon melanotheron)*; TCC- Total coliform count.

niloticus and *S. melanotheron* in the lagoon front.

For the gill length and buccal depth, there is no significant difference between *C. gariepinus* from pond A and *C. gariepinus* from lagoon front. The same goes for the *O. niloticus* and *S. melanotheron* in both Pond B and C, when compared with those in the lagoon front (P>0.05).

DISCUSSION

This study shows the isolation of various bacteria cells from three major fish species of commercial importance namely: *C. gariepinus, S. melanotheron and O. niloticus* which were harvested from the three grow out ponds of the Aquaculture Unit of the Department of Marine Sciences and Lagos Lagoon Front of the University of Lagos.

Seven, among the enteric gram negative rods and gram positive cocci and rods were investigated which includes*: E. coli*, *Salmonela spp, Shigella spp, Vibrio spp, S. aureus,* feacal *Streptococcus,* and *Clostridium spp*. However, during the biochemical tests, other bacteria such as *Klebsiella spp, Citrobacter spp, Proteus spp, P. aeroginosa, and Enterobacter spp* were also discovered. From the study so far, and with reference to Table 6, it could be deduced that the highest concentration of these bacteria is in the lagoon front when compared with the Departmental ponds. Also, the highly infested part in all the three fish species was gut, especially those one from the lagoon front. This was followed by the gill and mouth, while the least population was found in the flesh (Table 7 to 10).

However, the highest microbial load of each bacteria species as well as their total coliform count obtained in the pond fishes was less than x10^{6} count, except the total plate count of the gut which is 3.70±0.02x10^{6} for *C. gariepinus*, 3.30±0.07×10^{6} for *O. niloticus* and 2.81±0.04×10^{6} for *S. melanotheron*; while gill recorded total plate count of 8.88±0.02x10^{5} for *C. gariepinus*, 7.71±0.13x10^{5} for *O. niloticus* and 9.68±0.03x10^{5} for *S. melanotheron*. Total plate count for buccal cavity is 4.45±0.07×10^{4} for *C. gariepinus*, 5.55±0.21×10^{4} for *O. niloticus* and 5.10±0×03×10^{4} for *S. melanotheron*. Bacterial load of flesh samples (Total Plate Count) are 1.40±0.02x10^{3} for *C. gariepinus*, 1.35±0.07×10^{3} for *O. niloticus* and 1.95±0.04×10^{3} for *S. melanotheron*. The result of the bacterial population in the gill, buccal cavity and flesh samples of departmental pond fishes are within the acceptable limit according to ICMF (1986).

Moreover, the microbial load of these same species of fish in the lagoon front differs. The total plate count of the gut is 2.96±0.04x108 for *C. gariepinus*, 2.82±0.04×108 for *O. niloticus* and (2.92±0.04×108) for *S. melanotheron;*

Table 7. Bacteria load in the flesh of *Clarias gariepinus, Oreochromis niloticus and Sarotherodon melanotheron* (Ponds and Lagoon) (cfu/g±SD) × 10^3.

Type of organisms	FPCG	FLCG	FPON	FLON	FPSM	FLSM
Total coliform count	0.13±0.01^a	8.19±0.011^d	0.15±0.01^a	7.27.50±0.04^c	0.12±0.02^a	6.47.50±0.04^b
Total plate count	1.49±0.02^a	60.25±0.35^e	1.35±0.07^a	26.72±0.03^d	1.95±0.04^b	15.7±0.02^c
Staphylococcus aureus	0.02±0.00^a	0.8±0.03^c	0.02±0^a	0.42±0.04^b	0.03±0.00^a	0.43±0.05^b
Escherichial coli	0.01±0.00^a	0.74±0.03^a	0.03±0.00^a	0.70±0.01^b	0.03±0.00	0.17±0.02
Faecal streptococcus	0.01±0.00^a	0.16±0.01^a	0.01±0.00^a	0.29±0.01^b	0.01±0.00	0.14±0.01
Salmonella spp	0.02±0.00^a	0.28±0.01^d	0.01±0.00^a	0.18±0.01^c	0.02±0.01^a	0.11±0.01^b
Shigella spp	0.01±0.00^a	0.70±0.01^d	0.02±0.00^a	0.57±0.01^c	0.03±0.00^a	0.38±0.04^b
Vibrio spp	0.01±0.00^a	0.13±0.01^b	0.01±0.00^a	0.39±0.01^d	0.02±0.00^a	0.28±0.01^c
Clostridium spp	0.01±0.00^a	0.81±0.01^c	0.01±0.00^a	0.77±0.02^b	0.01±0.00a	0.84±0.01d

Mean±S.D with superscript of the same alphabet either 'a' or 'b' shows no significant difference (P>0.05); Mean±S.D. with superscript of different alphabet e.g 'ab' 'b' 'c' 'd' or 'e' shows that there was significant difference (P<0.05). FPCG- Fish pond *Clarias gariepinus*; FLCG- flesh lagoon *Clarias gariepinus*; FPON- flesh pond *Oreochromis niloticus*; FLON- Flesh lagoon *Oreochromis niloticus*; FPSM- Flesh pond *Sarotherodon melanotheron;* FLSM- Flesh lagoon *Sarotherodon melanotheron*.

Table 8. Bacteria load in the Bucca cavity (mouth) of *Clarias gariepinus, Oreochromis niloticus and Sarotherodon melanotheron* (Ponds and Lagoon) (cfu/g±SD) x 10^4.

Type of organism	MPCG	MLCG	MPON	MLON	MPSM	MLSM
Total coliform count	3.75±0.02^b	40.20±0.04^f	4.85±0.07^c	23.30±0.22^d	2.40±0.28^a	37.00±0.00^e
Total plate count	4.45±0.07^a	137.00±0.01^e	5.55±0.21^b	129.00±0.21^d	5.10±0.03^b	111.00±0.04^c
Staphylococcus aureus	0.14±0.01^a	2.95±0.21^c	0.17±0.02^a	2.95±0.00^c	0.16±0.02^a	2.49±0.02^b
Escherichial coli	0.54±0.04^a	4.95±0.01^d	0.88±0.06^b	2.15±0.07^c	0.57±0.05^a	2.12±0.02^c
Fecal streptococcus	0.33±0.08^a	2.05±0.07^e	0.64±0.01^b	1.25±0.07^c	0.42±0.06^a	1.91±0.01^d
Salmonella spp	0.36±0.04^a	5.95±0.02^e	0.52±0.05^b	4.15±0.00^d	0.73±0.04^c	6.08±0.04^f
Shigella spp	0.21±0.04^a	4.18±0.04^c	0.60±0.13^b	5.15±0.07^d	0.44±0.08^b	5.65±0.07^e
Vibrio spp	0.37±0.03^a	2.31±0.02^c	0.57±0.04^b	3.95±0.03^d	0.68±0.06^b	5.30±0.14^e
Clostridium spp	0.55±0.08^a	4.15±0.07^d	0.65±0.04^{a,b}	2.89±0.02^c	0.68±0.03^b	6.25±0.07^e

Mean±S.D with superscript of the same alphabet either 'a' or 'b' shows no significant difference (P>0.05); Mean±S.D. with superscript of different alphabet e.g 'ab' 'b' 'c' 'd' or 'e' shows that there was significant difference (P<0.05). MPCG- Mouth pond *Clarias gariepinus*; MLCG- Mouth lagoo*n Clarias gariepinus*; MPON-Mouth pond *Oreochromis niloticus*; MLON- Mouth lagoon *Oreochromis niloticus*; MPSM- Mouth pond *Sarotherodon melanotheron*; MLSM- Mouth lagoon *Sarotherodon melanotheron.*

Table 9. Bacteria load in the gill of *Clarias gariepinus, Oreochromis niloticus and Sarotherodon melanotheron* (Ponds and Lagoon) (cfu/g±SD) x 10^5.

Type of bacteria	GPCG	GLCG	GPON	GLON	GPSM	GLSM
Total coliform count	4.73±0.04^a	58.75±0.07^e	5.81±0.02^c	43.20±0.28^d	5.46±0.64^b	67.25±0.71^f
Total plate count	8.88±0.02^b	186.00±0.14^e	7.71±0.13^a	152.00±0.09^d	9.68±0.03^c	163.00±0.05^d
Staphylococcus aureus	0.40±0.04^b	4.95±0.07^d	0.24±0.01^a	5.95±0.07^e	0.24±0.01^a	4.05±0.03^c
Escherichia coli	0.76±0.05^b	6.25±0.08^e	0.59±0.01^a	2.85±0.03^c	0.75±0.06^b	3.65±0.07^d
Faecal streptococcus	0.76±0.17^a	3.65±0.07^c	0.31±0.04^a	3.25±0.07^b	0.41±0.05^a	3.15±0.07^b
Salmonella spp	0.27±0.05^a	5.65±0.07^d	0.26±O.O2^a	2.35±0.19^b	0.16±0.02^a	3.95±0.04^c
Shigella spp	0.16±0.04^a	3.40±0.00^d	0.37±0.04^b	3.65±0.07^e	0.30±0.01^b	3.05±0.07^c
Vibrio spp	0.20±0.01^a	1.95±0.17^b	0.32±0.01^a	1.98±0.01^b	0.31±0.03^a	2.75±0.00^c
Clostridium spp	0.30±0.05^a	1.88±0.07^c	0.32±0.06^a	1.75±0.07^b	0.46±0.05^a	3.15±0.07^d

Mean±S.D with superscript of the same alphabet either 'a' or 'b' shows no significant difference (P>0.05); Mean±S.D. with superscript of different alphabet e.g 'ab' 'b' 'c' 'd' or 'e' shows that there was significant difference (P<0.05). GPCG- Gill pond *Clarias gariepinus*; GLCG- Gill lagoon *Clarias gariepinus*; GPON- Gill pond *Oreochromis niloticus*; GLON- Gill lagoon *Oreochromis niloticus*; GPSM- Gill pond *Sarotherodon melanotheron;* FLSM- Gill lagoon *Sarotherodon melanotheron.*

Table 10. Bacteria load in the Gut of *Clarias gariepinus, Oreochromis niloticus and Sarotherodon melanotheron* (Ponds and Lagoon) (cfu/g±SD) × 10^5.

