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Research Article

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Assessment of the risks of heavy metals contamination of dairy products from cattle farming in urban and peri-urban areas in Benin: case of the commune of Abomey-Calavi

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Abstract Human activities, a potential source of environmental pollution, are more concentrated in cities. Thus the ecosystem is probably threatened. The present work aims to evaluate the metallic contamination of dairy products (milk and Peuhl cheese) by heavy metals (lead and cadmium). For doing this, milk sampled at Godomey and Akogbato as well as formulated cheeses have undergone various physicochemical analyzes including atomic absorption spectrometry. From results obtained, it appears that the samples investigated were contaminated with lead and cadmium with a high lead content. These contents, expressed as mg of metal per kg of sample, ranged from 0.0321 to 0.4224 for lead and from 0.0083 to 0.0392 for cadmium. These values are for the most part above those allowed (0.02 mg/kg, limit lead content and the total absence of cadmium in dairy products) by the codex alimentarius. Milk, staple food of the child, is itself a victim of the civilization disease: various pollutants come to contaminate it. Heavy metals, whatever their content, lead for example, never have a useful effect and are always harmful.

Keywords environmental pollution, heavy metals, Lead, Cadmium, milk, cheese

1. Introduction

In several countries of globe, particularly in sub-Saharan Africa, changes in the physical and climatic environment as well as the population explosion have led to a very pronounced impoverishment of the population with consequent increase in vulnerability and mass migration of rural people to urban centers. Very quickly, the transformation of agricultural production systems appeared as a response to the deterioration of the purchasing power of the most disadvantaged strata. In this evolution dynamic of the agrarian systems, livestock farming and particularly milk production occupy a prominent place as a factor in reducing poverty and economic growth [1]. In Benin, milk contributes more than 50% of the annual incomes of Peulh households [2]. Indeed, milk, a protein source of good quality, is one of the rare speculations that allows a daily entry of money, without damaging the system that produces it. The sale of milk and its derivatives thus makes it possible to keep the animal in better condition and to provide incomes to all actors in the sector (producers, collectors, processors and resellers) [1]. However, milk is a very fragile product, because of its richness in water and other constituents sought by microorganisms. The fragility of the milk exposes it to a rapid degradation in a peasant environment, because of the low technological level, and the limited means of conservation. This situation requires actors in the "milk" sector to develop conservation or processing techniques adapted to socio-economic and

environmental contexts [3]. Benin, like many African countries, has experienced in recent years a development of urban livestock farming of dairy animals such as cow. In the city of Cotonou and even the surrounding towns, the production of the by-products of this breeding precisely milk and cheese has taken an important part in this activity. Currently in Benin, Peulh cheese represents the most widespread and most consumed product of livestock products [4]. It is made from high cow's milk using exclusively ecological practices. The manufacture of Peulh cheese still retains a simple and traditional character in Benin and in the sub-region. The process is based on cooking the coagulated milk with a plant extract, the Sodomme apple (*Calotropis procera*). Several research studies have focused on the production technology, the microbiological quality of Peulh cheese and its preservation by chemical additives and heat treatments as well as by fermentative strains. In addition, the coagulant properties of *Calotropis procera* and its potential for development in the food industry have been studied by Baba-moussa *et al* [5]. However, *Calotropis* extracts use for Peulh cheese production remains largely traditional and based on processors' habits and experience. Improved technology proposals for the leaf extracts preparation to improve the production yield of Peulh cheese have been made by Kra *et al* [6]. These authors recommend a fine extraction followed by decantation of the juice from the leaves of *C. procera*. Recently, Chikpah *et al* [7] reported that fresh and dry extracts of *C. procera* significantly affect the coagulation time, yield and organoleptic properties of cheese [8]. Despite the innumerable virtues of dairy products, the practice of rearing in urban or peri-urban area is not without danger for the consumer. The presence of heavy metals, especially cadmium, even at low content in the samples constitutes a real danger for the consumer insofar as the Codex Alimentarius recommends the total absence of cadmium in milk and milk products. Indeed, animals are exposed to various sources of environmental pollution of cities such as the misuse of pesticides in urban agriculture, air pollution caused by automobiles and industrial pollution today very worrying in emerging countries. Heavy metals resulting from this pollution such as lead, copper, zinc, cadmium and mercury are not biodegradable and therefore persist in the environment; environment in which animals feed. In addition, there're varied factors of pollution related in particular to the polymetals industry and oil production. Intensive agricultural activities have been accompanied by soil degradation through salinisation, wind erosion and desertification. Atomic essays provoked radioactive contaminations at different scales. Pollution of some regions' soils by lead (Pb) and cadmium (Cd) is a health hazard to dairy consumers as these metals concentrated throughout the food chain [9]. Indeed, one of the risks to be feared and which is linked to anthropogenic actions is the accumulation of heavy metals in water, soil and vegetals. Given the mineral and organic polluting load produced, the quality of the various resources (groundwater, soil, market garden products, dairy products, etc.) is therefore threatened by the different forms of pollutants. The heavy metals associated with the various discharges (wild dumpsites, garbage heap, exhaust gases, etc.) represent the most feared pollutants for these environments because of their concentration by certain living organisms and their implication in bioaccumulation phenomena and biomagnification in food chains [10]. Thus, the aim of this work is to assess the impact of environmental pollution on cattle farming products in Benin.

