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Acuicultura en Camerún y el potencial de las bacterias lácticas para ser utilizadas como agentes controladores de enfermedades. Una revisión.

Aquaculture in Cameroon and potential of lactic acid bacteria to be used as diseases controlling agents. A Review.

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Resumen

La acuicultura es el sector de producción de alimentos del mundo que crece más rápido y puede ser una gran solución a la demanda masiva de proteínas animales, debido al aumento en la población de Camerún. Esta revisión resume la situación pasada y presente de la acuicultura de peces en Camerún, los nuevos desafíos para la intensificación de la producción de pescado y evalúa la posibilidad de utilizar las bacterias lácticas como agentes de control de la enfermedad. La acuicultura comenzó en Camerún en la década de 1940, y se ha visto poco progreso desde los últimos diez años donde la producción sigue siendo insuficiente para satisfacer la demanda de la población. Con el fin de reducir las importaciones masivas de peces, Camerún planea producir 100 000 toneladas de pescado por la acuicultura comercial. Para llegar a este resultado es necesario mejorar la calidad y aumentar la cantidad de alevines, donde el uso de bacterias lácticas como probióticos podría sustituir el uso de antibióticos, al ser agentes de control de enfermedades en la incubación de alevines y en estanques, con el fin de impulsar y garantizar la calidad y cantidad de producción.

Palabras clave: Acuicultura, peces, bacterias lácticas, probioticos, control de enfermedades, Camerún.

Abstract

Aquaculture is the world's fastest growing food production sector and can be a great solution to the massive demand for protein of animal due to increase in the Cameroonian population. This review summarizes the past and present status of fish aquaculture in Cameroon, the new challenges for intensifying fish production and evaluates the possibility of using lactic acid bacteria as disease control agents in order to overcome these challenges. Fish farming started in Cameroon in the late 1940s, and has seen little progress since the last ten years, but the production is still insufficient to meet the demand of the population estimated at 400 000 tons in 2015. In order to reduce massive fish imports, Cameroon plans to produce 100 000 tons of fish by commercial aquaculture. Achieving this task needs quality and quantity of fingerlings, and probiotic lactic acid bacteria instead of antibiotics could be used as disease control agents in young fish hatching and ponds in order to boost and ensure quality and quantity production.

Key words: Aquaculture, fish, lactic acid bacteria, probiotic, disease control, Cameroon.

INTRODUCTION

Aquaculture according to FAO (1997) is defined as "the farming of aquatic organisms including fish, molluscs, crustaceans and aquatic plants in selected or controlled environments". Today, aquaculture is the fastest growing food-producing sector in the world, with an average annual growth rate of 8.9% since 1970, compared to only 1.2% for capture fisheries and 2.8% for terrestrial farmed meat production systems over the same period (Subasinghe et al., 2003). World aquaculture has grown tremendously during the last fifty years from a production of less than a million ton in the early 1950s to 59.4 million tons by 2004. This level of production had a value of US$70.3 billion (Bondad-Reantaso et al., 2005). Its global importance is related to its contribution in the reduction of the supply–demand gap of fish products. In fact, the world needs for fish and fishery products are vision to expand to more than 2 million tons by 2020 (FAO, 2006). At the same time, natural fisheries stocks are maximally deteriorated and stocks of many fish species are in decline attributed to illegal and over-fishing. Some wild fish species became more and more attractive as potential aquaculture species, such as tilapia (*Oreochromis niloticus*), African catfish (*Clariasgaripienis*), cod (*Gadus morhua*), turbot (*Psetta maxima*), and tuna (*Thunnus* spp.) (Van de Nieuwegiessen, 2009), hence, farming of such species can fulfill consumer demand that no longer can be met by wild capture fisheries alone. It is therefore expected that the anticipated expansion of the consumer demand for fish and fishery products will predominantly be met by aquaculture, which was projected to account for 41% of global fish production in 2015 (FAO, 2006).