Type of bacteria	GTPCG	GTLCG	GTPON	GTLON	GTPSM	GTLSM
Total coliform count	9.68±0.04^b	125.49±0.02^d	8.22±0.03^a	127.22±0.04^e	9.85±0.02^c	135.57±0.06^f
Total plate count	37.00±0.02^c	2960.00±0.04^f	33.00±0.07^b	2820.00±0.04^d	28.00±0.04^a	2920.00±0.04^e
Staphylococcus aureus	3.58±0.04^b	70.83±^{a}0.04^d	2.90±0.00^a	27.30±0.28^c	3.49±0.01^b	27.37±0.05^c
Escherichia coli	2.15±0.07^a	55.57±0.05^f	3.45±0.07^c	26.43±0.04^d	2.84±0.09^b	26.68±0.03^e
Faecal streptococcus	2.45±0.07^a	62.25±0.07^e	2.83±0.11^b	17.03±0.04^c	2.69±0.01^b	19.37±0.05^d
Salmonella spp	2.10±0.14^b	39.45±0.07^f	2.88±0.04^c	16.19±0.01^d	1.37±0.05^a	25.030.04^e
Shigella spp	1.43±0.04^a	78.03±0.04^e	3.85±0.08^b	51.03±0.04^c	1.33±0.04^a	51.18±0.03^d
Vibrio spp	2.82±0.04^c	40.06±0.08^f	1.47±0.04^a	24.04±0.05^d	1.85±0.07^b	35.03±0.04^e
Clostridium spp	1.38±0.04^a	67.17±0.04^f	2.95±0.07^b	58.05±0.07^e	3.85±0.07^c	48.08±0.01^d

Mean±S.D with superscript of the same alphabet either 'a' or 'b' shows no significant difference (P>0.05); Mean±S.D. with superscript of different alphabet e.g 'ab' 'b' 'c' 'd' or 'e' shows that there was significant difference (P<0.05). GTPCG- Gut pond *Clarias gariepinus*; GTLCG- Gut lagoon *Clarias gariepinus*; GTPON- Gut pond *Oreochromis niloticus*; GTLON- Gut lagoon *Oreochromis niloticus*; GTPSM- Gut pond *Sarotherodon melanotheron*; GTLSM- Gut lagoon *Sarotherodon melanotheron.*

gill recorded 1.86±0.02×10^7 for *C. gariepinus,* 1.52±0.09×10^7 for *O. niloticus* and 1.63±0.05×10^7 for *S. melanotheron*. Buccal cavity recorded 1.37±0.07×10^6 for *C. gariepinus*, 1.29±0.21×10^6 for *O. niloticus* and 1.17±0.04×10^6 for *S. melanotheron*. Flesh recorded 6.03±0.35×10^4 for *C. gariepinus*, 2.67±0.03×10^4 for *O. niloticus* and 1.57±0.02×10^4 for *S. melanotheron*.

According to ICMF (1986) and Aitken et al. (1982) which say that any fish that have more than x10^6 bacteria count in one gram is not suitable for human consumption, but since gut and gill are always being removed and discarded, there is a tendency for safety, but the people should be encouraged not to consume them (gill and gut). Nevertheless, it is advisable (especially for those species from lagoon front) that good and effective processing treatment be employed such as washing, scraping of scales, removal of gill and gut (under a very hygienic condition), and proper cooking. These will help to reduce the microbial load on the flesh and muscle, thereby keeping the fish safe for human consumption.

It was also observed that even though there are no significance difference in the morphometric parameters of some of these fish species especially *O. niloticus* and *S. melanotheron* from Pond B, C and those of the Lagoon front, yet there was a high significance difference in their microbial populations. This suggests that the size or weight does not really determine the microbial load in any fish species, rather the nature of the fish environment and the extent of pollution around where fish lives. According to Cahill (1990), pathogens living in fish depend on the types and abundance of microorganism present in the water in which the fish lives. This can be inferred that the reason for higher population of bacteria in the lagoon front water and fishes as compared to the departmental pond was a function of pollution they were exposed to. Despite the fact that there was no significant difference in the morphometrics parameters of the fish species in the pond and thoe in the lagoon font yet the difference in their bacteria population was highly significant. The reason was simply because the departmental fishes were better catered for and their level of pollutions was being controlled through regular change of water. They were also not prone to discharge of domestic and industrial effluent unlike the lagoon front water.

The implication of this research finding to the fish shows that since the population of bacteria on the fishes from lagoon front was higher than the recommended limit, most of which are pathogenic; this may eventually lead to fish diseases and perhaps death. Also, the higher bacteria population in water can lead to increased biological oxygen demand and thus reduces the quantity of dissolve oxygen (DO) available for fish in the water; these reductions in DO will definitely impose stress on fish and give room for infection by pathogenic bacteria. Examples of fish bacterial diseases that could occur includes: enteric septicemia of catfish, motile aeromonas septicemia, mycobacteriosis, pseudominasis, vibriosis, and salmonellasis etc in a situation when man consumed a diseased fish there is a tendency to be infected by those pathogenic bacteria especially Zoonotic ones such as: *E. coli, Pseudomonas, Klebsiella, Edwardsiella, Vibrio Clostridium, Salmonella and Staphylococcus spp* (Stoskopf 1993).

Finally, effort should be made as much as possible to curtail the indiscriminate discharge of untreated sewage and industrial effluent into the lagoon as this will increase the microbial load in water and consequently inducing stress on fish and other aquatic organism present there. Good hygienic practices should be carried out when fish from the lagoon are purchased for consumption purposes. Bacteria in fish not properly cooked could be transferred to man as they establish themselves in the intestine particularly those that are pathogenic, leading to bacterial infections of various kinds. The good cultural and management practice in the Departmental ponds should be sustained and improved upon for higher productivity.

Conclusion

This study confirms the existence of pathogenic bacteria in the fish species analysed (*C. gariepinus, O. niloticus and S. melanotheron*) which are of public health significance. While the bacteria load recorded from the departmental ponds are still acceptable, being found within the acceptable limit of 10^6/g (ICMF, 1986; Aitken et al., 1982), their lagoon front counterparts were found to be densely populated, giving the TPC of the gut at 10^8, gill and mouth at 10^6 and 10^7 respectively. Although gill and gut are always being removed and discarded, yet it will require a careful handling to prevent contamination of other parts during processing, hence good hygiene and sanitation is very essential.

Moreover, bacteria isolated from the fish samples are a function of bacteria found in the lagoon which is influenced by industrial effluent, domestic and agricultural waste emptied into the lagoon. Findings have confirmed that fish can be infected with variety of microbial species especially bacteria, which is a function of bacteria found in their habitat (Olufemi, 1998).

Recommendations

Based on the findings during this study, the following recommendations are suggested.

(i) The Government, through Ministry of Environment, should enforce a regulation that will ensure that effluent or sewage are properly treated before being discharge into the lagoon, and this must be strictly adhere to by all industries and establishment concerned.
(ii) Government should make adequate provision for research grants to the relevant research institutes and institutions such as NIOMR, and Universities. This will give room for quality research work and thus help to improve the quality of water and fishes in our water bodies, for instance Lagos lagoon.
(iii) Fish should be properly processed before consumption in order to prevent the bacteria in the fish from infecting human.
(iv) Environmental education program and campaign should also be organized by the regulatory agency, this will help to put all hands on deck towards sustaining a good and save aquatic environment for our fisheries resources.

Conflict of Interest

There is no conflict of interest on this research paper.

REFERENCES

Aitken A, Mackie JH, Windsor ML (1982). Fish handling and Processing. pp. 167-186.
Atlas RM, Bartha R (1998). Microbial ecology, Fundamental and applications, 4th edition. Publish by Dorling Kinderskey (India) PVT Ltd. pp. 65-69.
Austin B, Austin DA (2007). Bacterial Fish Pathogens, Diseases of Farmed and Wild Fish. Fourth Edition, Springer Dordrecht Berlin Heidelberger New York and Praxis Publishing Ltd, Chichester, UK. (Springer-Praxis book in Aquatic and Marine Sciences). pp 112-113,136.
Cahill MM (1990). Bacteria floral of fishes. Springer, New York. ISSN-0095-3628 (print) 1432-184x (on-line). J. Microb. Ecol. 19(1):21-41.
Cameron BJ, Douglas LJ (2002). Fucose-containing glycosphingo-lipids as receptors for *Candida albicans*, abstr. A-36, p. 20. In Abstracts of the ASM Conference on Candida and Candidiasis 2002, American Society for Microbiology, Washington, D.C.
Cheesbrough M (1984). Medical laboratory manual for tropical countries. Buttersworth-Heineman Ltd, Linacre House, Jordan Hill, Oxford OX28DP. Vol. II. Pg 2-4, 60-69:225-229.
Cleube AB (2008). Bacteria ecology of Tilapia of fresh fillet and some factors that can influence their microbial quality. J. Microb. Ecol. 28(4):3.
Fawole MO, Oso BA (1988). Laboratory manual of microbiology. Spectrum books limited, Sunshine House, 1, Emmanuel Alayande Street, Oluyole industrial Estate, P.M.B. 5612, Ibadan Nigeria.
Hudson EB (1990). Development in fish diseases control: Fisheries in the year 2000. Proceeding of the 21st Anniversary Conference of the Institute of Fisheries Management, 10-14th September (1997): Contamination in Animal Health Products: Prevention and risks for Animal health. Rev Sci. Tech. Int. Epiz. 16:284.
ICMSF (1986). International Commission on Microbiological Specification for food, Fish and fishery products, 677 SW Tanglewood Circle McMinnville, United States of America .
Olutiola PO, Famurewa O, Sonntag HG (1991). An introduction to General Microbiology: A Practical approach. 1st edition, Heidelberger Verlugsanstalt and drukerei, GMB Heidelberger, p. 267.
Olufemi BE (1998). Fish husbandry and medicine: The experience of a tropical veterinarian. An inaugural Lecture 1998, University of Ibadan. P. 34.
Okafor N (1985). Aquatic and water Microbiology. Fourth Dimension Publishing Company Ltd. 64A, City Layout, PMB 1164, Enugu, Nigeria.
Sherman K, Ajayi T, Anang E, Cury P, Diaz-de-Leon AJ, Fréon P, Hardman-Mountford NJ, Ibe CA, Koranteng K (2000). Suitability of the Large Marine Ecosystem Concept. Fish. Res. 64:197204.
Stoskopf MK (1993). Fish Medicine. W.B. Sanders company, Harcourt Brace Jovanovick Inc. The Curtis centre, independence square, west Philadelphia, Pennyslavania. 19106, pp. 214-216.

