

Biovalorization of Four Main Traditional Food Products and By-products Produced in The Adamaoua Region (Cameroon)

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Abstract

Nowadays, the demand of traditional foodstuffs and by-products (Bio character) including traditional fermented milks by consumers is increased because of their numerous health benefits, important nutritional values and original organoleptic properties. A great diversity of indigenous food products that have potential functional properties is manufactured worldwide. The aim of the present work is to describe the main indigenous foodstuffs and by-products highly produced and consumed in the Adamaoua Region of Cameroon and to evocate their interesting potential functional properties, their utilizations and some related challenges. In the Adamaoua Region of Cameroon, the traditional foodstuffs produced abundantly and highly consumed are represented by four types: fermented milks (Pendidam and Kindirmou), a sun drying meat product (Kilishi) and honey bees. Pendidam and Kindirmou are dairy products produced by fermentation of raw fresh milk from cow origin. Kilishi is produced from a highly appreciated local zebu race "Goudali" meat after muscle meat cutting, trimming, slicing, sun drying, spicing and roasting operation steps successively. Honey bees are produced by exploiting local plants that confer its original taste and other organoleptic properties. All these foodstuffs are used mainly for feeding and therapeutic purposes. Thereby, the fermented milks produced in the Adamaoua Region of Cameroon are indigenous foodstuffs that cannot act only as nutrient sources but can also have potential health benefits like disease preventing or curing role. These dairy fermented products contain lactic acid bacteria (LABs) that produce a wide range of bioactive molecules such as biosurfactants that possess multiple interesting functional properties. One of the main challenges of the present study is to exploit the biosurfactants properties in fighting against diseases due to enveloped viruses (Covid-19, AIDS, Influenza, Hepatitis B and C viruses, etc.) and all their mutants, and against cardio and cerebro-vascular accidents.

Keywords: Adamaoua Region; Cameroon; Challenges; Fermented milks; Honey bees; *Kilishi*; Utilizations.

Introduction

The demand of traditional fermented foods by consumers is increased due to their numerous health benefits and important nutritional value (Sharma et al., 2014). Fermented milks are one of the most popular fermented foods produced and highly appreciated by consumers worldwide. Lactic acid bacteria (LABs) have been reported as the main actors of the fermentation process of indigenous fermented milks (Shalo et al., 1973; Kaktcham et al., 2012; Djoulde et al., 2013). LABs fermentation of foods improves both the nutritional value and digestibility of the end-products (Nout, 2009; Chelule et al., 2010; Sharma et al., 2014) and the bioavailability of minerals, proteins and free sugars (Sripriya et al., 1997; Santos et al., 2008; Sharma et al., 2014). During fermentation, LABs produce metabolites such as organic acids, bacteriocins (Abee et al., 1995; Joshi et al., 2006; Chelule et al., 2010) and biosurfactants

(Mbawala et al., 2017; Mouafo et al., 2018a; Mouafo et al., 2018b; Mouafo et al., 2020a; Mouafo et al., 2020b; Mouafo et al., 2020c; Mouafo et al., 2022) that have antimicrobial activity, thus prolong the shelf life of foods. Amongst these metabolites, biosurfactants particularly attracted attention worldwide due to their numerous properties including biodegradability, low toxicity, ecofriendly nature, green production, high selectivity, production from agro-waste substrates, structural diversity, stability over a wide range of pH, salinity and temperature (Mouafo et al., 2022; Mouafo et al., 2023a). From a biological point of view, biosurfactants deserve antimicrobial (Mouafo et al., 2023b; Tchakouani et al., 2023), antioxidant (Merghni et al., 2017; Mouafo et al., 2020c) antibiofilm and antiadhesive (Mouafo et al., 2020a; Mouafo et al., 2023b), antitumor, anti-inflammatory, anti-wound healing and anticancer (Wadhawan

et al., 2022; Ceresa et al., 2023) activities. Besides, due to their interesting emulsifying and surface activities, they showed ability to inactivate enveloped viruses through destabilization of membrane that enclosed vital proteins and RNA (Smith et al., 2020; Raza et al., 2022; Kumari et al., 2023). The inhibition of enzymes involved in viral replication including RNA and DNA polymerases by biosurfactants was also highlighted (Hegazy et al., 2022; Sarangi et al., 2022). The properties of biosurfactants in the prevention and management of cardiometabolic diseases were also reported (Kumar et al., 2021).

