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Research Article

Towards the Understanding of Fermented Food Biotechnology in Congo Brazzaville

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Abstract: Congo Brazzaville harbor a diversity of traditional fermented foods which involve complex interactions between various microorganisms groups and different molecules in detoxification, texture and organoleptic features. This first retrospective review aims to describe the various works that have been done regarding the biochemical and microbiological features of our traditional fermented foods including Nsamba, Poto-poto, Bikedi and Ntoba-Mbodi.

Keywords: Bacteriocin, Congo Brazzaville, diversity, lysinibacilluslouembei, probiotic, traditional fermented food

INTRODUCTION

Fermented foods play an important role in the daily diet in Congo Brazzaville. Cereals, fruits, vegetables, tubers and fish are various raw materials used in fermented foods. Among fermented food, *Pilipili*, *Bikedi*, *foufou*, *Chikwangue*, *Poto-poto* and *Ntoba Mbodi* are the most representatives (Louémbé *et al*., 1996, Louembé *et al*., 2003b; Miambi *et al*., 2003). Other fermented food including *Tutu*, *Tsiya* and fermented fish can be found (Table 1). The traditional fermented beverages are produced according to the areas of raw materials. Among beverages *Loungouila*, *Bounganda* and *Nsamba* are the most experienced (Louémbé *et al*., 1986; Malonga *et al*., 1995). Others beverages like *Malala*, pineapple wine, orange wine and *Mbamvou* are also found in Congo (Table 1). Fermented foods and beverages involve metabolic activities of microorganism and/or consortia (Louembé *et al*., 2003b; Malonga *et al*., 1993; Ouoba *et al*., 2010).

Technological processes for the traditional food production vary between areas (Table 2). However, they are generally based on the same techniques (Louémbé *et al*., 1986, 1996; Louembé *et al*., 2003b; Malonga *et al*., 1995). It is done with a non-sterile equipment and non-optimized conditions, resulting in food with an unpredictable nutritional quality (Olanrewaju *et al*., 2009).

Basing on microorganism diversities, enzymes, organoleptic molecules and preservative properties, this first review aims to describe four Congo traditional fermented foods including *Nsamba* (*NS*), *Poto-poto* (*PP*), *Bikedi* (Bk) and *Ntobambodi* (*NM*).

Palm wine "NSAMBA (NS)": NS is the most consumed in Congo Brazzaville andmore representatives among traditional fermented drink. It is obtained from a natural fermentation of the sweet sap of the oil palm (*Elaeisguineensis*). NS composition is about 1.5 to 2.1% alcohol (Bassir, 1962), pH between 4-5 (Faparusi and Bassir, 1972), 12 and 15% of soluble sugar (sucrose). There are also small amounts of glucose, fructose, raffinose, maltose, polysaccharides, organic acids and amino acids (Van Pee and Swings, 1971). NS Micro organisms differentiate from urban to rural areas. Lactic acid bacteria (LAB), acetic bacteria, *Zymomonas* spp., Micrococci and yeasts are more found (Faparusi, 1973; Okafor, 1972a, 1972b, 1975a, 1975b; Malonga *et al*., 1995). Yeasts, especially *Saccharomyces cerevisiae*, are less predominant than the homolactic and heterolactic bacteria. The consortia of heterolactic bacteria and yeast lead alcohol production from the palm sap to generate NS (Malonga *et al*., 1995; Louémbé *et al*., 1986). *Bacillus subtilis*, *B. sphaericus*, *B. pumilus*, *Corynebacterium* spp., *Lactococcuslactis*,

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Table 1: Non-exhaustive list of various fermented foods and beverages met in Congo Brazzaville