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Full Length Research Paper

Carcass yield and proximate composition of black caiman (*Melanosuchus niger*) meat

A. Kluczkovski Junior[1]*, A. M. Kluczkovski[1], F. T. Moroni[2], F. Markendorf[3] and A. J. Inhamuns[4]

[1]Faculty of Pharmaceutical Sciences, Federal University of Amazonas, Manaus, AM, Brazil R. Comendador Alexandre Amorim, n° 330, Manaus-AM-Brazil.
[2]Federal University of Amazonas, Biological Sciences Institute, Av. General Rodrigo Otávio, nº 3000, Manaus-AM-Brazil.
[3]DVISA/SEMSA Manaus; R. Comandante Paulo Lasmar S/N, Manaus-AM-Brazil, Zip code: 69049-110, Brazil.
[4]Fish Technology Laboratory, FCA/ Federal University of Amazonas, Av. General Rodrigo Otávio, nº 3000, Manaus-AM-Brazil.

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The Amazon region is recognized as source of fish for the food industry. The interest in new products made from exotic animal meat has increased. The present study was carried out to evaluate carcass and meat characteristics of Amazon caiman. Samples (*n*=184) of *Melanosuchus niger* were collected from a protected area in the Amazonas State (Brazil). The meat was analyzed for proximate composition: Moisture content 78.17%, protein 19.23%, lipids 1.09%, and ash 0.73%. The yield of the carcasses and cuts were evaluated, and the average yield of carcass was 57.02%. The tail cuts had the highest yield. The results obtained can be useful for new Amazon basin products as well as for product labeling.

Key words: Amazon, açu, crocodilian, protein, harvesting.

INTRODUCTION

In addition to environmental protection concerns, the trends in the current commercial market are towards creating supply chains that are socially responsible and economically viable. Accordingly, sustainable products have gained notoriety. Adding value through the characterization, qualification, and classification of crocodilian products is essential for fair trade in order to prevent *ribeirinhos,* local population who live on caiman hunting, from suffering loss of profit and to ensure that the product pricing is affordable and that the products are safe. In the Brazilian Amazon, two species of crocodilians have potential commercial applications due to their larger size, abundance, and natural history, spectacled caiman (*Caiman crocodilus*) and black caiman (*Melanosuchus niger*) (Da Silveira, 2000). The management systems in the alligator harvest units in the State of Amazonas follow the harvest and source-sink models. These models are based on the removal of individuals from a natural

*Corresponding author. E-mail: augustokjr@hotmail.com, Tel/Fax: +559233055000.

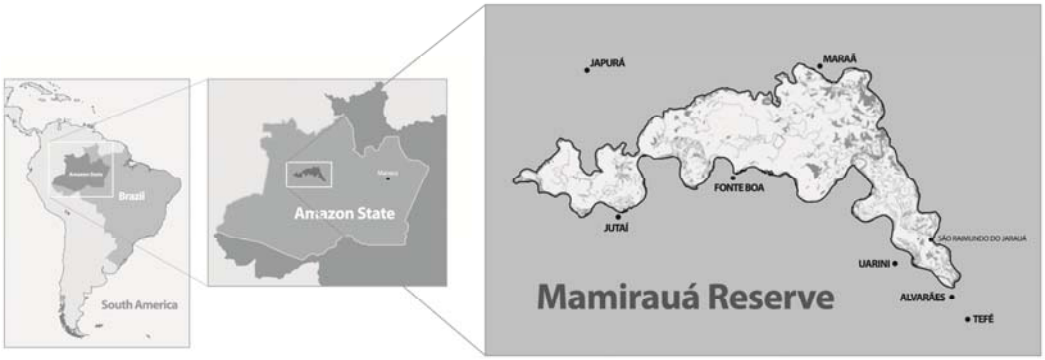

Figure 1. Mamirauá map showing the collection site and the surrounding municipalities.

population without reducing the population size (Chabreck et al., 1997). Despite the possibility of having an appropriate management of species, caimans are still subject to illegal hunting for meat (Da Silveira et al., 1998; Da Silveira and Thorbjarnarson, 1999) and be used as bait to capture other species such as piracatinga (*Calophysus macropterus*) in the Solimões, Purus, and Amazonas river basins. Da Silveira and Thorbjarnarson (1999) observed the recovery of *M. niger* population after extensive skin operating in the 1960 decade has taken place despite widespread commercial meat hunting. Somewhat paradoxically, while skin hunting significantly reduced caiman populations, meat hunting has not. Their study in the Mamirauá Sustainable Development Reserve shows how it differs from the previous system of skin hunting. This difference includes a complex interaction of factors: the legality of the hunt, differences in economic incentives of skin and meat hunting and the sizes of animals hunted, the ease of transport of the products (skins vs meat), caiman sexual size dimorphism, and patterns of sex-specific habitat selection by the two species of caiman. In general, the strategy of slow the rate of destruction of natural environments and the consequent extinction of wild species, could be a reasonable way to enhance the environment through the sustainable use of its natural flora and fauna (Hilborn et al., 1995). There has been growing international interest in exotic meats, and South American producers have seen this market as a new commercial possibility (Uhart and Milano, 2002). Therefore, scientific information on the standardization of commercial cuts, yield, meat quality, and nutritional values are necessary for the producers who are interested in offer these wild products for sale. The proximate composition data have been reported for other species, however, there are no data available for *M. niger*. In addition, its use could generate new jobs and increase the income of Amazon riverside populations involved in animal fishing and hunting, as well as increase the availability of new Amazon products. The acknowledgement about the meat quality and carcass yield is important for the evaluation of commercial viability focusing on the economic exploitation of species, in addition to providing subsidies for their technological use. According to the assumptions of conservation and sustainable use, and the findings of Da Silveira and Thorbjarnarson (1999), one of the important factors for conservation is the difficult to work with the meat than with skin. It is of great importance to know if the animal the size influences the yield of the carcass and its commercial cuts, to draw the minimum number of animals with the best possible performance. In this context, the objective of this study was to determine whether there is correlation between the size of the live animal and carcass yield or cuts yield.

MATERIALS AND METHODS

The samples were collected after the commercial slaughter of 184 *M. niger*, authorized by the Brazilian Environmental authorities and conducted by the São Raimundo Jarauá Community Fishing Association, Mamirauá Institute for Sustainable Development, Amazon Forests Agency, and Pescador Fish Industry. The animals were captured in their natural environment in the surrounding areas of São Raimundo do Jarauá, in the municipality of Maraã - AM - Brazil, a community within the focal area of Mamirauá Sustainable Development Reserve, which includes the caiman management in its Natural Resource Management Plan (Mamirauá, 1996). Figure 1 displays a map showing these locations. The animals were harvested in August and September during decrease water level season. A few number in the lakes and more intensity in the canals surround community.

The animals was captured at the night, between 10 p.m. and 2 a.m., by the local fishermen, were measured from the tip of the snout to the posterior edge of the cloaca, obtaining the snout-vent length (SVL) measurement, which corresponds to approximately half of the total length of the animal (Da Silveira and Thorbjarnarson, 1999). The animals were weighed using an analog scale (Pesola ®) of different capacities according to the animal size. They were determinate the sex by exposition of the penis in the males. Thus, the size, live weight and sex of the animals were determined. At 6 a.m. the slaughtering was initiated. The animals were washed, stunned by concussion, and the bleeding was performed by cutting the occipital region of the skull sectioning the occipital sinus. The animals were hung upside down to allow the blood to drain out and for skinning, removal of the head and feet, and evisceration. The carcasses

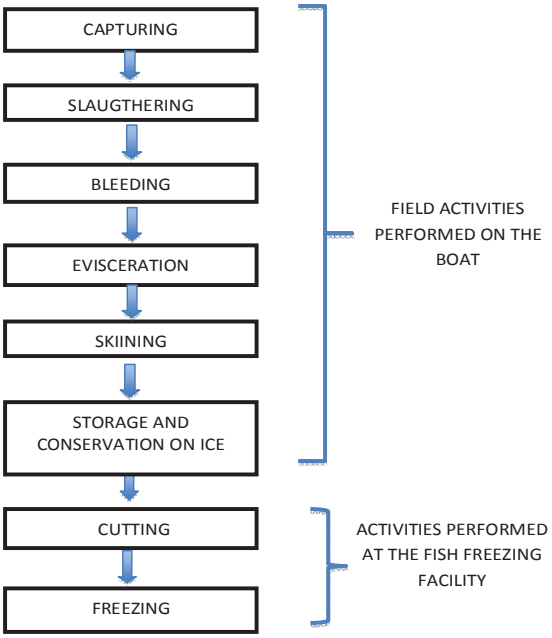

Figure 2. Flowchart of black caiman meat processing.