Regarding food consumption pattern, Adamaoua is the first Region of our country (Cameroon) where meat and meat products, hive products, milks and milk products are produced abundantly. *Kilishi*, a sun drying meat product and honey bees are a meat product and a hive product that are respectively produced locally, highly appreciated and consumed. Two types of traditional fermented milks are also produced locally and highly consumed for feeding and therapeutic purposes: *Kindirmou* and *Pendidam* (Jiwoua & Millière, 1990; Essomba et al., 2002). The specific properties of each traditional food and food by-products produced in the Adamaoua Region of Cameroon depend on the quality of raw materials, ingredients and the technological process used during its production. The skill of food making processes by the local inhabitants are inherited from the ancestors and can be subjected to industrial standardization leading to the popularization of the end-products (Puniya, 2016). The aim of the present study is to describe briefly each of the four main foodstuffs produced in the Adamaoua Region (Cameroon), to show the conditions that they must fulfill to preserve their qualities and to develop some challenges related to the traditional utilizations of one of the fermented milks produced: “*Pendidam*”.

Meat and hive products

A sun-dried meat product: *Kilishi*

Kilishi is a sun drying meat product that is manufactured according to the following steps during processing: trimming -> slicing -> sun-drying -> coating with groundnut paste and ingredients -> sun-drying -> roasting -> cooling -> storage (Figure 1). The main raw materials used are a highly appreciated beef meat from a local zebu race “Goudali” and groundnut paste. Some ingredients are used like spices (onion, pimento, etc.), salt, etc. which are added before roasting. In terms of nutritional values, *Kilishi* is mainly rich in animal proteins equilibrated with vegetal proteins and fats when considering the raw materials and ingredients used for its preparation. *Kilishi* is valorize as a form of long-term preservation of fresh and perishable beef meat in order to make it available as a ready-to-eat proteinaceous source.

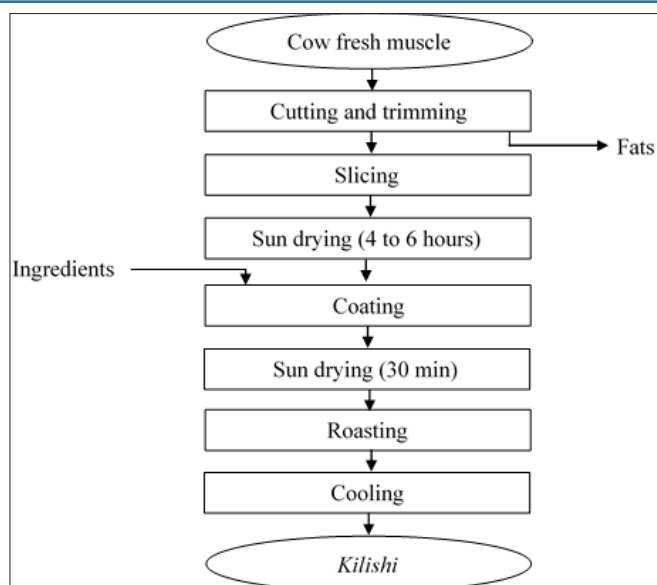


Figure 1: Flow diagram of *Kilishi* production process

The *Kilishi* produced (Figure 2) are preserved in a glass cupboard at ambient temperature in order to maintain them at the shelter of pests (flies, cockroaches, rodents, birds, etc.) (Mbawala et al., 2010b).



Figure 2: *Kilishi* ready to be consumed.

A hive product: honey bees

The qualities and the quantities of the honey bees produced depend widely on:

- The process: two extraction methods from the alveolus are practiced (pressing and heating);
- The type of plant-flower that bees fuel;
- The actors of production;
- The equipment and tools used for the production;
- The climatic data of localities of production (geographic situation, climate, seasons, etc.);
- The access to production parameter such as logistics and human resources, etc.

The best honey bees are produced by pressing by cornering the cells between two platforms which allows its slow flow for several hours while preserving all its qualities compared to those produced by heating.

These best honey bees produced must be kept in opaque containers at the shelter of light in order to preserve their advantageous nutritional, organoleptic, microbiological qualities and medicinal properties, etc. mainly due to the phenolic compounds that they contain (Mbawala et al., 2002a; Mbawala et al., 2002b; Mbawala et al., 2003; Tatsadjieu et al., 2008; Mbawala et al., 2009; Mbawala et al., 2010a). This is not always the case as depicted on Figure 3. Their biovalorization depend in parts on the respect of the above considerations.