Common Name	Area	Raw material	Characteristics	References
Fermented foods				
Ntoba Mbodi or Kingouari	Bouenza PoolBrazzaville Pointe Noire	*Manihotesculenta* Crantz (leaves)	Fermented cassava leaves (3 to 4 days)	Louembé *et al*. (2003b) and Ouoba *et al*. (2010)
Bikédi	National food	*Manihotesculenta* Crantz (tubers)	Fermented cassava tubers (2 to 4 days)	Malonga *et al*. (1993, 1996), Louémbé *et al*. (1997) and Kobawila *et al*. (2005)
Foufou	National food	*Manihotesculenta* Crantz (tubers)	Flour fermented cassava tubers	Not studied
Chikwangue	National food	*Manihotesculenta* Crantz (tubers)	Fermented cassava dough	Miambi *et al*. (2003)
Mbalampinda	Bouenza Niari	*Manihotesculenta* Crantz (tubers)	Fermented cassava dough mixed with peanut paste	Not studied
Tutu	North of Country	*Manihotesculenta* Crantz (tubers)	Starched and gelled mass of cassava flour	Not studied
Tsaba Minsela	North of Country	*Manihotesculenta* Crantz (tubers)	Cassava tubers fermented cooked lamellae	Designed and unpublished
Tsiya	North of Country	*Landolphi ajumelei*	Fermented pulp of a bay *Landolphi ajumelei*	Not studied
Poto-poto	National food	*Zea mays* (maize seeds)	fermented maize rough	Louémbé *et al*. (1996, 2003a) and Louembé *et al*. (2004)
Pilipili or Pidipidi	National food	*Capsicum* spp.(Chili)	Fermented chili sauce	Designed and unpublished
Mpandé	North of Country	*Raphiafarinifera*	Pulp of the fermented raffia palm nuts	Not studied
Moussa or Ngayi-Ngayi	Pool	*Hibiscus sabdarifa*	Fermented fruit sorrel	Not studied
Fermented beverages				
Nsamba	National food	*Elaeisguineensis*	Palm wine	Malonga *et al*. (1995) and Louémbé *et al*. (1986)
Bounganda or Loutoko or Biyoki	Bouenza Niari North of Country	*Zea mays* *Manihotesculenta* Crantz	Aqueous mixture of germinated maize flour and starched cassava flour	Not studied
Loungouila	Bouenza	*Saccharumofficinale*	Sugar cane wine obtained after fermentation of week	Outstanding Studies
Douma	North of country	Honey and wild water	Honey wine	Not studied
Ntombé	Lekoumou Niari	*Elaeisguineensis*	The fermented sap of the palm trunk	Not studied
Malala	Bouenza	*Cirus*sp.	Basing on grapefruit	Not studied
Ananas wine	Bouenza	*Ananas comosus* (fruits)	A fruit and pineapple juice	Not studied
Orange wine	Bounenza	*Citrus sinensis* (fruits)	Basing on orange fruit	Not studied
Mbamvou	Bouenza	*Musa* sp.	Fermented Bananas	Not studied

Table 2: Flowchart of production of three traditional fermented foods of Congo Brazzaville (Louembé *et al*., 1996, 2003b; Malonga *et al*., 1996)

A: Production of *Bikedi* (fermented cassava tubers)	B: Production of *Ntobambodi* (fermented cassava leaves)
Peeled Cassava tubers	Cassava leaves
↓	↓
Immersion in water for fermentation (3 to 4 days)	Partial dehydration with ambient air
↓	↓
Removing retted tubers from water	Cut into pieces
↓	↓
Washing and draining	Clean with water
↓	↓
Bikedi (Bk)	Packing in papaya leaves
	↓
	Fermentation (2 to 4 days)
	↓
	NtobaMbodi (NM)
C: Production of *Poto-poto* (fermented maize)	
Dried corn kernels	
↓	
Soaking in tap water	
↓	
Draining	
↓	
Grinding	

Table 2: Continue

↓
wet flour
↓
Defibration using water through a muslin cloth
↓
Settling for 15 hours
↓
Dripping with burlap
↓
Poto-poto (PP)

Table 3: Isolated microorganisms from NS

Raw material	Product	Microorganisms	References
Oil palm *Elaeisguineensis*	Nsamba (Palm wine)	Bacteria *Bacillus subtilis* *B. sphaericus* *B. pumilus* *Corynebacterium* spp. *Hanseniaspora guillermondii* *Pseudomonas fluorescens* *Staphylococcus piscifermentans* *Staphylococcus* spp. *Streptococcus* spp. *Strept. Lactis*sp. *Lactobacillus casei* *Lb. plantarum* *Ln. mesenteriodes* ssp *Ln. lactis* *Pediococcusparvulus* *Acetobacter pomorum* *Acetobacter pasteurianus* *Gluconobacter oxydans* *Acinetobacter calcoaceticus* *Enterobacterium bacterium* *Acidovorax* sp. *Comamonas* sp. Yeast *Saccharomyces cerevisiae*	Malonga *et al*. (1995) and Louémbé *et al*. (1986)

