EVALUATION OF THE ACIDITY AND MICROBIOLOGICAL QUALITY OF ARTISANAL MILK AND "DÈGUÊ" SOLD IN BAKERIES IN ABOBO (CÔTE D'IVOIRE)

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Abstract

This study was carried out in the locality of Abobo to examine the acidity and microbiological quality of artisanal milk and "dèguê" marketed in the commune of Abobo. Therefore, samples of milk and "dèguê" were taken from five bakeries following each delivery. These samples were taken five times while respecting the cold chain. pH, titratable acidity and microbiological tests were carried out in accordance with standard and referenced standards. The main results of this research showed that dairy products had a pH ranging from 4.1 ± 0.2 to 4.3 ± 0.3 for milk, and between 4.1 ± 0.1 and 4.6 ± 0.1 for "dèguê". The titratable acidity of the milk samples were all below 120 °D, thus showing that they were kept cold. The microbiological evaluation of milk and "dèguê" samples from various bakeries ("Pain choco", "Paris baguette", "Blé doré", "Samaké" and "Abobo gare") revealed poor microbiological quality. In fact, in most cases, we observed that the level of microorganisms exceeded the established standards. All samples analyzed showed a significant presence of total coliforms, *Escherichia coli*, *Listeria monocytogenes*, and *Staphylococcus aureus*. However, none of the milk and "dèguê" samples tested showed the presence of *Samonella*. It is important to note that regular consumption of these products, which are highly prized by the population, could pose a significant health risk to consumers.

Introduction:-

Dairy products are an important category of food mainly derived from the milk of animals such as cow, goat, sheep etc. (Codex Alimentarius, 2011). Dairy products have a significant place in the human diet due to their rich nutrient content, including proteins, fats, vitamins and minerals such as calcium, which is essential for healthy teeth and bones (Fink, 2020). Among these dairy products, milk and deguê are widely consumed foods in Africa, particularly in Côte d'Ivoire (Palé, 2006 ; Koffi, 2022). Particularly in the popular communes of Abidjan such as Abobo, almost all modern bakeries sell these products.

Milk, an essential source of proteins, vitamins, and minerals, can be exposed to contamination during the manufacturing process, transportation, or handling (Swotantra, 2025). Similarly, "dèguê", a traditionally fermented product made from cereals (often millet or couscous), can undergo microbiological alterations that could compromise its food safety (Zinzendorf *et al*., 2009).

In a context where foodborne illnesses represent a public health issue, assessing the quality of these products is essential. A rigorous analysis of physicochemical parameters, such as pH, density, and fat content, as well as microbiological aspects, such as the presence of pathogenic germs (coliforms, *Salmonella*, etc.), ensures their compliance with food standards.

The overall objective of this study is to assess the acidity and microbiological quality of artisanal milk and "dèguê" sold in the Abobo municipalities in order to identify potential risks for consumers. The aim was to determine the titratable acidity and pH of milk and "dèguê", identify microbiological contaminants, and compare the results obtained with current quality standards.

Biological materials:-

This study was conducted using bottles of milk and "dèguê" (Figure 1), purchased from bakeries in Abobo (Abidjan, Côte d'Ivoire). These products, obtained from five bakeries located in this locality, were placed in a cooler before being transported to the microbiology laboratory at Nangui ABROGOUA University for subsequent analyses.

Figure 1: Photograph of a sample of bottles of milk and "dèguê"

Technical equipment:-

The technical equipment used for this work consisted of microbiology and biochemistry laboratory equipment for isolating and enumerating microorganisms. The culture medium (PCA) was used for the enumeration of Total Mesophilic Aerobic Flora (TMAF) and Baird Parker agar was used for the enumeration of *Staphylococcus sp*. Total and fecal coliforms (*Escherichia coli*) were enumerated using Tryptone Bile Deoxycholate culture medium. Buffered Peptone Water broth was used to prepare the stock solution and the various dilutions.

Methods:-

Presentation of the study area

This study took place in the commune of Abobo, located in the northern district of Abidjan, Côte d'Ivoire (Figure 2). As part of this research, five bakeries located in different neighborhoods of the commune were targeted for milk and "dèguê" samples. These were "Paris Baguette", "Blé Doré", "Pain Choco", "Gare bakery", and "Samaké bakery".