Figure 3: Honey bees packaged in plastic and exposed for selling.

Fermented Milks Products

Description of indigenous fermented milks produced

There are only two types of indigenous fermented milks produced in the Adamaoua Region of Cameroon represented by *Pendidam* and *Kindirmou* produced mostly by Fulani people. They are all produced by fermentation of raw fresh milk from cow origin. Considering the production processes (Figure 4 A and B), *Pendidam* for which the product in Figure 5, is a raw fresh milk, heated, skimmed and fermented (Jiwoua & Millière, 1990) while *Kindirmou* is a raw fresh full-cream milk, heated and fermented (Essomba et al., 2002). Finally, *Pendidam* is a light curdled milk, very acidic while *Kindirmou* is a heavy fermented milk, less acidic than *Pendidam*.

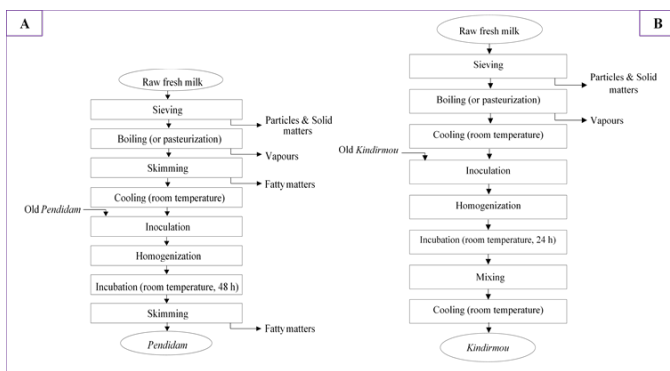


Figure 4: Flow diagram of production processes of *Pendidam* (A) and *Kindirmou* (B).



Figure 5: *Pendidam* packaged with display.

Local utilizations of fermented milks produced

According to Essomba et al. (2002), and Koussou and Duteurtre (2002), in Cameroon milk and fermented milks play an important role in the Fulani tribe of northern regions since they contribute to income and employment generation to generally female sex producers, transformers and traders. For Fulani people, fermented milks are considered as veritable foods whereas other people with nonbreeding traditions consume it as « dessert ». Fulani people recognize health benefits attributed to fermented milks: its acidity permit children to combat intestinal worms and to consumers they bring power, bravery and toughness. For Fulani people, *Pendidam* is appointed in priority to children who must consume it regularly while *Kindirmou* is mostly destined to adults particularly men to whom it gives virility.

Potential properties and challenges of indigenous fermented milks

In addition to investigated traditional utilizations, each indigenous fermented milk produced in the Adamaoua Region of Cameroon could:

- possess probiotics properties depending probably on the varieties of LABs it contains;
- be a source of specific and interesting flavors, aromas and textures due to the nature of end-products resulting to microbial phenomena occurring during fermentation processes;
- be a source of biomolecules probably produced by LABs, responsible of anti-constipation effect, antihypertensive properties, lipids metabolisms improvement, anti-obesity effect, and cholesterol-lowering activity, etc.

A general report can be remarked: absence or insufficiency of microbiological and biochemical investigations on indigenous fermented milks produced in the Adamaoua Region of Cameroon until now. Thus, a potential field for future research is opened to researchers in cooperation with industrials in how to vulgarize such authentic products with specific flavors, aromas and textures. Results of such studies could demonstrate

that most of the fermented milks produced in these regions cannot act only as sources of nutrients but also can:

- have health benefits like disease preventing or curing properties;
- possess properties of probiotic and/or functional foods.

For these reasons, the increase of their consumption by population must be recommended by administrative authorities throughout the concerned countries.

To satisfy the increase in demand, breeders have to ameliorate the quantity and the quality of milk produced independently to the season. Controlled fermentation during production can improve the quality and consequently the shelf life of the indigenous fermented milks produced.

Training of fermented milks producers on Good Hygiene Practices (GHP) and Good Manufacturing Practices (GMP) must be done to solve the potential problems due to their lack of education in food safety, particularly in areas where facilities for the safe preparation of foods are absent.