Streptococcus spp., *Hanseniaspora guilliermondii*, *Pseudomonas fluorescens* and *Staphylococcus* spp. were also found (Malonga *et al*., 1995) (Table 3). The 16S rRNA gene analysis revealed 32 community clones were identified as *Lb. casei* strain zhang, *Lb. plantarum*, *Leuconostoc mesenteriodes*, *Ln. lactis*, *Pediococcus parvulus* strain Bpe-299, *Acetobacter pomorum, Acetobacter pasteurianus*, *Gluconobacter oxydans*, *Acinetobacter calcoaceticus*, *Enterobacterium bacterium*, *Acidovorax* sp., *Comamonas* sp., *B. subtilis, Staphylococcus piscifermentans* (Okolie *et al*., 2013). This finding matched with previous studies assessed in palm wine in Congo Brazzaville (Louémbé *et al*., 1986; Malonga *et al*., 1995) (Table 3).

Poto-poto: fermented dough of maize: In Africa, the fermentation of maize (*Zea mays*) is achieved through an extremely long process. This dough is called *uji*or *akamu* in Kenya (Akingbala *et al*., 1981), *ogio*r*akamu* inNigeria (Akinrele, 1970), *koko* or *akasa*in Ghana (Andah and Muller, 1973), *mahewu* in South Africa (Schweigart and de Wit, 1960) and *Poto-poto* in Congo Brazzaville. It contains very poor nutritional value. 47% of the population in rural areas and 78% in Brazzaville feed on *poto-poto (PP)* (Treche *et al*., 1992). Louembé *et al*. (2004) had identified the major stages of fermentation and the microbiological diversity during the fermentation process. Nutritional quality was also documented (Elenga *et al*., 2009).

Dominant micro organisms are associated with *PP* consists of probiotics bacteria and LAB. Most found are *Lactoccus lactis, Lactobacillus plantarum*, *Lb. pentosus, Lb. cellobiosus*, *Lb. brevis*, *Leuconostoc mesenteroides*, *Ln. citreum*, *Pediococcus acidilactici*, *Enterrococcus* sp., molds and Yeasts (Table 4), were also identified (Louémbé *et al*., 1996, 2003a; Michel *et al*., 2012; Abriouel *et al*., 2006).

Biochemical and micribiological features of bikedi (bk): In Central Africa, especially in Congo, cassava tuber is consumed mainly as *foufou* (flour), *Chikwangue*, *Bikedi* (Bk), *Mibodo*, *Mayaka ma nkatu* (retted tuber dried and then fermented again), *Gari*, *Mbalampida* (fermented cassava bread with peanut paste), *Mbouata* (tuber retted slurry) and *Minsele* or *Tsaba* (lamellae of cassava tubers cooked and fermented).

In tubers and leaves, *Manihot esculenta* Crantz contains cyanide such cyanogenic glucosides compound like linamarin and lotaustralin (Montgomery, 1980; Dunstan *et al*., 1906; Kobawila *et al*., 2005; Louémbé *et al*., 1997) in a ratio of 93/7 (Butler *et al*., 1965). Hydrolysis of cyanogenic

Table 4: Isolated microorganisms of *Poto-poto*, food produced by natural fermentation of the maize dough

Raw material	Product	Bacteria	References
Maize (*Zea mays*)	*Poto-poto*	Bacteria	Louémbé *et al*. (1996, 2003a),
		Acinetobacter calcoaceticus	Louembé *et al*. (2004) and
		Agrobacterium radiobacter	Abriouel *et al*. (2006)
		Erwinia sp.	
		Micrococcus varians	
		Staphylococcus sciuri	
		Staphylococcus xylosus	
		Bacillus sp.	
		B. subtilis	
		B. cereus	
		B.macerans	
		Lactobacillus sp.	
		Lb. plantarum	
		Lb. paraplantarum	
		Lb. fermentum	
		Lb. gasseri	
		Lb. delbrueckii	
		Lb. reuteri	
		Lb. casei	
		Lb. brevis	
		Enterrococcus sp	
		Lc. lactis	
		Pediococcus acidilactici	
		Leuconostoc sp.	
		Ln. citreum	
		Ln. mesenteroides	
		Enterococcus sp	
		Yeast	
		Molds	

Table 5: Isolated microorganisms of *Bikédi* and fermented rough of cassava tubers

Raw material	Food	Microorganism	References
Cassaba tubers	Bikédi	Bacteria	Malonga *et al*. (1996, 1993)
(Manihotesculenta Crantz)	Retted cassava tubers	*Bacillus* sp.	
		B. amyloliquefasciens	
		B. cereus	
		B. polymyxa	
		Enterrobacter spp	
		Lb. coprophilus	
		Lb. delbrueckii	
		Lb. fermentum	
		Ln. mesenteroides	
		Ln. lactis	
		Lc. lactis	
		Klebsiella spp.	
		Clostridium butyricum	
		Yeast	
		Molds	

glycosides by endogenous linamarase enzyme releases the toxic hydrogen cyanide.