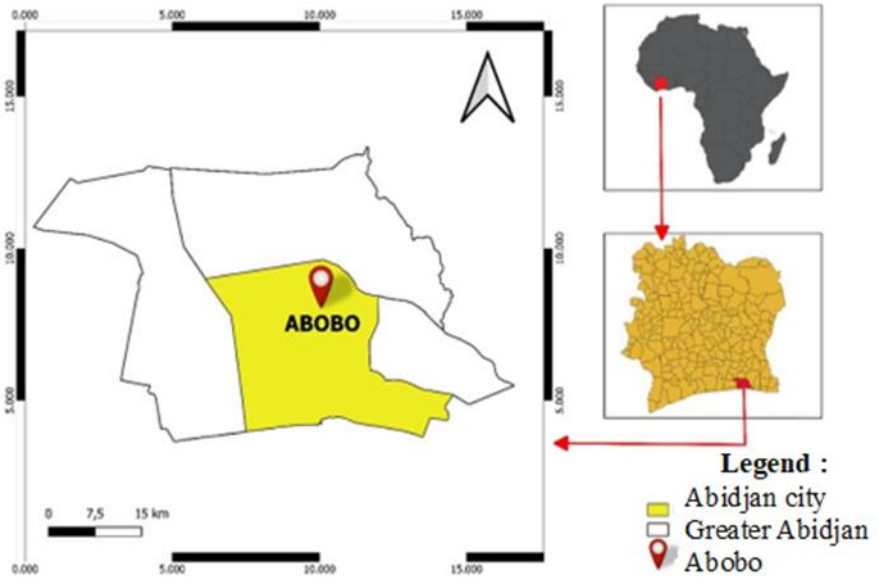

Figure 2: Map of the city of Abidjan showing the geographical position of the commune of Abobo

Sampling

Samples of milk and "dèguê" were collected from various bakeries located in the commune of Abobo. Five (5) bakeries were randomly selected. After delivery of the products by the suppliers, three (3) bottles of milk and three (3) bottles of "dèguê" were purchased and placed in a cooler at each bakery. We repeated the experiment five times to ensure the reliability of our data. In total, we conducted five sampling sessions over a period of one and a half months at each bakery, taking six bottles (three of milk and three of "dèguê") from each bakery and for each delivery. In total, this study was conducted with 75 bottles of milk and 75 bottles of "dèguê". It is important to emphasize that after purchase, the bottles are placed in a cooler so as not to break the cold chain and then sent to the microbiology laboratory of Nangui ABROGOUA University for the various analyses.

Physicochemical analyses of milk and "dèguê" :-

pH Determination

The pH of the milk and "dèguê" samples was determined using the method described in the international standard (ISO 11289 : 1993). For this analysis, a pH meter (Mettler Toledo, Switzerland) previously calibrated with a pH 7 buffer solution was used. The electrode was then immersed in a beaker containing 10 mL of milk and "dèguê", and the pH value was read directly from the meter's display.

Determination of titratable acidity

The acidity of milk, "dèguê", or a dairy product corresponds to the amount of lactic acid formed by the transformation of lactose under the action of lactic acid bacteria. Titratable acidity was determined by titration with sodium hydroxide (NaOH) solution in the presence of phenolphthalein as a color indicator using the international standard (ISO/TS 11869:2012). A 10 mL sample was taken from each sample. Three drops of phenolphthalein were then added under constant stirring. The titration was performed at room temperature by adding dropwise the NaOH solution to N/9 until the color turned persistently pink (equivalent point). The final volume of sodium hydroxide was then recorded. Acidity was expressed in degrees Dornic (1° Dornic corresponds to 0.1 g of lactic acid). Each sample was titrated 3 times. The Dornic degree is obtained using the following formula:

(1)

Avec $Co = C_1 x Veq x Mac / Vo$

C_1: sodium hydroxide concentration

Veq: equivalent volume

Mac: molar mass of the lactic acid molecule

Vo: volume of milk in mL

Microbiological analysis of milk and "dèguê":-

The microbiological analysis of artisanal milk and "dèguê" sold in Abobo bakeries is based on techniques for counting, isolating, and identifying microorganisms that can affect their hygienic and nutritional quality. The identification of these microorganisms constitutes the qualitative aspect of the analysis, determining their presence or absence. However, the enumeration is based on counting colonies after culture, followed by a calculation method, which provides a quantitative assessment of contamination.

Preparation of stock solution and dilutions

Stock solutions were prepared by combining 225 mL of buffered peptone water with 25 mL of milk and "dèguê". The resulting mixture was homogenized and then allowed to stand for 15 minutes to allow reactivation of the microorganisms. Starting from the stock solution, decimal dilutions were made until a final dilution of 10^{-4} was obtained. To achieve this dilution, 1 mL of the stock solution was extracted using a graduated pipette and mixed with 9 mL of buffered peptone water, resulting in a dilution of 10^{-1}. Subsequently, 1 mL of this first dilution was

poured into another tube containing 9 mL of buffered peptone water to achieve the 10^{-2} dilution, and so on (Coulibaly *et al*., 2015).

Detection and enumeration of total coliforms and *Escherichia coli*

The detection of total coliforms and *E. coli* was carried out using the method described in the standard (ISO 16649-2:2001). From the decimal dilutions, aseptically remove 1 mL of each dilution and inoculate it into empty, previously prepared and numbered Petri dishes. Approximately 15 mL of Tryptone Bile Deoxycholate medium was poured into each Petri dish, previously cooled in a water bath at a temperature between 44 °C and 47 °C. Then, thoroughly mix the inoculum with the medium and allow the mixture to solidify, placing the Petri dishes on a cool, horizontal surface.