In Cameroon, fish is the preferred protein source of the most underprivileged layers of society because being cheap (1-6 USD/kg); additionally, it is available in conveniently small units that can be easily purchased by the poor, with small heaps of smoked fish selling

(Nguenga and Pouomogne, 2006). The annual consumption of fish in Cameroon from 2008 to 2010 was estimated to be over 300,000 tons (Laurenti, 2013). The fisheries in Cameroon only produce approximately 176,000 tons of fish, out of which, only 1000 originate from aquaculture, thus representing 0.1% of national production (NIS, 2012). Therefore, according to official figures, Cameroon government spends close to 100 billion FCFA (Franc de la Communauté France Afrique), corresponding to about 200 million USD each year in imports to address the production deficit which is estimated to be 230 000 tons per year (Business in Cameroon, 2014). However, the demand for fish is increasing due to growing population (2.8% annually) which consequently causes significant increase in fish prices, and rapid urbanization; the fish consumption demand is projected to be 400,000 tons in 2015 (MINEPIA and FAO, 2009), which will be more costly to the Cameroonian government. Whereas, conditions for fish culture in Cameroon are good; there is a good climate suitable for the rearing of many warm water species, appropriate soil for pond construction and natural inland waters covering over 40,000 square kilometers, and freshwater fish suitable for aquaculture (Brummett, 2007). So, in response to the above mentioned situations, the Cameroonian government, according to the Cameroonian Minister of Fisheries, plans to produce around 100,000 tons of fish per annum by developing aquaculture, thanks to the construction of intensive production centers with modern ponds, and the training of young fish farmers (Business in Cameroun, 2014), even though available information suggests that aquaculture in Cameroon has grown over the past ten years (NIS, 2012).

However, among the problems which may impede the intensification and diversification of aquaculture are bacterial diseases, as fish interact involuntary with its surrounding environment; antibiotics have been routinely used for decades as traditional strategy for fish diseases management and growth promoters; however, the notorious adverse effects associated with this practice are the emergence and development of multi-drug resistant bacteria as well as the occurrence of antibiotics residues in aquaculture products. As alternatives to antibiotics, using probiotics as biological control agents may provide broad spectrum and greater nonspecific disease protection.

This review summarizes the past and present status of fish aquaculture in Cameroon, the new challenges for intensifying fish production and evaluates the possibility of using lactic acid bacteria (LAB) as disease control agents in order to overcome the above mentioned challenges.

Past and present status of fish aquaculture in Cameroon

The Republic of Cameron is situated at the bottom of the Gulf of Guinea in Central Africa, with its capital at Yaoundé. It lies between 2° and 3°N and between 9° and 16°E, covering an area of 475 000 square kilometers. Cameroon was given its name by Portuguese settlers who, upon arriving on the coast in the 1400s, found seafood in such abundance that they called the main estuary *Rio dos Camaroes*, or River of Prawns. This geographic extension gives the country wide-ranging geographical and ecological diversity, with its 3 climates (equatorial, soudanian and soudano-sahelian), hydrology (Almost 3.5 million ha of aquatic habitats) and soils (ferralitic) the country is almost favorable to aquaculture.

Evolution and status

Aquaculture, in the form of fish farming, was introduced into Cameroon in 1948. However, soon after independence in 1960, the extension effort collapsed, and most ponds were abandoned. Since then, the development of the Cameroonian aquaculture sector since independence up to year 2006s has been driven largely by international donors such as United Nations Development Program (UNDP), FAO, United States Agency for International Development (USAID), US Peace Corps volunteers, Canada's International Development and Research Centre (IDRC), the Belgian Administration for Development Cooperation (AGCD), World Fish Center, International Institute of Tropical Agriculture (IITA), and United Kingdom Department for International Development (DFID), and the French Department for Foreign Affairs, through several bilateral projects and a variety of different programs (Pouomogne and Pemsl, 2008). From the ichthyological point of view, fish culture began with tilapia followed by catfish. In 1969, the common carp was introduced followed by the African bonytongue (*Heterotis niloticus*). But Nile tilapia (*Oreochromis niloticus*) remains the most attractive for fish farming purposes. The most common practice is polyculture of Nile tilapia, with *Clarias gariepinus* where possible, or with other locally available species such as *Heterotis niloticus* ("kanga"), *Channa obscura* ("viper fish"), *Hemichromis fasciatus* ("panther fish"), common carp (*Cyprinus carpio*) or *Barbus species* (Pouomogne, 2005). Fig. 1 indicates the regions of Cameroon where fish farming are mostly practiced, whilst Fig. 2 presents the Fish species commonly cultured.