To remove hydrogen cyanide people practice traditional fermentation including retting and browning (Dunican, 1990; Lancaster *et al*., 1982; Ongusua *et al*., 1983). In addition, this allows a significant production of organic acids and a softening of tubers essential for the subsequent operations of transformation (Malonga *et al*., 1996; Kobawila *et al*., 2005). In order to improve the quality of final product, studies have been determined the effectiveness of these traditional techniques in reducing of cyanide compounds (Louémbé *et al*., 1997; Kobawila *et al*., 2005). Many studies have been devoted to microbiology in the study of retting and softening phenomenon (Okafor *et al*., 1984; Oyewole and Odunfa, 1990; Cooke, 1978; Malonga *et al*., 1996; Conn, 1969; Ampe *et al*., 1995), but the understanding on detoxification is still poor and controversial.

During retting of cassava tubers LAB such *Lc. lactis* is predominant among microorganisms. This species is supplanted between 48 and 96 hours of fermentation by *Ln. mesenteroides* and *Ln. lactis*. At the end of retting, between the third and fourth days, the number is close to 109 bacteria per gram of pulp in cassava (Malonga *et al*., 1996). LAB are essentially composed of Lactobacilli (73%), *Leuconostocs* (20%) and lactococci (6.7%). The isolated bacteria are *Lactobacillus plantarum, Lbdelbrueckii*, *Lb. fermentum*, *Lb. coprophilus*, *Lc. lactis, Ln.mesenteroides* and *Ln. lactis* (Table 5) (Louembé *et al*., 2003b). Many of them have an amylase activity such as *Lb. plantarum* and *Lactococcus* sp., *Bacillus* species including *B. cereus*, *B. amyloliquefaciens*, *B. polymyxa*, Enterobacteriaceae such as *Klebsiella* sp. and *Enterobacte*r sp. (Louembé *et al*., 2003b) were identified. The linamarasic activity has been observed with *Lc. lactis*, *Ln. mesenteroides*, *Lactobacillus* sp. and *Lb. Plantarum* (Louémbé *et al*., 1997). *Clostridium butyricum* MGPP179, a specie close to *Clostridium felcium*, was found in retting tubers of cassava (Kéléké *et al*., 2007).

Biotechnology of Ntoba Mbodi (NM): *NS*, *PP* and *BK* products are processed in acidic medium, while *Ntoba Mbodi* (NM) is accompanied by a significant alkalinization (pH 8.6) of fermentation medium. The fermented NM. Moreover, cassava leaves are used for human consumption due to their high nutritional value. Cassava leaves are highly rich in protein, minerals and vitamins and all essential amino acids except for methionine and phenylalanine (Eggum, 1970; Ravindran and Ravindran, 1988; Gómez and Valdivieso, 1985; Rogers and Milner, 1963; Ross and Enriquez, 1969). The transformation of cassava leaves in NM lasts only four days (Kobawila *et al*., 2005). Beyond 4 days, NM fermentation appears significantly altered. This had not been observed in acidifying fermentation (Malonga *et al*., 1993). The alkalization of the pH determines the appearance of the microbial flora. The activity of pectate-Iyases, polygalacturonase, pectinesterase, cellulases increases the softening from the first to the third day of NM fermentation (Mokemiabeka *et al*., 2011). As mentioned above with *Clotridium butyricum*, the action of pectin enzymes using polygalacturonate polymethyl substrate released by the microorganism is necessary for softening (Kéléké *et al*., 2007). The increase of browning is correlating with increase of the concentration of polyphenolic polymers due to the polyphenol oxidases activity. This phenomenon of browning is interesting for NM fermentation since it improves its sensory properties (Martinez and Whitaker, 1995; Whitaker, 1995). Enzymes like proteases, deaminases and decarboxylases which generate amines are responsible for the alkalinization in medium (pH 8.5). *B. Subtilis* and *B. amylolyquefasciens* isolated from NM would beinvolved for the pH increasing by producing ammonia released during the degradation of proteins and peptides (Steinkraus, 1991; Ouoba *et al*., 2015) (Table 5). The alkaline pH promote the development of other *Bacillus* species including *B. pumilus*, to use hydrogen cyanide for their nutrition and therefore to decrease detoxification (Knowles, 1976; Wong and Jackson, 1983). These microorganisms are commonly found in vegetable products (Etchells *et al*., 1975) and also some species like *Micrococcus varians*, *B. marcerans*, *B. susbtilis*, *Staphylococcus sciuri* et *Staphylococcus xylosus* (Pederson and Albury, 1983) (Table 5) are the more representatives.