Detection and enumeration of *Staphylococcus aureus*

For the detection of *Staphylococcus aureus*, ISO 6888-1:2021 was used. A volume of 0.1 mL of the stock solution and each dilution were inoculated per line on Petri dishes containing Baird Parker medium; then incubated at 37 °C for 24/48 hours. *Staphylococcus aureus* colonies appeared as black, shiny, convex formations with a clear halo approximately 2 to 5 mm in diameter.

Detection and enumeration of *Listeria monocytogenes*

The detection of *Listeria monocytogenes* was performed using the standard (ISO 11290-2:2017). Its detection in milk and "dèguê" is complex due to their low concentration (generally less than 10 CFU/mL) and their competition with the bacterial microflora present (Stéphanie *et al*., 2003). The detection of Listeria monocytogenes was carried out in three phases : enrichment, isolation, and identification. Enrichment was performed by taking 1 mL of the stock solution and dilutions, then adding it to Half-Fraser broth at 37 °C for 48 minutes. Regarding isolation, it was carried out by inoculation on *Listeria* agar, followed by incubation at 37 °C for 48 hours. Finally, the identification confirmed the presence of *Listeria monocytogenes* through specific identification tests.

Salmonella detection and enumeration

The ISO 6579-1:2017 standard was used to detect *Salmonella*. *Salmonella* detection is based on three main steps.

Pre-enrichment in a non-selective liquid medium

A suspension was prepared by adding 25 mL of milk or "dèguê" to 225 mL of buffered peptone water. This medium allows the recovery and multiplication of *Salmonella* present in low concentrations. Incubation was carried out at 37 °C for 16 to 24 hours (Bachtarzi *et al*., 2015).

Enrichment in liquid selective medium

To specifically promote the growth of *Salmonella* while inhibiting competing bacteria, 1 mL of the pre-enriched culture was transferred into 100 mL of Rappaport-Vassiliadis broth (Merck, Germany). The incubation process was maintained at 37 °C for 24 hours (Maiwore *et al*., 2018).

Isolation on solid selective medium

Using a platinum loop, a sample of the enriched culture was inoculated on Xylose-Lysine-Deoxycholate agar, a differential medium that allows the identification of *Salmonella*. After incubation at 37 °C for 24 hours, colonies deemed suspect were characterized by a red color with a black center (Oumarou *et al*., 2021).

Detection and enumeration of total mesophilic flora

The detection of total mesophilic flora was carried out according to the method described in the standard (ISO 4833-1:2013). The analysis of total flora consisted of inoculating 0.1 mL of the stock solution and prepared dilutions on Petri dishes containing PCA (Plate Count Agar) medium. These dishes were then incubated at 30 ± 1 °C for 72 ± 3 hours.

Statistical analysis:-

Data analyses of the germ counts and the construction of the various tables were performed using EXCEL 16.439 software. The germ counts in CFU/g were presented as means expressed in Log (CFU/g). The pH and acidity values of the samples were also presented as means. A one-way analysis of variance (ANOVA 1) was used to compare the different means. When, for all analyses, the ANOVA concluded a significant difference between the means compared at the 5% threshold ($\alpha < 0.05$), the Tukey post-ANOVA test was the most appropriate here to highlight the level of difference between the different means in order to rank them. All these statistical analyses were performed using XLSTAT 2017.02 software incorporated in EXCEL 16.4393.

Results:-

Measured pH and Dornic degree of milk and "dèguê"

The pH values of milk ranged between 4.1 ± 0.2 and 4.3 ± 0.1, while those "dèguê" ranged between 4.1 ± 0.1 and 4.6 ± 0.1 depending on the bakery (Table 1). Statistical analysis showed no significant difference between the pH values of milk. However, it revealed a significant difference at the 5% level between the pH values of the different "dèguê" samples. These values are lower than the norms for fresh milk, which normally range between 6.6 and 6.8. Therefore, such a low pH indicates advanced acidification of the milk and "dèguê".

As for the acidity of milk, it varies between 94 ± 16.3 and 115 ± 30.0 °D, and that of "dèguê" between 76.6 ± 32.7 and 115.2 ± 16.2 °D. These results are very high, therefore do not comply with the standard. Milk is said to be fresh if its Dornic degree is ≤ 18 °D. Statistical analysis showed that there is no significant difference at the 5% threshold between the Dornic degree values at all bakeries for both milk and "dèguê".