Production and contribution to economy

When fish farming was first introduced it only attracted the small farmers, but with the passage of time, all sections of society have come to see it as a major activity in nutritional and financial terms. According to the National Agricultural Extension and Research Programme (PNVRA), the Ministry of Livestock, Fisheries and animal Industries (MINEPIA) and FAO statistics, the annual production of farmed fish, estimated at 650 tons (of which about 90% is produced by small-scale farmers) in 2004, increased to up to 870 tons in 2010[1] as shown in Fig. 3.

Aquaculture production is solely for local consumption, as in Cameroon, fish is a major source of protein for most of the population for whom it accounts for about 40 % of the protein intake of animal origin and 9.5 % of total protein requirements. Fresh farmed fish

[1]http://www.fao.org/fishery/countrysector/naso_cameroun/en

Figure 1: Map of Cameroon indicating the regions where fish farming is most practiced (adapted from Tekwombou, 2014).

is very popular and since demand exceeds supply, fish is rarely processed but unsold fish is smoked. Fishes are sold at prices, averaging 1000 FCFA (2.07 USD) per kg of tilapia, 1500 FCFA (3.11 USD) per kg of common carp and 1500 FCFA (3.11 USD) per kg of catfish. So, considering that the mean price of fish is 1300 FCFA per kg and that all the production is sold, the actual annual production (based on the data obtained in 2010) raises as income about 10 billion FCFA, which is still less than 1% of the PIB.

Aquaculture production has remained insignificant, given that the government actually spends over 100 billion FCFA (200 million USD) annually on fish imports, according to Dr. Belal Emma, Director of Fisheries and aquaculture in the Ministry of Livestock, Fisheries and Animal Industries (MINEPIA) during a recent workshop in Yaoundé (Business in Cameroon, 2013). In fact, the volume of imported fish per year jumped from a 1989 level of 60,000 tons to 166,000 tons in 2010, to 212,000 tons in 2011 and further 230 000 tons in 2013.Despite this minimal contribution, feasibility studies have shown that the sector has very great potentials for development.

Government driving forces to intensify fish aquaculture production

Not only the Cameroonian Government spent a lot of money for fish imports, the demand for fish is increasing due to growing population (2.8% annually) and rapid urbanization. In fact, the average annual per capita fish consumption in Cameroon which was 14 kg