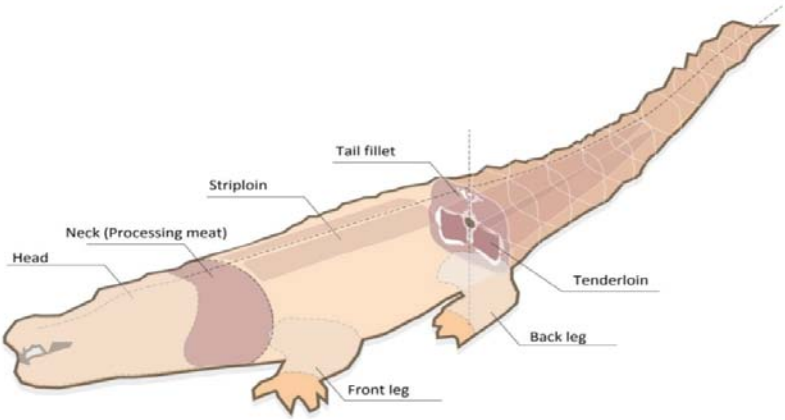

Figure 3. *M. niger* carcass components.

were washed with chlorinated water and weighed using Pesola ® scales. The clean carcasses were sent to an isothermal container of a fishing boat and kept on ice at temperatures between 0 and 1°C. After capturing and slaughtering, the carcasses were transported, 3 6 h , to a fish facility and submitted to cutting into parts two days after slaughtering. A flowchart outlining the experimental procedures is shown in Figure 2. To better use and to establish Brazilian patterns for *M. niger* meat, the carcasses were performed in cuts: neck (processing meat), front legs, back legs, boneless back legs, striploin, T-Bone, ribs, tail, tail fillet, tenderloin, and tail steaks (darnes) (Figures 3 to 5), based on the Australian Standard Cuts of *Crocodylus porosus* (Queensland, 1996).

In addition to measuring the carcass weight, the individual weights of each cut was measured using a 15 kg capacity electronic scale; when the cut exceeded this weight, weighing was performed using an analog Pesola ® scale. The cuts were frozen in a freezing tunnel at -45°C. Cuts from ten randomly chosen animals were homogenized and analyzed in triplicate for moisture content, protein, lipids, and ash, according to the AOAC (2005). The carcass yield (%) was determined by the ratio between the final weight of the carcass and the live weight of the animal; the cut yield was determined by the ration between the final weight of the cut and the live weight of the animal, as follows:

$$\frac{\text{Carcass weight} \times 100}{\text{Live weight}} = \text{carcass yield (\%)}$$

$$\frac{\text{Cut weight} \times 100}{\text{Live weight}} = \text{Cut yield (\%)}$$

The results were tabulated and analyzed statistically. Analysis of variance was used to evaluate the proximate composition, and a significant difference was observed. The carcass and cut yield data were subjected to the Tukey's test at a significance level of 5%. The linear relationship between SVL (cm) and the cut yield (%) and also between SVL (cm) and the cut weight (kg) was verified by the

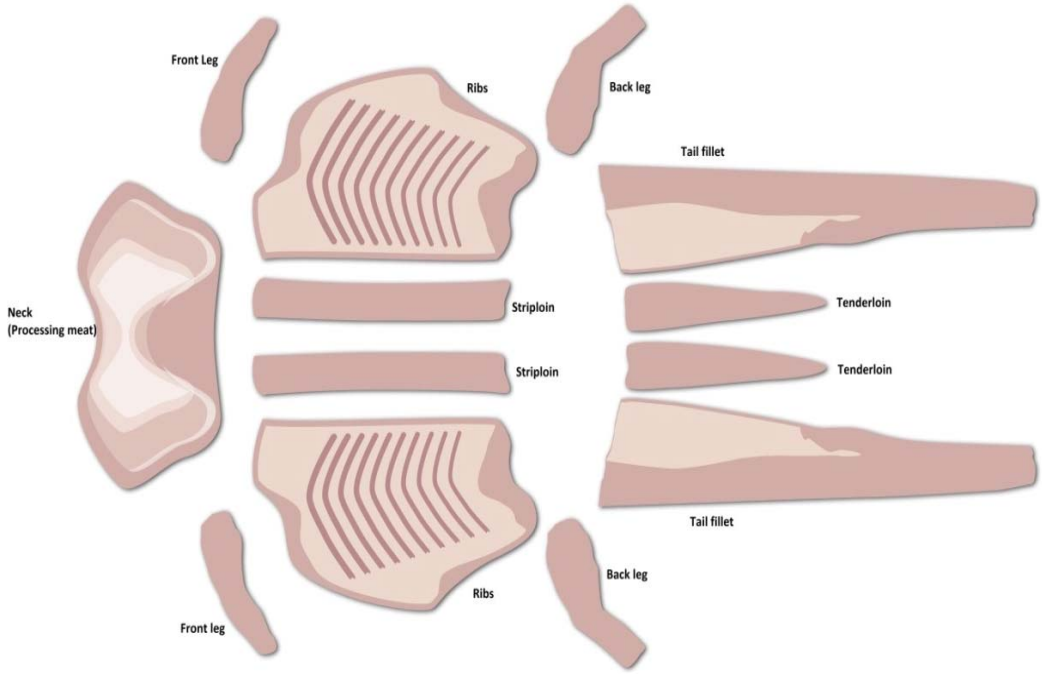

Figure 4. *M. niger* separated cuts.

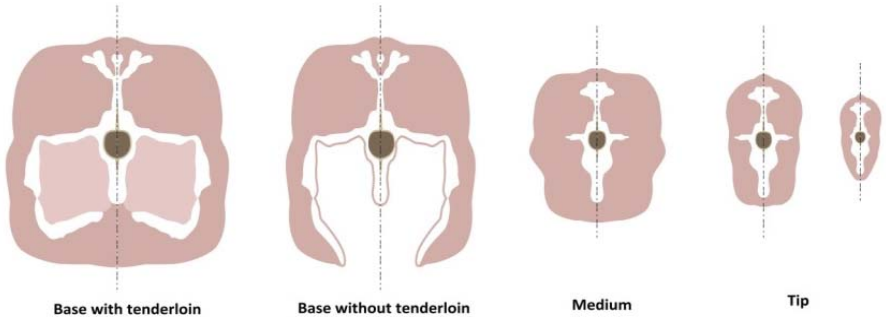

Figure 5. Cross sections of the tail: from the base of the tail to the tail tip.

Pearson's correlation coefficient (r); the Student-t test was used to determine the statistical significance. The linear relationship coefficients were determined by the method of least squares. The analysis was performed using the R statistical software (R Development Core Team, 2011). Lattice graphics were implemented in Sarkar (2008).

RESULTS AND DISCUSSION

The proximate composition data of some cuts are showed in Table 1. The average values for proximate composition of *M. niger* were: moisture content 78.17%, protein 19.23 g%, and lipids 1.09 g%. The mean levels found were similar to those of other studies conducted on other species of crocodilians, as shown in Table 2. Different values were observed for other animal species commonly found in butcher shops, for example, beef (beef for stewing): moisture 71.9 to 72.5%, protein 21.4 to 21.8 g%, lipids 4.6 to 5.3% (West et al., 2014); chicken meat: moisture 72.9%, protein 17.1 g%, and lipids 9.8 g% (NEPA-UNICAMP, 2011); pork: moisture 67.7%, protein 22.6 g%, and lipids 8.8 g% (NEPA-UNICAMP, 2011). Special attention should be paid when comparing the results of this study with those of other species of crocodilians since the animals used in the present study were captured in their natural environment (Table 2). Vicente et al. (2006) reported the proximate composition of captive-bred animals, with controlled environmental and feeding conditions, different from those of the caimans in the Amazon region. The samples in the present study showed lower lipid content than that of captive-bred animals because lipid content can vary with seasonal changes, type of feeding, and animal's exercise intensity. This hypothesis is supported by the findings of

Table 1. Proximate composition of different cuts of black caiman ($p < 0.05$).

Cut description	Proximate composition variables (%)			
	Moisture	Protein	Lipid	Ash
Tail fillet	77.4±0.39	20.68±0.2	0.63±0.07	0.8±0.03
Tenderloin	78.87±0.1	19.22±0.12	0.75±0.2	0.73±0.02
Strip loin	78.42±0.26	17.79±0.41	1.75±0.12	0.88±0.05
Boneless ribs	77.44±0.57	18.87±0.22	1.44±0.15	0.96±0.26
Neck	77.23±0.3	20.94±0.35	1.74±0.007	0.63±0.15
Boneless back legs	78.52±1.76	18.63±0.78	0.57±0.06	0.6±0.11
Boneless front legs	79.28±0.3	18.47±1.01	0.75±0.26	0.49±0.11

Table 2. Comparison between carcass yield and proximate composition of different species of crocodilians and regular meats.

Meats	Carcass yield %	Proximate composition (g%)			
		Moisture	Protein	Lipid	Ash
Crocodilians					
Melanosuchus niger	57.02	78.17	19.23	1.09	0.73
Caiman latirostris[a]	54.00	74.00	16.90	4.39	1.00
Cayman yacare[b]	59.50	74.49	21.88	2.98	1.17
Crocodilus niloticus[c]	56.50	71.64	22.08	6.23	0.51
Alligator mississipiensis[d]	62.35	75.50	21.45	1.22	1.30
Regular meats					
Beef	53.2[e]	72.4[f]	21.6[f]	5.5[f]	1.00[f]
Pork	59[g]	67.7[f]	22.6[f]	8.8[f]	1.00[f]
Chicken	73.3 to 74.5[h]	76.4[f]	17.8[f]	4.9[f]	0.9[f]

(a) Cossu et al. (2007); (b) Romanelli and Felicio (1999); (c) Hoffman et al. (2000); Moody et al. (1980); (e) Spanguero et al. (2004); (f) NEPA-UNICAMP (2011); (g) Fortin et al. (2003); (h) Kokoszynski and Bernacki (2008).

Almeida et al. (2008). They observed tambaquis (*Colossoma macropomum*) and reported that nature animals had between 42 and 48% less fat than farmed animals. Horna et al. (2001) report that *M. niger* are predators to suit a wide variety of prey, feeding almost anything that moves around. However, they observed a positive relationship between a mean proportion of snails and fish in the diet and the black caiman size, and a negative relationship between insects larvae and the animals size. Therefore, Da Silveira and Magnusson (1999) observed a higher amount of fish in stomachs of *C. crocodilus* during the rising and decrease water level season of the Rio Negro (26 m > 20 m) in animals captured in canals, demonstrating increased availability of fish in these stations and environment. In our work the *M. niger* samples were harvested in canals in August and September, with the water level between 30 and 25 m. These animals were captured with the best possible body status. However, it is important to repeat the experiment in other seasons to check the body status and carcass yield.