Table 1: pH and titratable acidity of milk and "dèguê" sold in Abobo bakeries

Bakeries	Milk		"Dèguê"	
	pH	°Dornic	pH	°Dornic
"Paris baguette"	4.3 ± 0.1[a]	106.6 ± 20.8[a]	4.2 ± 0.1[b]	89.2 ± 23.3[a]
"Abobo gare"	4.2 ± 0.4[a]	115 ± 30.0[a]	4.1 ± 0.4[b]	115.2 ± 16.2[a]
"Blé doré"	4.3 ± 0.3[a]	101.6 ± 22.5[a]	4.6 ± 0.1[a]	77.4 ± 15.5[a]
"Samaké"	4.3 ± 0.2[a]	107.2 ± 46.9[a]	4.3 ± 0.2[ab]	76.6 ± 32.7[a]
"Pain choco"	4.1 ± 0.2[a]	94 ± 16.3[a]	4.1 ± 0.1[b]	112 ± 41.7[a]

Values in the same column followed by different letters show significant differences ($p < 0.05$). Each value is the average of the results obtained over 15 determinations ± standard deviation of this average.

Microbiological analysis

Microbiological tests included Total Aerobic Mesophilic Flora (TAMF), total coliforms, *Escherichia coli*, *Listeria monocytogenes*, *Staphylococcus aureus*, and *Salmonella*. Enumeration revealed the absence of *Salmonella* in all milk and "dèguê" samples.

Total mesophilic aerobic flora

Table 2 presents the total mesophilic aerobic flora (TMAF) counts in the various samples analyzed. The "Paris baguette" bakery recorded the lowest total mesophilic aerobic flora level (6.89 ± 1.43 [Log (CFU/g)]), and the highest value was observed at the "Samaké" bakery with a level of 8.09 ± 0.46 [Log (CFU/g)] for the milk samples. Regarding the "dèguê" samples, the "Abobo gare" bakery recorded the highest value (8.18 ± 2.84 [Log (CFU/g)]) and the lowest value was observed at the "Blé doré" bakery (7.63 ± 0.72 (Log (CFU/g)). Statistical analysis at the 5% threshold did not reveal any significant difference between the TMAF values of milk and "dèguê". The recorded levels are higher than the standard (≤ 6 to 7 [Log (CFU/g)]), which indicates contamination. A total mesophilic aerobic flora indicates microbial proliferation.

Table 2 : Enumeration of FAMT in milk and "dèguê" sold in Abobo bakeries

Bakeries	**Total Mesophilic Aerobic Flora [Log (UFC/g)]**		**Appreciation**	
	Milk	**"Dèguê"**	**Milk**	**"Dèguê"**
"Pain choco"	7.73 ± 1.32[a]	7.83 ± 2.19[a]	UMQ	UMQ
"Samaké"	8.09 ± 0.46[a]	7.96 ± 0.57[a]	UMQ	UMQ
"Blé doré"	7.81 ± 0.24[a]	7.63 ± 0.72[a]	UMQ	UMQ
"Paris baguette"	6.89 ± 1.43[a]	7.72 ± 0.21[a]	UMQ	UMQ
"Abobo gare"	7.73 ± 0.67[a]	8.18 ± 2.84a	UMQ	UMQ
Reference criteria [Log (UFC/g)]	≤ 6 à 7			

Values in the same column followed by different letters show significant differences ($p < 0.05$). Each value is the average of the results obtained over 15 determinations ± standard deviation of this average.

UMQ : Unsatisfactory Microbiological Quality

Total coliforms

Total coliforms present in milk and "dèguê" samples sold in bakeries in the municipality of Abobo exceeded the standards (≤ 2 to 3 [Log (CFU/g)]). This indicates probable fecal contamination. The recorded values showed a significant difference at the 5% level for total coliforms values in milk samples (Table 3). However, for "dèguê" samples, there was no significant difference between the recorded values. The "Pain choco" bakery recorded the highest total coliforms levels with values of 4.40 ± 0.40 and 4.55 ± 0.88 [Log (CFU/g)], respectively, for milk and "dèguê".

Table 3 : Enumeration of total coliforms in milk and "dèguê" sold in Abobo bakeries

Bakeries	**Total coliforms [Log (UFC/g)]**		**Appreciation**	
	Milk	**"Dèguê"**	**Milk**	**"Dèguê"**
"Pain choco"	4.40 ± 0.40[a]	4.55 ± 0.88[a]	UMQ	UMQ
"Samaké"	4.19 ± 0.63[ab]	4.28 ± 0.33[a]	UMQ	UMQ
"Blé doré"	3.69 ± 0.24[bc]	3.99 ± 0.57[a]	UMQ	UMQ
"Paris baguette"	3.77 ± 0.72[abc]	4.12 ± 0.50[a]	UMQ	UMQ
"Abobo gare"	3.23 ± 0.33[c]	4.28 ± 1.10[a]	UMQ	UMQ

Reference criteria [Log (UFC/g)]	≤ 2 à 3

Values in the same column followed by different letters show significant differences ($p < 0.05$). Each value is the average of the results obtained over 15 determinations ± standard deviation of this average.