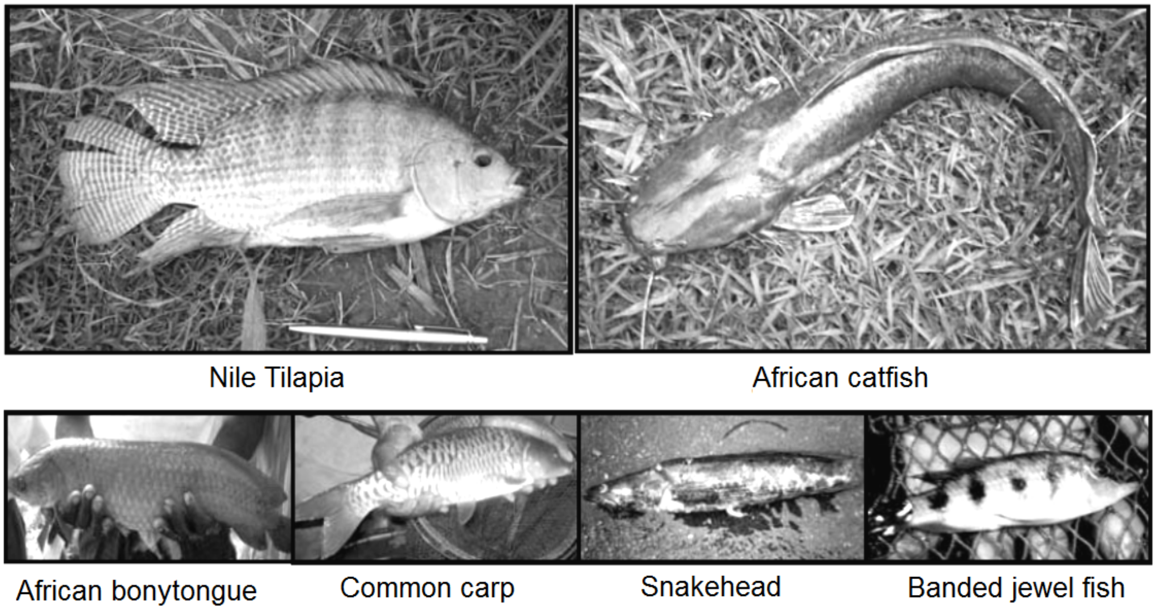

Figure 2: Most commonly cultured fish species in Cameroon (Pouomogne and Pemsl, 2008)

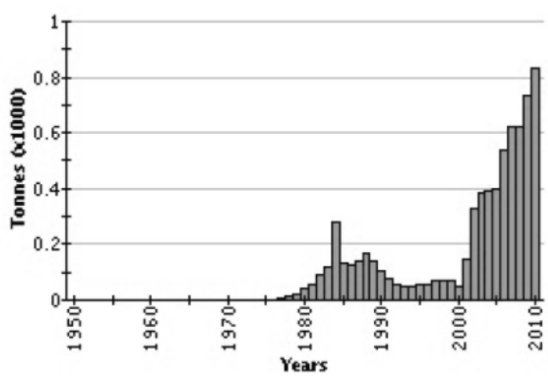

Figure 3: Reported aquaculture production in Cameroon (FAO Fishery and Aquaculture statistics, 2015)

per person in 1989 increased to more than 21 kg in 2011, and it is projected that the demand will be 400,000 tons in 2015 (MINEPIA and FAO, 2009). In response to this situation and according to the statement of Dr. Taïga, the actual Cameroonian Minister of Livestock, Fisheries and Animal Industries (MINEPIA) in February 2014, Cameroon plans to produce around 100,000 tons of fish per annum by developing commercial aquaculture."The aim is not fish for self-subsistence, but fish to feed the population, and thus avoid imports," explained the authorities, hence goals are ambitious. This is the goal for the intensive production centers the Cameroonian government has just begun building in several regions across the country. The first of these plants (a prototype catfish farm) was inaugurated on February 8, 2014 in Meyomessala, in southern, and will produce 17 tons of fish thanks to the construction of modern ponds and the training of young fish farmers by the Ministry of Fisheries. The funding was provided by the Maritime Development Fund (Doing Business In, 2012; Business in Cameroon, 2013; 2014). The government has announced the construction of similar fish farms in each of the ten national provinces. In order to palliate to the lack of trained human resource, Fishermen in Cameroon regions were trained on the 23-28 September 2013 by the United Nation's FAO and the government of Japan on best practices in aquaculture with the aims to boost fish farmers harvest, helping produce more for an increasing demand for fish in the country[2]. Further training of aquaculture technicians in Cameroon was done through a five-day EU-funded workshop on boosting production of fingerlings, helping to meet demand and improve quality. Also, The government of Israel, through the Israeli Agency for International Development Cooperation – MASHAV dispatched two experts in aquaculture (Dr. Bejerano and Dr. Rothbard) at the Institute of Fisheries and Aquatic Sciences at Yabassi in the Littoral Region of Cameroon (from 4th to 13th March 2013) to share their technical know-how with students of the Institute, invited practitioners of aquaculture and government officials of the fisheries sector[3]. It's worthwhile noting that others training as the SOWEDA workshop (April 2008) for improving aqua-farm skills to fish farmers in rural areas, as well as the research carried out by the Cameroon's Institute of Agricultural Research for Development (IRAD) since 2011 in view of putting at the disposal of fish farmers and donors a new development strategy that is expected to boost local production and bail the country out of incessant importation of fish[4]. Other efforts are that a fish meal factory is under construction in Foumban, in the western province, whilst a hatchling breeding unit has already been established in Douala.