2. Material and Methods

2.1. Material

The biological material consisted of fresh cow's milk used in the preparation of cheeses and coagulant extracted from *Calotropis procera* still known as milk plant. At the laboratory, reagents and solvents used are of an analytical nature.

2.2. Methods

Milk samples' collection was carried out after a survey of the methods of feeding and milking cows on the sites investigated. Then the samples of milk and cheese were the subject of physico-chemical analyzes to ensure their quality.

2.2.1. Sampling

During the survey phase, a ten (10) question questionnaire was used to check the cows' feed, respect of cheese production diagram and breeding farms' areas. On the basis of the urban and peri-urban area criteria, Godomey

and Akôgbato were selected as sampling sites for the tangibility of the results. The fresh milk collected at each site is a milk mixture of all lactating cows. Some of this fresh milk collected was used to produce cheese. Thus, two (02) samples of fresh milk and two (02) samples of cheese were made. The milking of milk at each site was carried out by the drovers under the usual conditions in buckets. The milk samples were then transferred into 1L cans previously washed and sterilized. The samples are transported under cold conditions (+ 4°C) to the laboratory in coolers containing ice cubes in order to conserve the milk's flora. Finally, in the laboratory, the milk samples were exposed to the open air in order to appropriate the temperature of the laboratory before the stage of the various analyzes.

2.2.2. Technological process for obtaining the coagulant extract

The fresh leaves of *Calotropis procera* harvested, weighed, washed, crushed and filtered after the addition of about 50 mL of fresh milk. The coagulant extract was used during the production of Peulh cheese in the concentration of 35 g of leaf per liter of milk.

2.2.3. Formulation's technology of Peulh cheese

The production method of peulh cheese uses cow's milk and *Calotropis procera* leaf as raw materials. Peulh cheese was produced according to the method described by Dossou *et al* [2]. After preheating 950 mL of milk over low heat at 60°C for 5 to 10 minutes, the coagulant was added. Then, the whole was heated at a temperature of 95°C until the formation of curd supernatant whey (or whey). The coagulation was characterized by the appearance on the surface of the cream in the form of oily foam. At this time, the fire was activated during 2 to 3 minutes to allow a rise in temperature to 100°C for cooking the curd formed until whey color became light yellow and transparent; the coagulum tends to fall back on itself. It breaks into small pieces under heat effect and floats whey. The curd was poured just after cooling, in the strainers and underwent the dripping-molding (Fig 1).

Figure 1: Technological diagram of Peulh cheese's formulation

2.2.4. Physico-chemical analyzes

Peulh cheese's physicochemical characteristics (pH and acidity) were determined in three replicates according to the methods of analysis described in AOAC [11]. The pH of the milk was measured using portable pH meter (HANNA HI 98129) previously calibrated with buffer solutions of pH = 4.0 and pH = 7.0 at 25°C. Total acidity was determined on 10 mL of milk by titration with sodium hydroxide (0.1N) with phenolphthalein as a colored indicator and expressed in Dornic degree. The water and volatile matter content was determined in three repetitions by thermogravimetric according to AOAC [11]. Lead (Pb) and Cadmium (Cd) in milk and cheese samples were quantified by mineralization according to HACH followed by DR 2800 spectrophotometer's dosages using Dithizone methods [10].

3. Results and Discussion

3.1. Physico-chemical parameters of milk samples

The physicochemical parameters investigated on the milk samples made it possible to obtain the results of table 1. The analysis of the physicochemical characteristics of the milk revealed that the pH, the acidity and the content of water and volatile matter did not presented no significant difference (P> 0.05). The pH values (7.42 and 7.53) obtained for the two milk samples were slightly higher than the neutral pH. The milk samples are therefore alkaline. The high pH value was recorded at the milk sampled at Akôgbato.MakambalaN'Deke (2012) confirmed that the pH of the milk is between 6.4 and 6.8 and remains at this level for a long time. Any values outside these limits (6.4 and 6.8) indicate an abnormal case. Hodonou also revealed in 2015 on cow's milk a pH of 6.60±0.05 with a titratable acidity, (121.5±1.2) % lactic acid [12].