UMQ : Unsatisfactory Microbiological Quality

Escherichia coli

Table 4 presents the *Escherichia coli* counts in the various samples analyzed. The recorded levels are above the standard (≤ 1 to 2 [Log (CFU/g)]), indicating *E. coli* contamination of milk and "dèguê" samples sold in bakeries in the Abobo commune. The "Samaké" bakery recorded the highest *E. coli* level (3.43 ± 0.76 [Log (CFU/g)]), and the lowest value was observed at the "Abobo gare" bakery with a level of 2.86 ± 0.27 [Log (CFU/g)] for milk samples. Regarding the "dèguê" samples, the "Pain choco" bakery recorded the highest value (3.81 ± 1.03 [Log (CFU/g)]) and the lowest value was observed at the "Paris baguette" bakery (3.22 ± 0.99 [Log (CFU/g)]). Statistical analysis at the 5% level did not reveal any significant difference between the *E. coli* values of milk and "dèguê".

Table 4: Enumeration of *Escherichia coli* in milk and "dèguê" sold in bakeries in Abobo

Bakeries	***Escherichia coli* [Log (UFC/g)]**		**Appreciation**	
	Milk	**"Dèguê"**	**Milk**	**"Dèguê"**
"Pain choco"	3.29 ± 0.67[a]	3.81 ± 1.03[a]	UMQ	UMQ
"Samaké"	3.43 ± 0.76[a]	3.50 ± 0.90[a]	UMQ	UMQ
"Blé doré"	3.19 ± 0.57[a]	3.43 ± 0.99[a]	UMQ	UMQ
"Paris baguette"	3.22 ± 0.41[a]	3.22 ± 0.99[a]	UMQ	UMQ
"Abobo gare"	2.86 ± 0.27[a]	3.38 ± 0.67[a]	UMQ	UMQ
Reference criteria [Log (UFC/g)]	≤ 1 à 2			

Values in the same column followed by different letters show significant differences ($p < 0.05$). Each value is the average of the results obtained over 15 determinations ± standard deviation of this average.

UMQ : Unsatisfactory Microbiological Quality

Listeria monocytogenes

Listeria monocytogenes counts in the various samples analyzed showed that out of the five bakeries, two, namely the "Samaké" bakery and the "Abobo gare" bakery, met the international standard (≤ 2 to 3 [Log (CFU/g)]) in both milk and "dèguê" samples. The "Blé Doré" bakery recorded the highest *L. monocytogenes* levels for both milk and "dèguê" samples, with respective values of 3.31 ± 0.58 and 3.48 ± 0.53 [Log (CFU/g)]). Statistical analysis at the 5% level revealed a significant difference in *L. monocytogenes* values for the "dèguê" samples. However, it did not reveal a significant difference at the 5% level for the milk samples (Table 5).

Table 5 : Enumeration of *Listeria monocytogenes* in milk and "dèguê" sold in Abobo bakeries

Bakeries	***Listeria monocytogenes* (Log (UFC/g))**		**Appreciation**	
	Milk	**"Dèguê"**	**Milk**	**"Dèguê"**
"Pain choco"	3.24 ± 0.77[a]	3.01 ± 0.83[ab]	UMQ	UMQ
"Samaké"	2.87 ± 0.94[a]	2.88 ± 0.79[ab]	AMQ	AMQ

"Blé doré"	3.31 ± 0.58[a]	3.48 ± 0.53[a]	UMQ	UMQ
"Paris baguette"	3.10 ± 0.83[a]	3.24 ± 0.52[ab]	UMQ	UMQ
"Abobo gare"	2.81 ± 0.25[a]	2.65 ± 0.47[b]	AMQ	AMQ
Reference criteria [Log (UFC/g)]		≤ 2 à 3		

Values in the same column followed by different letters show significant differences ($p < 0.05$). Each value is the average of the results obtained over 15 determinations ± standard deviation of this average.
UMQ : Unsatisfactory Microbiological Quality
AMQ : Acceptable Microbiological Quality

Staphylococcus aureus

Table 6 presents the *Staphylococcus aureus* counts in the various samples analyzed. The levels recorded were above the standard (≤ 2 to 3 [Log (CFU/g)]), except for the milk sample sold at the "Samaké" bakery, which indicates *Staphylococcus aureus* contamination of the milk and "dèguê" samples sold in bakeries in the Abobo commune. The "Abobo gare" bakery recorded the highest *S. aureus* level (3.95 ± 0.33 [Log (CFU/g)]), and the lowest value was observed at the "Samaké" bakery with a level of 2.53 ± 0.78 [Log (CFU/g)] for the milk samples. The milk produced at the "Samaké" bakery is therefore of acceptable microbiological quality considering *Staphylococcus aureus*. Regarding the "dèguê" samples, the "Pain choco" bakery recorded the highest value (3.85 ± 0.20 [Log (CFU/g)]) and the lowest value was observed at the "Samaké" bakery (3.32 ± 1.16 [Log (CFU/g)]). Statistical analysis at the 5% level did not reveal any significant difference between the *S. aureus* values of the "dèguê". However, in the milk, the analysis revealed a significant difference at the 5% level for the *S. aureus* values.