Three international agencies (World Fish Center, the French Centre de Coopération Internationale en Recherche Agronomique pour le Développement, and FAO) are currently active in Cameroon's aquaculture and are working closely with the government and each other to ensure that past mistakes are not repeated and best practices are put in place to ensure that future growth of the sector is sustainable.

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[2] http://www.thefishsite.com/fishnews/21355/cameroon-to-boost-fish-production-through-aquaculture-training/#sthash.J4MsrW0S.dpuf

[3] http://embassies.gov.il/yaounde/NewsAndEvents/Pages/MASHAV AQUACULTURE-YABASSI.aspx

[4] http://www.thefishsite.com/fishnews/14791/new-fish-development-strategy-in-view/#sthash.oSiVcpgq.dpuf

Problems, including diseases as constraints in aquaculture production in Cameroon

The limited growth of aquaculture in Cameroon can be attributed to many factors. Yet to reach the 100,000 ton fish target, two main constraints need to be addressed. First comes the production of fish meal to feed the fish in the farms, second, the production of enough hatchlings, as the Director of Fisheries and Aquaculture in the Ministry of Livestock, Fisheries and Animal Industries, Dr. Belal Emma also reported insufficient quality and quantity of fingerlings, inadequate quality and quantity of feed[5]. Government owned aquaculture and fish fry stations as well as private backyard hatcheries have over the years failed to supply the number of seed needed by farmers. Though statistics on fingerling production are not well known as no documented information exists, farmers report that fingerlings are usually of low quality and their demands are never met. Most farmers resort to collecting wild fish to stock their ponds but only limited amount of fingerlings can be obtained this way (Brummett, 2007; Pouomogne, 2007). One of the main reasons of the low fingerlings quality and supply is the low and highly variable fry survival in nursery ponds; mortality is caused by shortage of adequate feed, poor water quality and parasitism of eggs by aquatic fungi and bacteria. Aside, in small-scale farms, the indirect feeding is the general practice using compost cribs loaded with materials sourced from the farm, mainly grass, weeds and kitchen refuse, which are vehicles of pathogenic bacteria which infections cause mortality of adult fishes. Hence, techniques to control pathogenic bacteria are paramount to the further development of the aquaculture sector.

As is the case in terrestrial animal production, antibiotics are also used in aquaculture in attempts to control bacterial disease. The worse is when these compounds are used routinely, even when there are no apparent disease problems, as in the case for some farmers in Cameroon who mainly used oxytetracycline. During the last decades, antibiotics used as traditional strategy for therapy, prophylactic reasons and growth promotion. However, the development and spread of antimicrobial resistant pathogens were well documented (Cabello, 2006; Sorum, 2006). There is a risk associated with the transmission of resistant bacteria from aquaculture environments to humans, and risk associated with the introduction in the human environment of non pathogenic bacteria, containing antimicrobial resistance genes, and the subsequent horizontal transfer of such genes to human pathogens, as has been reported for *Salmonella enterica* serotype *Typhimurium* and *Vibrio cholera* (Cabello, 2006). Besides, antibiotic residues may be present in some aquatic products and many countries' (specifically Europe, North America and Japan) regulations on the use of antibiotic are strict, with only in few licensed antibiotics to be used in aquaculture (Defoirdt, Sorgeloos and Bossier, 2011). Considering

[5]http://www.thefishsite.com/fishnews/21099/farmers-trained-on-fingerling production/#sthash.m9TzLz6y.dpuf

these factors, there has been heightened research in discovering new alternatives or approaches for the abuse of antibiotics. The use of probiotics, which control pathogens through a variety of mechanisms, is increasingly viewed as an alternative to antibiotic treatment (Verschuere et al., 2000).