Table 1: Physico-chemical parameters of milk samples

	Milk L1	**Milk L2**	**Standard***
pH	6.420 ± 0.001	6.530 ± 0.002	6.6 et 6.8 à 20°C
DegreeDornic(°D)	41.6± 0.2	38.0± 0.1	18°D
Water content and volatile matter (%)	86.64± 0.01	84.28± 0.01	87-88

**AFNOR; L1:* milk from farm*1 (Godomey) ; L2:* milk from farm*2 (Akôgbato)*

3.2. Heavy metals of milk and cheese

The investigations carried out on the heavy metal composition in the different milk and cheese samples led to the results shown in fig 2. The Pb contents of the samples ranged from 0.0321 mg/kg to 0.4224 mg/kg and those in Cd from 0.0083 mg/kg to 0.0392 mg/kg. The codex alimentarius admits 0.02 mg/kg, for lead's limit content and total absence of cadmium in dairy products. In all milk and cheese samples, Pb and Cd contents were above accepted standards. Lead was the most abundant metal in all samples explored. So we noticed that milk samples have been less concentrated in these metals than cheese samples, although milk is the basic raw material for Peulh cheese's formulation. Milk is an emulsion (coarse dispersion) of fats matters in a colloidal protein solution whose inter-micellar liquid is a real solution [13]. The high metal content observed in the cheese is explained by a migration of these metals from milk to cheese during milk processing operations. These results are compliant with those of Bui [14] who revealed that after separation of the main milk hashes (proteins, lipids, serum), lead and cadmium are found completely in the protein phase whereas no trace of these elements is observed in the others two fractions. Since cheese is a concentrate of milk proteins, the presence of these metals in cheese could be justified by their transfer during milk processing into cheese. Lead has a harmful role in the body, because it blocks the amino-levulinic-dehydrastase o, the heme group synthesis and that of the protoporphyrin. It is thus distinguished from iron, copper and zinc, which have a favorable diastatic action at low concentration.

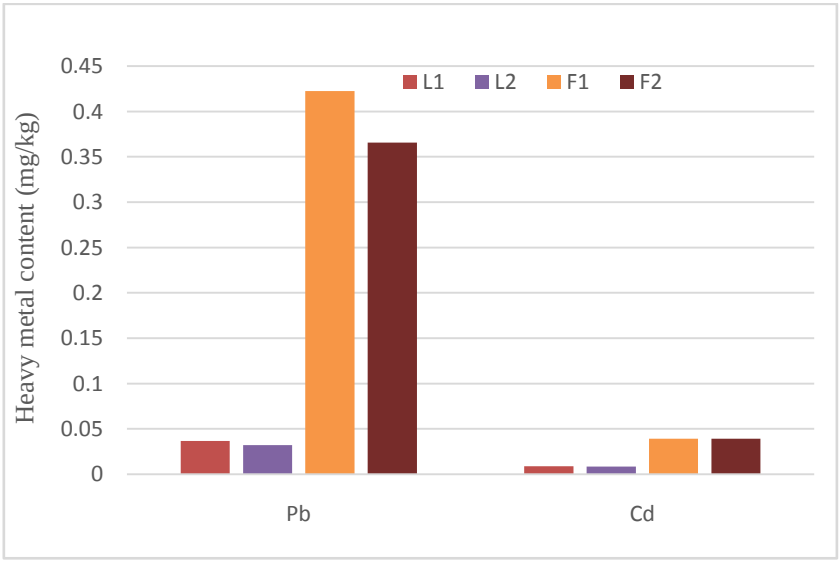

Figure 2: Heavy metal content (Lead and Cadmium) samples
F1: cheese from farm 1 milk (Godomey); F2: Cheese from farm 2 milk (Akôgbato)

4. Conclusion

Benin is a country in full emergence. One of the major brakes to its development is environmental pollution. Through the present study, it was noted that the milk and cheese samples investigated were contaminated with heavy metals such as lead and cadmium. Even low-dose toxicity and bioaccumulation of these heavy metals make them hazardous to humans (this too is a quality factor as important as the microbiological characteristics of milk and cheese). The consequences induced by this contamination are health risks for consumers and producers. To remedy this situation, it is necessary to take steps to identify all potential sources of contamination, especially domestic and commercial activities, in order to abandon or control them.

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