However *Ln. mesenteroides* is mainly met in the initial stage of the NM fermentation (Mukherjee *et al*., 1983; Garvie, 1986). It is worthy notedthat yeasts are

Table 6: Ntoba Mbodi (NM) isolated microorganisms from the natural fermentation of cassava leaves

Raw material	Foods	Microorganism	References
Cassava leaves	Ntobambodi (Fermented cassava leaves)	*Acinetobacter calcoaceticus* *Agrobacterium radiobacter* *Bacillus* sp. *B. amyloliquefasciens* *B. macerans* *B.circulans* *B. subtilis* *B. pumilus* *B. polymyxa* *B. megaterium* *B. sphaericus* *B. brevis* *Erwiniia*spp. *Lysinibacillus louembei sp.* *Lactobacillus* spp. *Lb. fermentum* *Lb. plantarum* *Lb. lactisdiacetylactis* *Micrococcus varians* *Pediococ cuscerevisiae* *Pediococ cusacidilactici* *Staphylococcus sciuri* *Staphylococcus xylosus* *Weissella confusa* *Weissella cibaria* *Pediococcus pentosaceus* *Enterococcus* sp. *E. casseliflavus* *E. faecium* *E. faecalis* *E. avium* *E. hirae*	Louembé *et al*. (2003b) and Ouoba *et al*. (2010, 2015)

absent in the fermentation of residual sugars maybe due to the high pH on NM fermentation.

Besides microorganisms previously mentioned, *Acinetobacter calcoaceticus*, *Agrobacterium radiobacter*, *Erwinia* spp. *Bacillus cereus, Lb. plantarum*, *Lb. fermentum*, *Lactobacillus spp*, *Lactococcuslactis diacetylactis* and *Pediococcus acidilactici* (Table 6) are also found. Recently, a novel spore-forming bacterium was isolated from NM, *Lysinibacillus louembei* sp. nov. (Ouoba *et al*., 2015). Some of strains isolated from NM have both a pectinolytic and proteolytic activity and others are only one (Kéléké *et al*., 2007; Kobawila *et al*., 2005; Nguimbi *et al*., 2014). Bacteria which may play a significant role in this transformation would be *B. macerans*, *B. subtilis*, *B. amyloliquefasciens*, *B. cereus*, *Staphylococcus xylosus* and *Erwinia* sp. (Peter, 1986; Nguimbi *et al*., 2014). By degrading pectins and polysaccharides, enzymes promote softening of cassava leaves (Schleifer, 1986; Sheiman *et al*., 1976) and thereby improving the digestibility of the organic plant.

Amplification of 16S RNA gene and Sequencing experiments of in NM isolates allowed identification some bacteria including *Weissella confusa*, *W. cibaria, Lb. plantarum*, *Pediococcus pentosaceus*, *Enterococcus casseliflavus*, *E. faecium*, *E. faecalis*, *E. avium* and *E. hirae* (Ouoba *et al*., 2010). The presence of this type of bacteria demonstrates the attention that should be brought to NM, regarding different stages of quality control and HACCP procedures. These bacteria are typically found at the beginning of fermentation and some of them are responsible for nosocomial infections (Khan *et al*., 2015).