Potential of lactic acid bacteria (LAB) to be used as disease control agents in fish aquaculture in Cameroon.

Definition of Probiotics

The term probiotic (the opposite of the term antibiotic), meaning “for life” and originating from the Greek words “pro” and “bios”, was previously defined by Fuller (1989) as “a live microbial feed supplement which beneficially affects the host animal by improving its intestinal microbial balance; but the Food and Agriculture Organization of the United Nations/World Health Organization (FAO/WHO) defined probiotics as living microorganisms, which, once administered in appropriate amounts, confer a health profit on the host (FAO/WHO, 2002).The nature of the aquatic species and their intimate interaction with environment forced to a more complicated and precise definition for probiotics in aquatic hosts. Verschuere et al. (2000) suggested the probiotics to be outlined as live microorganism adjunct that have useful effects on the host by modifying the host-associated or close microorganism community, by guaranteeing improved use of the feed or enhancing its nutrition worth, by enhancing the host response toward malady, or by rising the quality of its close setting.

Knowledge of probiotics has increased; currently it is known that these microorganisms have an antimicrobial effect through modifying the intestinal microbiota, secreting antibacterial substances (bacteriocins and organic acids), competing with pathogens to prevent their adhesion to the intestine, competing for nutrients necessary for pathogen survival, and producing an antitoxin effect. Probiotics are also capable of modulating the immune system, regulating allergic response of the body, and reducing proliferation of cancer in mammals (Martinez Cruz et al., 2012). Typically, the lactic acid bacteria have been widely used and researched for human and terrestrial animal purposes, and LAB are also known to be present in the intestine of healthy fish.

The use of lactic acid bacteria for disease control in aquaculture has been highlighted by several workers, as listed by Ram and Parvati (2012). The mechanism by which they protect their host from pathogens (pathogens biocontrol or bioremediation) is by means of production of metabolites which inhibit the growth/colonization of other microorganisms or by competing with them for the resources such as nutrients or space, antiviral effects or enhancement of the immune system.

Mechanism of action for disease control

Competitive exclusion of pathogenic bacteria. Competitive exclusion is a phenomenon whereby an established microflora prevents or reduces the colonization of a competing bacterial challenge for the same location on the intestine. The aim of probiotic products designed under competitive exclusion is to obtain stable, agreeable and controlled microbiota in cultures based on the following: competition for attachment sites on the mucosa, competition for nutrients and production of inhibitory substances by the microflora which prevents replication and/destroys the challenging bacteria and hence reduce colonization (Moriarty, 1998). Different strategies are displayed in the adhesion of microorganism to those attachment sites as passive forces, electrostatic interactions, hydrophobic, steric forces, lipoteichoic acids, adhesions and specific structures of adhesion. Adhesion and colonization of the mucosal surfaces are possible protective mechanisms against pathogens through competition for binding sites and nutrients (Westerdahl et al., 1991). Studies have shown that *Lactobacillus* can prevent adherence of *Escherichia coli*, *Klebsiella* species and *Pseudomonas aeruginosa* to intestinal cells (Nwanna, 2010).