Table 3 shows the average weight and carcass and cut yield (%) of *M. niger*. The carcass yield values were satisfactory when compared to those of meat animals: bovine 53.2% (Spanghero et al., 2004), bubaline 52.6% (Spanghero et al., 2004), swine 59% (Fortin et al., 2003), ovine 53.16% (Bueno et al., 2000). The results obtained were significantly lower than the existing data of broilers, 73.3 to 74.5% (Kokoszynski and Bernacki, 2008), animals with considerable genetic improvement and bred with high feeding technology, use of good management practices, and intended for meat.

All of the cuts had a positive correlation between weight (kg) and SVL (cm) ($p < 0.0001$), with a correlation coefficient r greater than 0.80. The average SVL was 109.99 ± 15.55 cm, including animals from 59.50 to 151.10 cm, and the average live weight of 40.90 kg ±18:22, including animals of 14.00 to 96.00 kg. This is an expected exponential relationship, as shown in Figure 6, amongst all animal species considering that animals gain muscle mass with growth. The carcass yield of *M. niger* obtained in the present study was higher than those found by Cossu et al. (2007), 54.0% for *Caiman latirostris* and *Caiman yacare* and 56.5% for *Caiman niloticus* (Hoffman et al., 2000). On the other hand, the carcass yield of *M. niger* obtained here was lower than those found by

Table 3. Cut weight and cut yield and correlation between weight and SVL of black caiman.

Component	n	Cut weight (kg)	Yield (%)	Cut weight – SVL		Yield – SVL	
				r	p	r	p
Empty carcass weight	15	23.26 ± 9.75	57.02 ± 6.20	0.93	0.0010	0.10	0.7285
Commercial cuts total	163	18.29 ± 8.74	44.80 ± 5.77	0.93	0.0000	0.17	0.0326
Tail	51	5.11 ± 1.25	19.61 ± 1.80	0.89	0.0001	-0.12	0.3840
Tail steaks (darnes)	68	7.30 ± 3.92	14.85 ± 6.82	0.51	0.0001	-0.18	0.1427
Tail fillet	66	6.16 ± 3.15	13.82 ± 3.68	0.77	0.0001	-0.01	0.9163
Ribs	184	4.72 ± 2.49	11.53 ± 3.64	0.78	0.0001	0.07	0.3233
T-bone	19	3.46 ± 1.81	8.28 ± 2.04	0.91	0.0001	-0.19	0.4319
Neck (processing meat)	181	1.92 ± 1.16	4.69 ± 1.34	0.84	0.0000	0.33	0.0000
Back legs	184	1.72 ± 0.74	4.20 ± 0.42	0.92	0.0001	-0.20	0.0060
Striploin	159	1.25 ± 0.60	3.05 ± 0.60	0.91	0.0000	0.13	0.1058
Boneless back legs	91	1.30 ± 0.59	3.00 ± 0.45	0.90	0.0001	-0.15	0.1620
Tenderloin	125	1.31 ± 0.48	2.77 ± 0.37	0.92	0.0000	-0.21	0.0203
Front legs	184	0.60 ± 0.28	1.46 ± 0.27	0.89	0.0001	0.07	0.3169

SVL= Snout-vent length; n= number of samples.

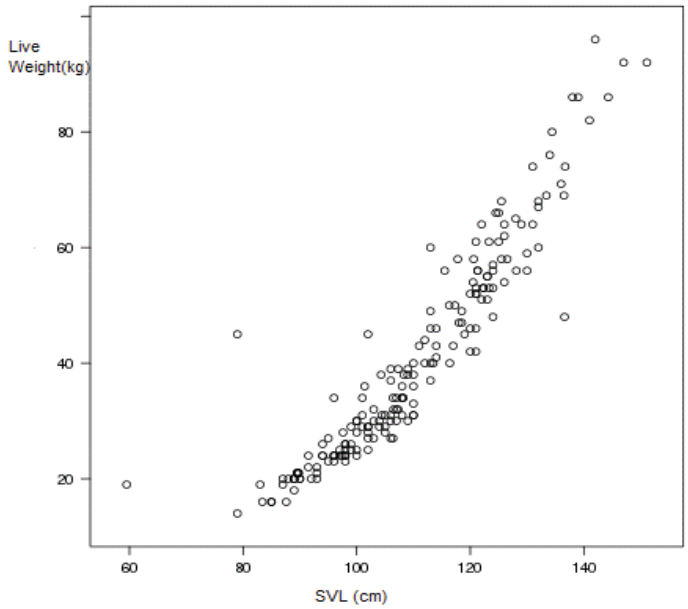

Figure 6. Live weight-SVL relationship.

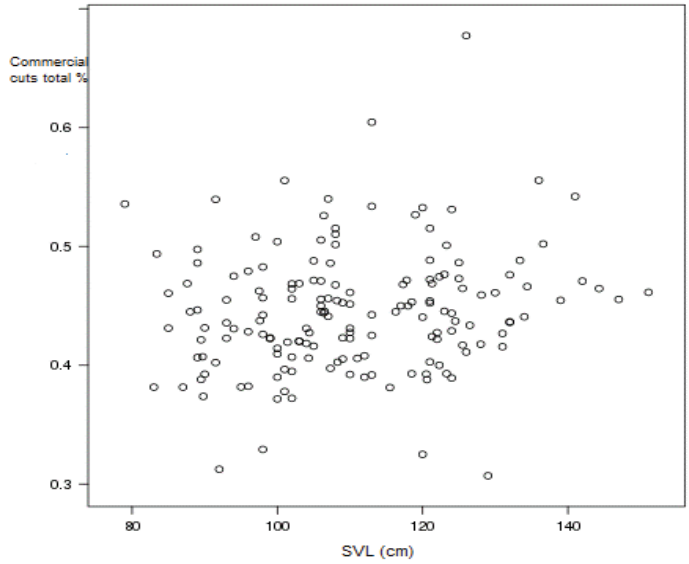

Figure 7. Dispersion of the relationship between commercial cuts total (%) and SVL (cm) data.

Romanelli and Felicio (1999), 59.5% for *C. yacare* and by Moody et al. (1980), 62.35% for *Alligator mississippiensis.* The reasons for these differences may be based on gender, food availability, hormonal changes, and handling techniques during cutting, according to Hoffman et al. (2000). In our work, even larger variation was possible, considering that those studies were conducted with captive-bred animals with standard group, and the animals analyzed in the present study were captured in their natural environment. Despite of the crocodilians phenotype similarity, it is hard to make a comparison with other authors considering that they used different cutting patterns and farmed animals. A positive or direct correlation between yield (%) and SVL (cm) was observed for the cut "neck" ($p<0.0001$), and a negative or inverse correlation was observed for the cuts "bone-in back legs" and "tenderloin" ($p<0.0402$). However, the correlation coefficient r was below 0.35 in all cases. Therefore, these correlations are considered weak or not statistically significant. No correlation was observed between yield (%) and SVL (cm) for carcass yield, commercial cuts total (Figure 7), and for the cuts: front legs, boneless back legs, ribs, striploin, T-Bone, tail, tail steaks, and tail fillet ($p > 0.1427$).

Conclusions

M. niger is an excellent source of animal protein found in the Amazon region. The results obtained demonstrate that the black caiman meat can be considered an important nutritional resource compared with other animal's meat. The proximate composition and carcass yield of *M. niger* are similar to those of other crocodilians analyzed in different regions in the world. Our findings suggest that the size of the animal not affect carcass yield economically significant. Thus the choice of the size classes of *M. niger* for slaughter is not necessary based on this variable. On the other hand, more studies are necessary to establish texture, color, flavor standards and other variables that may influence sensory or economically the meat of black caiman.

Conflict of Interest

The authors have not declared any conflict of interest.

ACKNOWLEDGEMENTS

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REFERENCES

Almeida NM, Visentainer JV, Franco RB (2008). Composition of total, neutral and phospholipids in wild and farmed tambaqui (*Colossoma macropomum*) in the Brazilian Amazon area. J. Sci. Food Agric. 88:1739-1747.

AOAC, Association of Official Analytical Chemists (2005). Official methods of analysis of AOAC international, 17th ed. Gaithersburg, MD, USA: AOAC International.

Bueno MS, Cunha EA, Santos LE, Roda DS, Leinz FF (2000). Características de carcaças de cordeiros Suffolk abatidos em diferentes idades. Revista Brasileira de Zootecnia 29:1803-1810.

Chabreck RH, Wright VL, Addison JRB, Bossert DC (1997). Survival of farm- released alligators in a freshwater marsh in Louisiana, USA. *In:* ARRIAGA-WEISS, S. L. & CONTRERAS S., W. Memórias de la 4a. Reunión Regional del Grupo de Especialistas en Cocodrilos de América latina y el Caribe. Centro Regional de Innovación Agroindustrial S.C. pp. 60-69.

Cossu ME, Gonzalez OM, Wawrzkiewic M, Moreno D, Vieite CM (2007). Carcass and meat characterization of “yacare overo” (*Caiman latirostris*) and “yacare negro” (*Caiman yacare*). Braz. J. Vet. Res. Anim. Sci. 44:329-336.

Da Silveira R (2000). Black caiman density. Newsletter Crocodile Specialist Group IUCN/SSC.19:18.

Da Silveira R, Thorbjarnarson J (1999). Conservation implications of commercial hunting of black and spectacled caiman in the Mamirauá Sustainable Development Reserve, Brazil. Biol. Conserv. 88:103-109.

Da Silveira R, Gordo M, Marcon J, Silva JR (1998). Skins from wild Spectacled caiman confiscated in the Amazônia. Newslett. Crocodile Specialist Group/IUCN-SSC 17:7- 8.