Challenges about some applications of LABs metabolites: Biosurfactants

A published data on Biosurfactants (Smith et al., 2020) hypothesizing that these bioactive molecules are a Covid-19 perspective with an expected antiviral mechanism, could be verified when considering the fact that Biosurfactants (BS) are:

- amphiphilic molecules with both hydrophobic and hydrophilic moieties (Figure 6);
- bioemulsifiers (BE) since they possess emulsifying properties (water/oil and oil/water) with additional surface tension characteristics;
- mostly produced by bacteria, yeasts, etc. and those produced by *Lactobacillus spp.* have GRAS (Generally Recognized As Safe) status;
- cell wall-linked and/or extracellular metabolites;
- commonly extracted and/or precipitated from the cell wall or the cell-free supernatant (CFS) of a culture of Lactobacilli by chemical solvents (acids, ethyl acetate, acetone, methanol, ethanol, etc.). Bioethanol is a bio-solvent that can be used to precipitate the Bioemulsifiers/ Biosurfactants (BE/BS) from the CFS of cultured Lactobacilli leading to their GRAS status.

There several reports highlighting the production of BE/BS by Lactobacilli isolated from a Cameroonian hard acidic fermented milk (*Pendidam*) highly consumed by all classes of the population independent of their age and socioeconomic status (Mbawala et al., 2013a; Mouafo et al., 2018a; Mouafo et al., 2018b; Mouafo et al., 2020a; Mouafo et al., 2020b; Mouafo et al., 2020c; Fookao et al., 2022; Mouafo et al., 2023b; Tchakouani et al., 2023). Some applications of BE/BS produced by Lactobacilli isolated from *Pendidam* were demonstrated. They included:

- Antimicrobial activities against *Pseudomonas spp.* (Fresh Beef), against bacteria and yeasts (Yellow *Achu* Soup) (Mbawala et al., 2013a; Mbawala et al., 2017).

- Emulsifying and sensory properties that improve the shelf life (*Pendidam*, Yellow *Achu* Soup), the organoleptic quality (milk bread, sausage), the texture (beef patties) and the stability of cold emulsion (milk chocolate drinks) (Mbawala et al., 2015a; Mbawala et al., 2015b; Fookao et al., 2022).
- Biopreservatives properties (ground beef, raw ground goat meat, etc.) through antimicrobial, antioxidant and antiadhesive activities, prevention of lipid oxidation and proteolysis and color stabilization, etc. (Mouafo et al., 2018a; Mouafo et al., 2018b; Mouafo et al., 2020a; Mouafo et al., 2020b; Mouafo et al., 2020c).

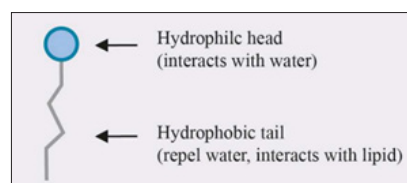


Figure 6: Structure of a biosurfactant (Smith et al., 2020)

In brief, *Pendidam* contains Lactobacilli which produce BE/BS that can be extracted with bioethanol to minimize their toxicity. The extracted BE/BS form stable emulsions (72 hours) at extreme pH and temperature, and at varied salinity (NaCl) that render these biomolecules' multiple properties exploitable in many fields (Mouafo et al., 2022). These last observations allowed us to give the name "black gold of the Bororo" to the *Pendidam*.

Considering the remarkable potential properties of these BE/BS as GRAS bioactive compounds, great challenges about health care can be hypothesized such as their utilizations to fight against viruses and all their mutants of the Covid-19 pandemic, the AIDS pandemic, the *Influenza* pandemic, Hepatitis B and C pandemic via oral capsules administration and, the cerebrovascular accident (CVA) and the myocardial infarction (MI) by emulsifying LDL-cholesterol depots in blood vessels, etc. via Seldinger technique (coronarography).

Conclusions

Fermented milks are the most fermented foods consumed by people of Adamaoua Region of Cameroon regardless to religious, ethnical and social considerations because of their health benefits. Suitable and available studies on traditional processes of milk fermentation may provide to people basic information on good manufacturing practices and good hygiene practices which are helpful to realize safe productions. Considering the multiple advantageous nutritional and functional properties of the indigenous food products and by-products produced in the Adamaoua Region of Cameroon, their challenges must be:

- The standardization and popularization of their technological processes in order to generate income and employment, and permit economic growth;
- The exploitation of the interesting properties of some of them to provide health benefits to humanity.

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