Production of inhibitory compounds. Bacterial antagonism is a common phenomenon in nature; therefore, microbial interactions play a major role in the equilibrium between competing beneficial and potentially pathogenic microorganisms (Balcazar et al., 2006). Antagonistic compounds are defined as chemical substances produced by microorganisms (in this case bacteria) that are toxic (bactericidal) or inhibitory (bacteriostatic) toward other microorganisms. Lactic acid bacteria produce a variety of substances that are inhibitory to both gram-positive and gram-negative bacteria; these include organic acids, such as acetic, butyric and lactic acids, hydrogen peroxide and bacteriocins. The presence of bacteria producing antibacterial compounds in the intestine of the host, on its surface, or in its culture water is thought to prevent proliferation of pathogenic bacteria and even eliminate these. Although in vitro results of inhibition do not guarantee the *in vivo* results, due to a multifactor equation which can be summarized in host, pathogen, probiotic strain and environment factors (Pandiyan et al., 2013). If the production of antibacterial compound is the only mode of action, it is possible that the pathogen eventually will develop resistance toward the compound. This will result in an ineffective treatment. The risk of the pathogen to develop resistance against the active compound has to be evaluated, to assure a stable effect of the probiotic bacterium.

Enhancement of the immune response against pathogenic microorganisms. The immune systems of fish and higher vertebrates are similar and both have two integral components: 1) the innate, natural or nonspecific defense system formed by a series of cellular and humoral components, and 2) the adaptive, acquired or specific immune system characterized by the humoral immune response through the production of antibodies and by the cellular immune response which is mediated by T lymphocytes, capable of reacting specifically with antigens (Pandiyan et al., 2013). The normal microbiota in the gastro intestinal ecosystem influences the innate immune system, which is of vital importance for the disease resistance of fish and is divided into physical barriers, humoral and cellular components. Innate humoral parameters include antimicrobial peptides, lysozyme, complement components, transferring, pentraxins, lectins, antiproteases and natural antibodies, whereas nonspecific cytotoxic cells and phagocytes constitute innate cellular immune effectors. Cytokines are an integral component of the adaptive and innate immune response, particularly IL-1b, interferon, tumor necrosis factor-a, transforming growth factor-b and several chemokines regulate innate immunity (Gomez and Balcazar, 2008). The non specific immune system can be stimulated by probiotics. The ability of the administered probiotic to modulate the non specific immune responses thus, increase disease resistance during bacterial infections in aquatic animals was documented by several studies (Balcazar et al., 2006; Gatesoupe, 2008). Recent studies have focused on the possible role of probiotics in immune system functions. Villamil et al. (2002) found that *Lactococcus lactis* caused the higher increases in immune functions of turbot (*S. maximus*). Later, Villamil, Figueras and Novoa (2003) proved that the whole cell, fractions whole cell and the extra cellular products of LAB such as nisin act as immune modulator in turbot (*Scophthalmus maximus*); the increase was in chemiluminescence's and nitricoxide production in a dose and time dependant manner. Liu et al. (2012) proved that *B. subtilis* was able to survive in grouper, *Epinepheluscoioides*, and posterior intestines during the feeding period; the relative survival percentages of fish challenged with *Streptococcus* spp. and iridovirus were increased in time and dose dependent manner. Activating the immune system is a costly operation. Probiotics can positively stimulate various immune hematological parameters such as mononuclear phagocytic cells (monocytes, macrophages) and polymorphonuclear leukocytes (neutrophils) and NK cells (Balcazar, 2003). Probiotics actively stimulate the proliferation of *B lymphocytes*, thus elevation of immunoglobulin level in both in vitro and *in vivo* conditions. Elevation of immunoglobulin level by probiotics supplementation is reported in many animals and fish (Panigrahi et al., 2004; Nayak, Swain and Mukherjee, 2007; Jatoba, 2011). Probiotics can effectively stimulate phagocytosis through alarming of the phagocytic cells, the latter is accountable for early intervention through activation of inflammatory responses before antibody production and plays a crucial role in antibacterial defenses in numerous fish and shellfish species (Cerezuela et al., 2012; Roman et al., 2012; Touraki et al., 2012).