Fortin A, Robertson WM, Kibite S, Landry SJ (2003). Growth performance, carcass and pork quality of finisher pigs fed oat-based diets containing different levels of beta- glucans. J. Anim. Sci. 8:1449-1456.

Hilborn R, Walters CJ, Ludwig D (1995). Sustainable exploitation of renewable resources. Annu. Rev. Ecol. Systematics 26:45-67.

Hoffman LC, Fisher PP, Sales J (2000). Carcass and meat characteristics of the Nile Crocodile (*Crocodylus niloticus*). J. Sci. Food Agric. 80:390-396.

Horna JV, Cintra R, Ruesta PV (2001). Feeding ecology of black caiman *Melanosuchus niger* in a western amazoniam forest: the effects of ontogeny and seasonality on the diet composition. *Ecotropica* 7:1-11.

Kokoszynski D, Bernacki Z. (2008). Comparison of slaughter yield and carcass tissue composition in broiler chickens of various origin. J. Central Eur. Agric. 9:11-16.

Mamirauá (1996). Plano de Manejo da Reserva de Desenvolvimento Sustentável Mamirauá. *Mamirauá: Plano de Manejo*. 96 p.

Moody MW, Coreil PD, Rutledge JE (1980). Alligator meat: Yields, quality studied. Lousiana Agric. 24:14-15.

NEPA-UNICAMP (2011). Tabela brasileira de composição de alimentos, 4 ed., Campinas: NEPAUNICAMP, 4:161.

QUENSLAND GOVERNMENT, Department of Primary Industries – Cairns, Quensland. (1996). Department of Primary Industries, Rural Industries Research and Development Corporation, Northern Territory. Department of Primary Industry and Fisheries. Handbook of Australian Crocodile Meat, 18 p.

R Development Core Team (2011). A language and environment for statistical computing. R Foundation for Statistical Computing.

Romanelli PF, Felicio PE (1999). Jacaré do Pantanal (*Caiman crocodilus yacare*): Rendimentos de abate e composição da carne. *Higiene Alimentar* 13:11-15.

Sarkar D (2008) Lattice: Multivariate Data Visualization with R. Springer-Verlag New York. P. 268.

Spanguero M, Gracco L, Valusso R, Piasentier E (2004). *In vivo* performance, slaughtering traits and meat quality of bovine (Italian Simmental) and buffalo (Italian Mediterraneam) bulls. Livest. Prod. Sci. 91:129-141.

Uhart M, Milano F (2002). Multiple species production systems. eversingun der development and non sustainability in Latin America. Annals New York Academy Sci. 969:20-23.

Vicente NJ, Bressan MC, Faria PB, Vieira JO, Santana MTA, Kloster M (2006). Composição centesimal e colesterol da carne de jacaré-do-Pantanal ((*Caiman yacare* DAUDIN (1802) oriundo de zoocriadouro e habitat natural. *Ciência agrotécnica* 30: 701-706.

West SE, Harris KB, Haneklaus AN, Savell JW, Thompson LD, BrooksJC, Pool JK, Luna AM, Engle TE, Schutz JS, Woerner DR, Arcibeque SL, Belk KE, Douglass L, Leheska JM, McNeill S, Howe JC, Holden JM, Duvall M, Patterson K (2014). Nutrient Database Improvement Project: The influence of USDA Quality and Yield Grade on the separable components and proximate composition of raw and cooked retail cuts from the beef chuck. Meat Sci. 97:558-567.

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Full Length Research Paper

Benefits derived from National Fadama Development Project II by fish farmers in Lagos State, Nigeria

Tiamiyu, S. A[1], Olaoye, O. J.[2], Ashimolowo, O. R.[1], Fakoya, E. O.[1] and Ojebiyi, W. G.[1]*

[1]Department of Agricultural Extension and Rural Development, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria.
[2]Agricultural Media Resources and Extension Center, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria.

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This study assessed the benefits derived by fish farmers from Fadama II project in Lagos State by interviewing 185 fish farmers who participated in Fadama II project from 9 Fadama Community Associations (FCAs) through a multistage sampling technique. Data collected with the aid of structured interview guide were analyzed with descriptive statistics and Chi-square. Majority of the fish farmers were male (71.89%), Christians (53.51%), married (41.62%) and educated (89.19%). The mean level of participation indicated that fish farmers participated mostly in decision making (2.97), election of group/association executives (2.95) and attendance at group meetings (2.86). The fish farmers benefited mainly from technical support through training, technological and material supports via the project. The fish farmers greatly benefited from the provision of fingerlings (96.77%), provision of drag net (96.77%), provision of generator (94.05%), purchase of weighing machine (92.97%) and provision of pelleting machine (92.43%). Acceptance of production system for use was high for concrete tanks (69.73%), earthen pond (58.92%) and wooden tank system (50.27%). The result of Chi-square deduced that there were significant associations between the fish farmers' level of benefit derived from Fadama II project and their level of participation in decision making (χ^2=7.153, p<0.05), financial contribution (χ^2=6.122, p<0.05), advisory services to other group members (χ^2=10.903, p<0.01), maintenance of association equipments (χ^2=10.121, p<0.01), rehabilitation or construction of local fish markets (χ^2=0.003, p<0.01) and election of association executives (χ^2=11.415, p<0.01). The study therefore concluded that NFDP II has not only economic benefits but also social, technological, technical and material supports on fish farming in Lagos State and recommended that development projects should employ the demand-driven, bottom-top, informal and community-driven approaches in addressing the need of the poor in rural areas.

Key words: Training, social benefits, group participation, fisheries, National Fadama Development Project (NFDP II).

INTRODUCTION

Agriculture remains the most important sector of the Nigeria's economy despite the nation's reliance on crude oil and its products since the commercial exploration of oil in the early 1970s and the consequent neglect of the

*Corresponding author. E-mail: josephgbojo2012@gmail.com Tel: +2348057008301.

agricultural sector. The continued importance of the sector is because, it accounts for about 42% of the nation's total Gross Domestic Product-GDP (Olomola, 2013) and employing 65 to 70% of the nation's working population (Olomola, 2013; Emeka, 2007 cited by Olajide et al., n.d.; Sekumade, 2009 cited in PRESHSTORE, 2013).

The neglect of the agricultural sector by the government coupled with the teeming population of Nigeria led to decrease in the exportation of important cash crops like cocoa, palm-oil, groundnut, etc and even decreased production of staple food. This made the country to expend billions of Naira on importation of food crops like rice, wheat, sugar and even fish (Nwajiuba, 2013). Fisheries are one of the four important subsectors of Nigeria's agriculture. Fisheries contribute about 4% agriculture's share of the GDP (National Technical Working Group- NTWG, 2009). While the crop and livestock production subsectors had been stable over the years in terms of their contributions to the nation's GDP, the contribution of fisheries has been on the increase with forestry's share declining. According to Adekoya and Miller (2004) cited by Kudi et al. (2008), fish and its products contribute more than 60% of the total protein intake of adults, especially in rural areas.

Despite the favourable natural endowments that the country has been blessed with in terms of the coastal shelf area and the vast networks of inland waters like rivers, flood plains, lakes and reservoirs, local fish production has failed to meet the nation's domestic demand (FAO, 1995 in Kudi et al., 2008; Federal Department of Fisheries- FDF, 2007 cited in NTWG, 2009). This led to the importation of about 700,000 tonnes of fish per year (FDF, 2007). No wonder, Nigeria has been regarded as the biggest importer of fish in Africa when the present per capita fish consumption level in the country is considered (Olaoye et al., 2014).

To arrest this ugly situation, successive Nigerian governments initiated and implemented series of agricultural development policies, strategies and programmes with very few making significant impact while most had little or no effect in the lives of the people. Such programmes were aimed at increasing local food production, increasing income of farmers, improving the living condition of the poor, women and other vulnerable groups among other good intentions of the government in order to ultimately reduce poverty which is one of the Millennium Development Goals (MDGs). One of the poverty reduction programme of the Nigerian government is the National Fadama Development Programme (NFDP). The programme is being implemented in phases known as projects.

The first phase of the National Fadama Development Programme, known as Fadama I was implemented between 1993 and 1999 through the top-down and supply-driven approach. It focused on crop production leaving out other subsectors of agriculture by providing crop farmers with boreholes and pumps through simple credit arrangements. Following the shortcomings of Fadama I, the second phase, branded as Fadama II was Fadama I, the second phase, branded as Fadama II was launched in 2004 and first implemented in 2005. Fadama II employed the bottom-top approach, community-driven and participatory development approaches and included other Fadama resource users like fisher-folks, hunters, vegetable farmers, etc with the primary aim of empowering the local communities in order to improve governments' capacity to reach out to poor people in Fadama areas (FDF, 2008). This was achieved by designing and implementing production plans through the respective Fadama User Groups (FUGs) in the different Fadama Community Associations (FCAs).

Benefits derivable from any empowerment projects, especially those that incorporated the essential components of community-driven development (like Fadama II) could be financial (increased income or decreased production cost), social (human relations within groups), technological (use of improved technologies) and technical (acquisition of technical skills through training). It has been noticed that most researches that assessed Fadama II project had concentrated on the economic benefits through increased production output, increased income and decreased production cost while neglecting other categories of benefits. It is against this background that this study assessed these other benefits (technological, technical and social benefits) that the participants (fish farmers) derived from the implementation of the project in Lagos State, Nigeria. These benefits are expected to sustain the interest of fish farmers in fish farming even at the expiration of the project.

Fishing is the most important occupation of the rural population along the coastline and river courses, ranking next to crop farming in terms of occupation of all rural households in the state. Artisanal fishing is prominent along the coastal areas of the State covering Ibeju-Lekki, Lagos Island, Epe, Ikorodu and Badagry. The state has an extensive network of Lagoon Rivers, creeks, swamps and estuaries which makes up 22% of its total land mass and this gives the state a comparative advantage over other states of the Federation in fishing and related activities (Olaoye, 2010; National Bureau of Statistics-NBS, 2007).