Table 6: Enumeration of *Staphylococcus aureus* in milk and "dèguê" sold in bakeries in Abobo

Bakeries	***Staphylococcus aureus* (Log (UFC/g))**		**Appreciation**	
	Milk	**"Dèguê"**	**Milk**	**"Dèguê"**
"Pain choco"	3.87 ± 1.32[a]	3.85 ± 0.20[a]	UMQ	UMQ
"Samaké"	2.53 ± 0.78[b]	3.32 ± 1.16[a]	AMQ	UMQ
"Blé doré"	3.47 ± 0.59[ab]	3.64 ± 0.53[a]	UMQ	UMQ
"Paris baguette"	3.57 ± 0.46[ab]	3.95 ± 0.57[a]	UMQ	UMQ
"Abobo gare"	3.95 ± 0.33[a]	3.46 ± 0.56[a]	UMQ	UMQ
Reference criteria (Log (UFC/g))	≤ 2 à 3			

Values in the same column followed by different letters show significant differences ($p < 0.05$). Each value is the average of the results obtained over 15 determinations ± standard deviation of this average.
UMQ : Unsatisfactory Microbiological Quality
AMQ : Acceptable Microbiological Quality

Discussion:-

The study conducted on various samples of milk and "dèguê" sold in bakeries in the commune of Abobo consisted of measuring the physicochemical parameters and assessing the microbiological quality of these dairy products. The pH and titratable acidity measured on milk and "dèguê" sold in five bakeries in this locality showed that the pH values of milk ranged between 4.1 ± 0.2 and 4.3 ± 0.1, while those "dèguê" ranged between 4.1 ± 0.1 and 4.6 ± 0.1. However, the pH of fresh milk is 6.7. This drop in pH in these dairy products could be explained by the fermentation that occurs during their manufacturing. Indeed, during the milk fermentation process, the lactic acid bacteria contained in the ferment used to make curdled milk and « dèguê » transform lactose into lactic acid. This leads to a decrease in pH and an increase in titratable acidity, which causes the coagulation of the casein present in the milk and ensures the preservation of the product (Bourdichon *et al*., 2021). Also, these lactic acid bacteria generate aromatic compounds, enzymes and other elements that significantly influence the texture and taste of dairy products (Maïwore *et al*., 2018).

Regarding the acidity of milk, it is between 94 ± 16.3 and 115 ± 30.0 °D, and that of "dèguê" between 76.6 ± 32.7 and 115.2 ± 16.2 °D. These recorded values are higher than that of the Dornic degree of fresh milk which is less than or equal to eighteen Dornic degrees (≤ 18 °D). This increase in titratable acidity could also be explained by the fermentation process which acidifies the environment by reducing the pH. Our results corroborate those of Biatcho (2006) and Ngassam (2007), who showed that the acidity of curdled milk produced in Dakar is in the order of 100 to 127.5 ° D. In addition, research conducted by Maïwore *et al*. (2018) revealed that the acidity of refrigerated dairy products was less than 120 °D (≤ 120 °D). In contrast, an unpreserved dairy product had an acidity greater than 120°D (>120 °D). This would mean that the milk and "dèguê" offered in bakeries in the commune of Abobo are kept refrigerated.

The observed differences in pH and acidity between milk and "dèguê" from various bakeries could be explained by the fact that these dairy products are produced in an artisanal and uncontrolled manner.

Regarding microbial analysis, significant contamination of the total mesophilic aerobic flora was observed in all milk and "dèguê" samples provided by Abobo bakeries. This contamination could be due to the unsanitary environment where the product is produced, as well as the use of unsuitable tools and equipment; non-compliance with hygiene standards during the individual stages of processing the raw material into dairy products. Some previous studies have shown that various factors such as fingers, dust, poor hygiene, containers used during the production of milk and deguê can be responsible for the contamination of the finished product (Tourette, 2002; Biatcho, 2006).

The complete absence of *Salmonella* in all milk and "dèguê" samples analyzed is good news. Indeed, standards require the complete absence of this bacterium in 25 g of product. This indicates that, despite other potential contaminants, the danger associated with this bacterium responsible for severe poisoning remains low (Frédérique, 1993).