Antiviral effects. Some bacteria used as candidate probiotics have antiviral effects. Although the exact mechanism by which these bacteria exerts their antiviral effects is not known, laboratory tests indicates that the inactivation of viruses can occur by chemical and biological substances, such as extracts from marine algae and extracellular agents of bacteria. The production of antagonistic compounds may also be active against virus as documented by Balcazar et al. (2007) who reported antiviral activity from *Vibrios* spp., Pseudomonas spp., *Aeromonas* spp. obtained from salmon hatcheries against infectious hematopoietic necrosis virus (IHNV). Harikrishnan, Balasundaram and Heo (2010) studied the Effect of feeding two probiotics *Lactobacilli* and *sporolac*, on *Lymphocystis* disease virus (LCDV) infected olive flounder, *Paralichthy solivaceus*, and they recorded desired effects in viral disease control.

Current status and future prospects of using LAB in aquaculture in Cameroon

In Cameroon, LAB have been mostly isolated and characterized from the fermented food ecological niches. Several LAB strains from Cameroonian raw milk and fermented milk have been characterized for their technological properties (Zambou et al., 2004, 2007).Their antimicrobial properties have also been characterized by few researchers; Some LAB from fermented milk (pendidam) and from chicken intestine in the Adamaoua region were characterized for their antibacterial activities including bacteriocin production (Tatsadjieu et al., 2009; Bakari et al., 2011; Mbawala et al., 2011). The LAB isolated mostly from raw or fermented dairy products in the western highlands region as well as a maize-based traditionally fermented beverage, showed antimicrobial activities against Gram-positive and Gram-negative pathogenic bacteria, bacteriocins being between the antimicrobial substances produced; they also proved to be safe from virulence factors (Kaktcham et al., 2011; Kaktcham et al., 2012a; Kaktcham et al., 2012b; Zambou et al., 2013a, Zambou, Moumbe Fossi and Kaktcham, 2014). Aside, many strains have been also characterized and proved good probiotic properties (Sieladie et al., 2011: Zambou et al., 2013b) as well as immune system stimulation (Tiepma, Zambou and Tchouanguep, 2010). If the Cameroonian food ecosystem has received attention by researchers for characterization of their LAB microbiota for antimicrobial or probiotic potential, there is a crucial lack of information on the LAB microbiota of the Cameroonian aquatic ecosystems, whereas it can be a reservoir of LAB which could be used as probiotic for disease control in aquaculture in general and Cameroonian fish aquaculture in particular. Regrettably, no study or field survey reveals the use of LAB in controlling disease or as growth promoters in Cameroonian fish aquaculture, despite their proved good antimicrobial activities and probiotic properties. Recent investigations in some ponds farm in the western highlands showed that the ponds water as well as the gut of the fishes carries abnormal charges of pathogenic bacteria such as *Vibrios* spp, *E. coli*, *Salmonella* spp. and *S. aureus* (unpublished results); interestingly, the LAB isolated from this water and gut showed antagonistic effects on the above mentioned pathogens. This should be a motivation for further research for isolation and evaluation of the probiotic potential of LAB from the Cameroonian aquatic ecosystems for their use in aquaculture.

Conclusion

Fish farming started in Cameroon in the late 1940s, and the principal farmed species are Nile tilapia (*Oreochromis niloticus*), African catfish (*Clarias gariepinus*) and common carp (*Cyprinus carpio*). Aquaculture in Cameroon has grown over the past ten years, but the production, estimated at 870 tons in 2010 is still less than 1% of the PIB and also insufficient to meet the demand of the population estimated at 400 000 tons in 2015, reason why the Cameroonian Government actually spends over 100 billion FCFA (200 million USD) for fish imports. In order to reduce massive fish imports, Cameroon plans to produce 100 000 tons of fish by commercial aquaculture. Achieving this task could be done by the insurance of quality and quantity of fingerlings; probiotic lactic acid bacteria instead of antibiotics could be used as disease control agents in alevin hatching in order to boost and ensure quality and quantity production. Based on the aforementioned, it is obvious that the use of probiotic bacteria from Cameroonian origins (mainly aquatic environments) as disease control agents in Cameroonian fish aquaculture is needed.

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