The enzymes of biotechnological interest: fibrinolytic and pectinolytic enzymes: *Bacillus* sp. has been considered for their capacity to secrete more therapeutic enzymes. Fibrinolytic and pectinolytic enzymeshave been identified (Nguimbi and Wu, 2002; Nguimbi *et al*., 2014; Ouoba *et al*., 2015). Previous studies have been shown that several bacilli species are able to produce fibrinolytic enzymes including *Bacillus* natto, *B. amyloliquefaciens* DC-4, *Bacillus* sp. CK, *B. subtilis* EM 29 and *B. amyloliquefaciens* CH51 (Sumi *et al*., 1987; Peng and Zhang, 2002; Kim *et al*., 1996; Nguimbi and Wu, 2002; Kim *et al*., 2009). *B. sutilis* and *B. amyloliquefasciens* isolated from NM are able to degrade fibrin and casein (Nguimbi *et al*., 2014). Deep studies will be specially addressed to *Lysinibacillus louembei,* novel exciting bacteria (Ouoba *et al*., 2015).
Softening of cassava leaves is the main stage which indicates the end of the fermentation. *Clostridium bytirycum* MGPP179 genetically close to *Clostridium felcium* seems to have the necessary assets for his involvement in the retting process of cassava tubers and softening (Kéléké *et al*., 2007). Several bacteria secrete enzymes degrading cell walls (Nambisan and Sundaresan, 1985). Alteration of pectic compounds is generally related to the action of pectinolytic enzymes that generate significant changes in cell structures. This is especially saponifying enzymes like pectin Iyase, pectate lyase, polygalacturonase and some unknown hydrolases that can hydrolyze pectin containing in cell wall (Rexová-Benková and Markovic, 1976; Thibault, 1980). These enzymes allow the destruction of plant tissues and therefore the opening of target compartments thus favoring contact between the endogenous linamarase and linamarin (Okafor *et al*., 1984; Nambisan and Sundaresan, 1985). Microorganisms associated in pectinolytic activities and the evolution of softening were therefore studied. Studies showed that many bacteria are able to synthesize linamarase enzyme in the presence of appropriate linamarin or lotaustralin substrate. This includes *Lc. lactis*, *Ln. mesenteroides* and *Lb. plantarum* (Okafor and Ejiofor, 1985).

Bacteriocins and probiotic bacteria of congo brazzaville fermented foods: Bacteriocins are antimicrobial peptides produced by bacteria and could present a bactericidal effect against closely related species (Cotter *et al*., 2005). LAB represents a model of choice to ensure the absence pathogenic bacteria in the final product (Konings *et al*., 2000). Nisin from LAB is the only bacteriocin approved for use as a food preservative (Balciunas *et al*., 2013). Thirty-one bacteriocins from *Lactobacillus* specie were identified in Congolese fermented maize product (*Poto-poto*). *Lactobacillus* sp. can inhibit pathogenic bacteria including *Escherichia coli*, *Salmonella enterica*, *Enterobacter aerogenes*, *Bacillus cereus*, *Staphylococcus aureus*, *Listeria monocytogenes* and *Enterococcus faecalis*. Specific studies were performed on the correlation and the involvement between LAB fermentation and the reduction of pathogenic bacteria such as *Salmonella typhimurium*, *Staphylococcus aureus*, *Escherichia coli* and *Shigella* sp. Children fed with fermented starches showed very positive effects by reducing the risk of childhood diarrhea (Svangberg, 1991a, 1991b; Svangberg and Svanberg, 1989).

Fermented foods like NM, PP and BK are a best ecological niche to isolate microorganism producing bacteriocins. The new strain *Lysinibacillus louembei* isolated from NN could be interesting to investigate (Ouoba *et al*., 2015).

Promising and sustainable future: The use of bacteriocin-producing bacteria may be interesting as well as economic and legislative level. Producing bacteria bacteriocins may be added as a starter in fermented products (Gálvez *et al*., 2007; Dortu and Thonart, 2009). Their use must consider the *Quorum Sensing* System, the product composition (available nutrients, pH and food additives) and storage conditions. Bacteria with pectynolytic and linamarasic activities isolated from Congo Brazzaville traditional fermented foods are particularly interesting as a starter in fermented products. The characterization of these enzymes, from gene isolation to the final product will be an essential biotechnological tool for use in Bio-catalysis. New isolated strains such as *Lysinibacillus louembei* could be interesting for the discovery of new molecules of biotechnological interest.

CONCLUSION

Basing on numerous studies discussing and mentioned above, we conclude that Congo Brazzaville fermented foods contain a fascinating diversity of microorganism. Many of them have a biotechnological interest and therapeutic properties. In addition molecules delivered from bacteria could be a great use to humanity and the natural world for a sustainable future. This discovery opens a promising future for the valuation through research and development.

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