The levels of total coliforms and *E. coli* far exceeded the established limits (≤ 2 to 3 [Log (CFU/g)] for coliforms ; ≤ 1 to 2 [Log (CFU/g)] for *E. coli*). This suggests possible fecal contamination, which could result from the water used, tools, or poor hygiene among employees (Tourette, 2002). Indeed, insufficient hand hygiene, an unfavorable manufacturing environment and the use of milk from a contaminated source may be probable contamination factors (Sissoko *et al*., 2023). These levels indicate an increased danger of the presence of infectious agents of fecal origin for all milk and "dèguê" samples analyzed from different bakeries in Abobo. However, the identification of a high concentration of total coliforms in milk and "dèguê" samples and *E. coli* in "dèguê" samples from the bakery" "Pain choco" and that of *E. coli* in milk samples from the bakery"Samaké"could be linked to a pronounced inadequacy of hygiene standards observed by the production staff of these dairy products but also by a failure of production equipment as mentioned by Maïwore *et al*. (2018) during this work on dairy products. The differences in the total coliform and E. coli counts between samples from various bakeries could be attributed to the fact that some producers make efforts to follow hygiene regulations, while others do not.

Regarding the presence of *L. monocytogenes*, analysis of the samples revealed that out of five bakeries, only two, namely the "Samaké" bakery and the "Abobo gare" bakery, met international standards (≤ 2 to 3 [Log (CFU/g)]) for both milk and deguê.

In contrast, the levels detected in the other three exceeded the standard. Theoretically, the acidic pH obtained during the production of these dairy products (milk and dèguê) marketed in these bakeries should prevent the proliferation of *L. monocytogenes* (Dumas, 2007). In particular, the "Blé doré" bakery displayed the highest level of *L. monocytogenes* for the milk and "dèguê" samples. However, this bacterium poses a major risk, especially for pregnant women, children and immunocompromised individuals, as it can induce listeriosis (Baira & Benmohamed, 2021). Populations who regularly consume these bakeries are therefore exposed to the risk of listeriosis. The results showed that, among the samples examined, the milk offered at the " Samaké " bakery has an acceptable microbiological quality, taking into account *Staphylococcus aureus*. The samples of "dèguê" from this bakery, like other dairy products from other bakeries, have levels exceeding the standard (≤ 2 to 3 [Log (CFU/g)]). *Staphylococci* are ubiquitous pathogenic microorganisms, frequently present in the environment, but their main source of contamination remains humans (Sissoko *et al.*, 2023). They can cause severe food poisoning. The detection of this bacterium signals a lack of hygiene, because the contamination of the product could result from a set of inappropriate actions, inadequate storage and cross-contamination (Bonfoh *et al.*, 2003).

CONCLUSION

The objective of this study was to assess the acidity and microbiological quality of artisanal milk and "dèguê" sold in the Abobo municipalities, in order to identify potential risks for consumers. The results obtained during this study indicate that dairy products have pH values ranging from 4.1 ± 0.2 to 4.3 ± 0.3 for milk, and from 4.1 ± 0.1 to 4.6 ± 0.1 for "dèguê", with a negative correlation with titratable acidity levels below 120 °D.

Analysis of milk and "dèguê" samples from bakeries revealed unsatisfactory microbiological quality, as in most cases, the microbial load exceeded established standards. However, an absence of *Samonella* was observed in all milk and "dèguê" samples examined. A significant presence of total coliforms, *Escherichia coli*, *Listeria monocytogenes* and *Staphylococcus aureus* was found in all samples examined. Therefore, frequent consumption of these popular products could pose a significant health risk to consumers.

REFERENCES

1. Bachtarzi N, Amourache L & Dehkal G. Quality of raw milk for the manufacture of a Camembert -type soft cheese in a dairy of Constantine (eastern Algeria). *International Journal of Innovation and Scientific Research*, August 2015, 17(1), 34-42.

2. Baira M I & Benmohamed A. La listériose chez la femme enceinte Master Professionnalisant Filière: Sciences Biologiques. Spécialité : Microbiologie et Hygiène Hospitalière, Université des Frères Mentouri Constantine 1, Algérie, 2021, 63 p.

3. Biatcho N S. Appréciation de la mise en œuvre de l'hygiène dans une laiterie artisanale de Dakar « LE DIRFEL » de la récolte du lait à sa transformation en lait caillé dit « SOW PUR ». Thèse de médecine de vétérinaire, Université de Dakar, Dakar, 2006, 101 p.

4. Bonfoh B, Fané A, Steinmann P, Hetzel M, Traoré A N, Traoré M, Simbé C F, Alfaroukh I O, Nicolet J, Akakpo J A, Farah Z & Zinsstag J. Qualité microbiologique du lait et des produits laitiers vendus au Mali et leurs implications en santé publique. *Etudes et Recherches Saheliennes*, 2003, 8(9) :19-27.

5. Bourdichon F, Arias E, Babuchowski A, Bückle A, Bello FD, Dubois A, Fontana A, Fritz D, Kemperman R, Laulund S, McAuliffe O, Miks MH, Papademas P, Patrone V, Sharma DK, Sliwinski E, Stanton C, Von Ah U, Yao S, Morelli L. The forgotten role of food cultures. *FEMS Microbiology Letters*, July 2021, 368(14):1-15 doi: 10.1093/femsle/fnab085. [DOI] [PMC free article] [PubMed] [Google Scholar]

6. Codex Alimentarius. Lait et produits laitiers, Rome, Deuxième édition, 2011, 266p.

7. Coulibaly L., Kouame-Elongne C., Yeo A. & Dosso M. Qualité microbiologique des produits laitiers industriels vendus à Abidjan 2009-2012. *Revue Bio-Africa*, 2015, 14, 44-52.