METHODOLOGY

This study was carried out in Lagos State. Lagos State is the second most populated country in Nigeria (National Population Commission- NPC, 2006). It is a state located in the southwestern part of the country with 20 local government areas (LGAs).). Lagos is a marine state in the Federal Republic of Nigeria and has a land area of 3,577 km^2 representing 0.4% of the total land mass of Nigeria, making it the smallest state in Nigeria in terms of its land mass (but it is arguably the most economically important state in Nigeria). It is bordered in the South by the Atlantic Ocean, in the

West by the Republic of Benin, in the East and North by Ogun State and stretches over 180 km along the coast of the Atlantic Ocean (Lagos State Agricultural Development Agency- LASADA, 2002). Fishing is the most important occupation of the rural population along the coastline and river courses, ranking next to crop farming in terms of occupation of all rural households in the state. Artisanal fishing is prominent along the coastal areas of the State covering Ibeju-Lekki, Lagos Island, Epe, Ikorodu and Badagry. The state has an extensive network of Lagoon Rivers, creeks, swamps and estuaries which makes up 22% of its total land mass and this gives the state a comparative advantage over other states of the Federation in fishing and related activities (Olaoye, 2010; National Bureau of Statistics- NBS, 2007).

Out of the 10 local government areas (LGAs) of Lagos State that participated in Fadama II project, 7 had fish farmers in their Fadama Community Associations. One hundred and eighty-five fish farmers were sampled through the multistage sampling technique as described below and presented in Table 1.

Stage 1 involves the random selection of 9 out of 14 Fadama Community Associations of fish farmers from the 7 LGAs. This constitutes two-thirds of the FCAs. This was followed by the random selection of two-thirds of the Fadama Users groups (FUGs) which resulted in the selection of 24 out of the 34 FUGs in the 9 FCAs. The final stage involves the random sampling of 60% of the members in each of the selected FUGs and this resulted in 185 fish farmers.

Information was elicited on the socioeconomic characteristics, level of participation in Fadama groups' activities, kinds of benefits derived from Fadama II project and the level of benefit derived from the project from the 185 sampled participants of Fadama II projects who were fish farmers. Collected data were analyzed with both descriptive (frequency, percentage and mean) and inferential (Chi-square) statistics. Results were presented in distribution tables.

RESULTS AND DISCUSSION

Socioeconomic characteristics of Fadama II fish farmers

In Table 2, about 90.81% of the Fadama II fish farmers were 60 years or less. This implies that higher proportion of the fish farmers who participated in the Fadama II project were in the working population. Majority of the fish farmers were male (71.89%), Christians (53.51%), married (41.62%) and educated (89.19%). Table 2 further reveals that the highest proportion (40.54%) of the fish farmers had at least secondary education while about 27.57% of them had at least tertiary education. This shows that the fish farmers who participated in Fadama II project in Lagos State were not illiterates. These findings were in line with the reports of Oladoja and Adeokun (2009) and Henri-Ukoha et al. (2011) which found that most Fadama fish farmers were still active, vibrant and dynamic; married and practiced Christianity, male-dominated and moderately educated. Similar findings about the socio-economic characteristics were observed among the Fadama II fish farmers in Ogun State (Olaoye et al., 2011).

Result from Table 2 further reveals that majority (52.97%) of the fish farmers had household sizes of 6 to 10 persons with a mean household size of approximately 6 persons. A mean fish farming experience of 11.6 years was found among the Fadama II fish farmers with the majority (62.70%) of the fish farmers having between 1 and 10 years of fish farming experience. The participants were culturing *Clarias sp*; tilapia and *Heterobranchus sp.* Table 2 shows that all (100%) of the fish farmers cultured *Clarias sp* in combination with either tilapia or *Heterobranchus sp.* with only 5.95% combining the three species. This agrees with the findings of Olaoye et al. (2011) that many of the fish farmers cultured *Clarias sp.* more than any other fish species. The reasons attributed to this are that *Clarias sp.* have higher market value, is more tolerant, hardy and attain market size in a shorter time (Olaoye et al., 2007).

Level of participation in group activities

Table 3 reveals that all the group activities identified in this study received high level of participation from fish farmers. However, their degree of participation varied. The mean level of participation in Table 3 further ranked fish farmers' participation in decision making (2.97) first, followed by their participation in election of group/association executives (2.95), attendance in group meetings (2.86), maintenance of association materials and equipments (2.77), financial contribution to the growth and development of Fadama User Groups (2.50), handling of association equipments (2.46), advisory services to other group members (2.44) and rehabilitation/construction of local markets (2.31). The high level of participation of the fish farmers in their respective FUGs and FCAs is expected to strengthen both the associations and group members socially, economically and financially. This is in consonance with the views of Ladele (1995) cited by Oladele and Afolayan (2005) that included self improvement due to skill acquisition and provision of supportive services to compliment education function of extension as some of the advantages of using farmers' associations.

Technologies adopted by fish farmers from the Fadama II project

Improved technologies like earthen pond, concrete pond, wooden tank, cage culture and improvised recirculatory systems were introduced and disseminated to the fish farmers within the six years of implementing the Fadama II project. Table 4 shows the varied degree of acceptability the different technologies received by the fish farmers. While earthen pond and concrete pond production systems were accepted for use by 58.92% and 69.73% of the fish farmers respectively, just about half (50.27%) accepted the use of wooden tank system. Also, the cage culture and improvised recirculatory systems were only accepted by 21.08 and 41.08% respectively. The variation observed in the adoption of the different technologies by the fish farmers proves the

Table 1. Sampling procedure showing the number of selected fish farmers from the FUGs and FCAs in Lagos State, Nigeria.

List of FCAs	Lists of FUGs in the FCAs	No. of members in the FUGs	Number of selected members from the FUGs	Total
Agbeyewa FCA	Ore-Ofe FUG	16	10	20
	Farmate FUG	17		
	Dolphin FUG	17	10	
Agbede FCA	Ebuwawa zone 1 FUG	14	8	27
	Agbede Eleja FUG	16	10	
	Mowowale Ebuwawa	15	9	
	Tikulosoro	12		
Progressive FCA	Oluwatobi FUG	11		
	Nobel FUG	20		
Ikosi marketers FCA	Igbehinadun FUG	21	13	13
Irepodun FCA	Agbegbemi Fish FUG	17	10	25
	Thethewagbe FUG	13	8	
	Albarka Ajido FUG	14		
	Wheviyon fish FUG	12	7	
Orisunmibare FCA	Kajola fishery FUG	13	8	27
	Kajola poultry FUG	8		
	Agbelo Gbon Fishery FUG	9		
	Anuoluwapo FUG	12	7	
	Divine strategic fish Farming FUG	10	6	
	Success fish Farmers FUG	10	6	
Blessed FCA	Blessed Assurance FUG	10		
	Bless Grace Leads FUG	10		
	Blessed God's Favour FUG	10		
Divine FCA	Devine Favour FUG	11	7	19
	Devine Touch FUG	10		
	Devine solution FUG	10	6	
	Devine Dominion FUG	10	6	
Igbehin Adun FCA	Amunidara FUG	10		
	Owomilere FUG	10		
	Anu Oluwapo FUG	10		
Itoikin Idena FCA	Assefad FUG	10	6	25
	Omega FUG	10		
	Citicol FUG	10	6	
	Gold Water FUG	10		
	Irewolede FUG	12	7	
	Simisola FUG	10	6	
Osapa women FCA	Olohuntosin FUG	12	7	22
	Oredola FUG	12		
	Irewolede FUG	12	7	
	Progressive FUG	12	8	
Aldamak FCA	Aldamak FUG	11		
	Owotutu FUG	14		
Ayo FCA	Olorunda FUG	11	7	7
	God's Will FUG	10		
Ayetoro FCA	Access Divine	13		
Total		**547**		**185**

Based on Preliminary Survey (2013).

Table 2. Socio-economic characteristics of Fadama II fish farmers.

Socioeconomic characteristics	Frequency	Percentages (%)	Mean
Age (years)			
≤60	168	90.81	47.8 years
>60	17	9.19	
Sex			
Male	133	71.89	
Female	52	28.11	
Religion			
Islam	74	40.00	
Christianity	99	53.51	
Traditional	12	6.49	
Marital status			
Single	59	31.89	
Married	77	41.62	
Divorced	40	21.62	
Widowed	9	4.86	
Highest educational level attained			
No formal education	20	10.81	
Adult education	17	9.19	
Primary education	22	11.89	
Secondary education	75	40.54	
Tertiary education	51	27.57	
Household size (persons)			
1-5	70	37.84	6.08 persons
6-10	98	52.97	
11-15	17	9.19	
Fish farming experience (years)			
1-10	116	62.70	
11-20	23	12.43	11.6 years
>20	46	24.86	
Species cultured			
Clarias sp	185	100.00	
Tilapia	80	43.24	
Heterobranchus spp.	11	5.95	

Source: Field Survey (2013).

Table 3. Interviewer's level of participation in group activities.

Group activities	Level of participation			Mean	Ranking
	High	Medium	Low		
Decision making	179 (96.76)	6 (3.24)	0 (0.00)	2.97	1st
Financial contribution	104 (56.22)	70 (37.84)	11 (5.95)	2.50	5th
Operation/handling of equipments owned by the group	100 (54.05)	70 (37.84)	15 (8.11)	2.46	6th
Rehabilitation/construction of local markets	89 (48.11)	64 (34.59)	32 (17.30)	2.31	8th
Maintenance of equipments owned by the association	148 (80.00)	31 (16.76)	6 (3.24)	2.77	4th
Election of association executives	176 (95.14)	9 (4.86)	0 (0.00)	2.95	2nd
Attending meetings	160 (86.49)	25 (13.51)	0 (0.00)	2.86	3rd
Advisory services to other group members	118 (63.78)	30 (16.22)	37 (20.00)	2.44	7th

Source: Field Survey (2013).