8. Dumas E (2007). Listeria monocytogenes : Caractérisation fonctionnelle d'un mutant ferritine. Etude de la biodiversité par une approche protéomique. Ingénierie des aliments. Université Blaise Pascal - Clermont-Ferrand II; Université d'Auvergne - Clermont-Ferrand I, 2007. Français. 238p.
9. Fink A. Les produits laitiers: Etude des bénéfices et des risques potentiels pour la santé, Diplôme d'Etat de Docteur en Pharmacie, Université de Rouen Normandie, 2020, 94 p.
10. Frédérique L. Salmonelles et toxi-infections alimentaires : épidémiologie et prévention. Sciences pharmaceutiques, Université Grenoble Alpes, 1993, 116 p.
11. ISO 6888-1. Microbiologie de la chaîne alimentaire - Méthode horizontale pour le dénombrement des staphylocoques à coagulase positive (*Staphylococcus aureus* et autres espèces), Deuxième édition, août 2021, 12 p.
12. ISO 11290-2. Microbiologie de la chaîne alimentaire — Méthode horizontale pour la recherche et le dénombrement de *Listeria monocytogenes* et de *Listeria* spp., Deuxième édition, mai 2017, 12 p.
13. ISO 6579-1. Microbiologie de la chaîne alimentaire — Méthode horizontale pour la recherche, le dénombrement et le sérotypage des *Salmonella*, Première édition, février 2017, 15 p.
14. ISO 4833-1. Microbiologie de la chaîne alimentaire - Méthode horizontale pour le dénombrement des microorganismes, Première édition, 01 septembre 2013, 9 p.
15. ISO 16649-2. Microbiologie des aliments - Méthode horizontale pour le dénombrement des Escherichia coli β-glucuronidase positive, Première édition, 15 avril 2001, 9 p.
16. ISO 11289. Produits alimentaires détermination en conserves - du pH, Première édition, 1 septembre 1993, 8 p.
17. ISO/TS 11869. Laits fermentés - Détermination de l'acidité titrable - Méthode potentiométrique, Première édition, 15 janvier 2012, 9 p.
18. Koffi G J J. Contamination microbienne et caractéristiques physicochimiques du lait caillé artisanal, vendu sur les marchés publics de la ville de Daloa, Côte d'Ivoire. Master Biotechnologie Agroalimentaire et Biosécurité Alimentaire, Université Jean Lorougnon Guédé (Daloa), 2022, 63 p.
19. Maiwore J, Baane P M, Amadou T, Ouassing A, Ngoune I & Montet D. Influence des conditions de traite sur la qualité physico-chimique et microbiologique du lait cru collecté à Maroua, Cameroun. *Afrique Science*, 2018, 14(4) : 235-248.
20. Ngassam T C. Caractérisation de la flore lactique des laits fermentés artisanaux au Sénégal : cas de la zone de Niaye. Thèse de Doctorat, Université Cheikh Anta Diop de Dakar, Dakar, 2007, 109 p.
21. Oumarou D, Haziz S, Pocoun D, Wilfrande M, Virgile A, Issaka Y, Adolphe A, Manuel R & Lamine B. Uses and microbiological quality of fresh cow's milk sold in three markets in South Benin. *African Journal of Food Science*, 2021, 15(10), 345-352.
22. Palé E. Analyse de la consommation du lait et des produits laitiers : Cas de la ville de BoboDioulasso. Mémoire diplôme d'ingénieur du développement rural option sociologie et économie rurales. 2006, 45 p.
23. Sissoko A, Samake F, Maïga D A B M, Dembele S, Koné F, Tembely S. Evaluation de la qualité microbiologique du lait frais pasteurisé et du lait local transforme (thiakry) vendus dans district de Bamako, Mali. *Agronomie Africaine*,2023, 35 (2) : 323 – 332.
24. Swotantra D. Chapter 35 - Various sources of milk contamination. *Handbook of Milk Production, Quality and Nutrition*,June 2025, Pages 427-435
25. Tourette I. Filières laitières en Afrique et points critiques pour la maîtrise des dangers sanitaires des laits et produits laitiers. 2002, 32 p.
26. Zinzendorf N Y, Baba-Moussa L, Yao C, Bouhoua L G, Sanni A, Loukou Y G. Prévalence de *Staphylococcus aureus* enterotoxinogène dans le « dèguê » vendu dans trois communes de la ville d'Abidjan, Côte d'Ivoire. *Microbiologie Hygiène Alimentaire*, 2009, 21 (62): 41-44.