Table 4. Technologies adopted from Fadama II.

Disseminated technologies	Frequency	Percentage
Earthen pond system	109	58.92
Concrete pond system	129	69.73
Wooden tank system	93	50.27
Cage culture system	39	21.08
Improvised recirculatory system	76	41.08

Source: Field Survey (2013).

Table 5. Kind of benefits derived from Fadama II project.

Kind of benefits	Frequency	Percentage
Technical know-how through training	94	50.81
Material supports through provision of inputs	179	96.76
Pilot asset acquisition	181	97.84

Source: Field Survey (2013).

fact that innovations are not usually adopted by all farmers at the same rate. This made Adekoya and Tologbonse (2005) to categorize adopters into the innovators, early adopters, early majority, late majority and the laggards/late adopters. The variation in the rate at which the fish farmers adopted the different technologies is also attributed to the compatibility, relative advantage and complexity of the different technologies to their existing production systems.

Kind of benefits derived from Fadama II project

The fish farmers' benefits were categorized as technical, material supports and pilot asset acquisition in this study. Table 5 reveals that almost all the fish farmers benefited from material supports through the provision of inputs (96.76%) and pilot asset acquisition (97.84%) while just about half of the fish farmers benefited from technical know-how through trainings received on fish preservation and hatching of fingerlings. This supports the findings of Olaoye et al. (2011) which reported that majority of the fish farmers had one form of training or the other on fish production. Olaoye et al. (2011) also reported that Fadama II project supported fish farmers with inputs while also providing them with pilot asset acquisition support. All the broad categories will ultimately contribute to the social and economic benefits of the farmers.

Level of benefits derived by fish farmers

Table 6 reveals that majority of the fish farmers greatly benefited from the provision of overhead tank (83.24%), provision of generator (94.05%), provision of pelleting machine (92.43%), provision of hatchery equipments (85.95%), provision of drag net (96.77%), provision of deep well (84.32%), rehabilitation of earthen ponds (77.84%), rehabilitation of homestead pond (90.81%), purchase of weighing machine (92.97%), provision of fingerlings (96.77%), training on hatching technique (76.60%) and training on fish preservation techniques (72.34%). The mean level of benefit derived from Fadama II indicated that the fish farmers benefited most from provision of drag net and provision of fingerlings while the least benefits were derived from rehabilitation of earthen pond and training on fish preservation techniques. With the great benefits derived by the fish farmers from Fadama II project, there is an assurance that fish farming in Lagos State could be sustained and hence, there is high potential that local fish production in Lagos State can be increased in the shortest period of time.

Association between fish farmers' level of participation in Fadama group activities and the level of benefits derived from the project

Table 7 shows that there were significant associations between the fish farmers' level of benefit derived from Fadama II project and their level of participation in decision making (χ^2=7.153, $p<0.05$), financial contribution (χ^2=6.122, $p<0.05$), advisory services to group members (χ^2=10.903, $p<0.01$), maintenance of association equipments (χ^2=10.121, $p<0.01$), rehabilitation or construction of local fish markets (χ^2=0.003, $p<0.01$) and election of association executives (χ^2=11.415, $p<0.01$). This implies that fish farmers who highly participated in these group activities benefited more greatly from the

Table 6. Level of benefits derived by participants.

Benefits from Fadama II project	Level of benefit			Mean	Ranking
	Great benefit	Little benefit	No benefit		
Provision of overhead tank	154 (83.24)	17 (9.19)	14 (7.57)	1.76	9th
Provision of generator	174 (94.05)	7 (3.78)	4 (2.16)	1.92	3rd
Provision of pelleting machine	171 (92.43)	9 (4.86)	5 (2.70)	1.90	4th
Provision of hatchery equipments	159 (85.95)	19 (10.27)	3 (1.62)	1.82	7th
Provision of drag net	179 (96.77)	2 (1.08)	4 (2.16)	1.95	1st
Provision of deep well	156 (84.32)	25 (13.51)	4 (2.16)	1.82	7th
Rehabilitation of earthen ponds	144 (77.84)	20 (10.81)	21 (11.35)	1.66	11th
Rehabilitation of homestead pond	168 (90.81)	13 (7.03)	4 (2.16)	1.89	5th
Purchase of weighing machine	172 (92.97)	4 (2.16)	9 (4.86)	1.88	6th
Provision of fingerlings	179 (96.77)	2 (1.08)	4 (2.16)	1.95	1st
*Training on hatching technique	72 (76.60)	19 (20.21)	3 (3.19)	1.73	10th
*Training on fish preservation techniques	68 (72.34)	20 (21.28)	6 (6.38)	1.66	11th

Figures in parentheses were expressed as percentages. The percentages and mean of the asterisked (*) benefits were based on those that were trained by Fadama II project (94). Source: Field Survey (2013).

Table 7. Chi-square result showing associations between levels of participation in Fadama group activities and level of benefits derived from Fadama II Project.

Fadama group activities	χ^2	df	p-value	Decision
Decision making	7.153	2	0.034	S
Financial contribution to group activities	6.122	2	0.045	S
Advisory services to group members	10.903	2	0.004	S
Attendance at meetings	1.643	2	0.607	NS
Maintenance of association equipments	10.121	2	0.004	S
Operation or handling of equipment	4.421	2	0.474	NS
Rehabilitation or construction of local markets	15.539	2	0.003	S
Election of association executives	11.415	2	0.000	S

Source: Field Survey (2013).

Fadama II project than those who participated at a lower level. This is because those who participated highly in these group activities are more recognized by group representatives; and hence may be better informed about the project than members who participated at lower level. Also, level of participation in terms of meeting attendance and handling of equipments do not affect farmers' benefit level.

CONCLUSION AND RECOMMENDATIONS

Increased income and other economic benefits may not be separated from projects that focused on poverty reduction. This study revealed that social benefits are also possible in most projects like Fadama II. It concludes that a fish farmer benefited from the Fadama II project according to his/her extent of participation in Fadama group activities. Benefits derived from Fadama II project, according to the result of this study were technical, technological and material supports. Great benefits were derived from all material and technical supports. It is therefore concluded that social benefits are essential in ensuring the sustainability of a project directed at the poor, rural dwellers with the aim of reducing poverty. This study recommends that the organizers, coordinators as well as planners of poverty reduction and rural development projects should adopt the use of community-driven development, bottom-top and demand-driven approaches that centered on the beneficiaries in the implementation of such important projects. Also, project assessment agents or organizations should not leave out social benefits from the indicators of success of a project.

Conflict of Interest

The authors have not declared any conflict of interests.

REFERENCES

Adekoya AE, Tologbonse EB (2005). Adoption and Diffusion of Innovations. In: S. F. Adedoyin (Ed.). Agricultural Extension in Nigeria, pp. 28-37.

Adekoya BB, Miller JW (2004). Fish cage culture potential in Nigeria-An overview. National Cultures. Agric. Focus 1(5):10.

Federal Department of Fisheries- FDF. (2008). Fisheries Statistics of Nigeria, Fourth Edition, 1995-2007, Nigeria. p 48.

Henri-Ukoha A, Ohajianya DO, Nwosu F O, Onyeagocha SUO, Nwankwo UE (2011). Effect of World Bank Assisted Fadama II Project on the Performance of Fish Farming in IMO State, South East Nigeria: A Comparative Evaluation. Am. J. Exp. Agric. 1(4):450-457.

Kudi TM, Bako FP, Atala TK (2008). Economics of fish production in Kaduna state, Nigeria. ARPN J. Agric. Biol. Sci. 3 (5&6):17-21.

Lagos State Agricultural Development Agency- LASADA. (2002). Mid-Year Review of Agricultural Activities in Lagos State, ADP. P. 80.

National Bureau of Statistics- NBS. (2007). Nigeria Poverty Assessment (harmonized). National Bureau of Statistics, Abuja.

National Population Commission- NPC (2006). Human Population Figures of Census in Nigeria.

National Technical Working Group- NTWG. (2009). A 2009 report of the Vision 2020 of the National Technical Working Group on Agriculture and Food Security.

Nwajiuba, C (2012). Nigeria's agriculture and food security challenges.*Available on www. boell. org/downloads/4_Green_Deal_Nigeria_AGRICULTURE. pdf*.

Oladele W, Afolayan SO (2005). Group dynamics and leadership in Agricultural Extension. In: S. F. Adedoyin (Ed.). Agricultural Extension in Nigeria, pp. 134-138.

Oladoja MA, Adeokun OA (2009). An appraisal of National Fadama Development Project (NFDP) in Ogun State, Nigeria.

Olajide OT, Akinlabi BH, Tijani AA (n.d.). Agriculture resource and economic growth in Nigeria. Eur. Sci. J. 8(22):103-115.

Olaoye OJ (2010). Dynamics of the adoption Process of Improved Fisheries Technologies in Lagos and Ogun State. An unpublished Ph.D thesis, Federal University of Agriculture, Abeokuta, Ogun State. p. 2.

Olaoye OJ, Adekoye BB, Ezeri GNO, Omoyinmi GAK, Ayansanwo TO (2007). Fish hatchery production trends in Ogun State: 2001-2006. J. Field Aquat. Stud.-Aquafield 3:29-40

Olaoye OJ, Oyekunle O, Omoyinmi GA K, Akintayo IA, Arogundade BF (2011). Contributions of the Fadama II project to aquaculture development in Ogun State, Nigeria. J. Humanit. Social Sci. Creative Arts 6(1):11-24.

Olaoye OJ, Oyekunle O, Akintayo IA, Ahhibi G, Abdulraheem I (2014). Farmers' use of improved acquaculture management practices in Western zone of Lagos State Agricultural Development Programme (ADP), Nigeria. Nig. J. Anim. Prod. 41(1): 244-257.

Olomola AS (2013). The political economy of food price policy in Nigeria. World Institute for Development Economics Research, WIDER Working Paper No. 2013/016.

PRESHSTORE (2013). The impact of agricultural development on Nigerian economic growth. Powered by Preshnet.

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