



RESEARCH ARTICLE

**« EVALUATION DE LA QUALITE MICROBIOLOGIQUE DES “DEGUES”
PRODUITS ET VENDUS DANS LA COMMUNE DE LA VILLE DE N'DJAMENA,
TCHAD »**

**« MICROBIOLOGICAL QUALITY ASSESSMENT OF "DEGUE" PRODUCED AND
SOLD IN N'DJAMENA MUNICIPALITY, CHAD »**

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Abstract

Background: Dégué is a traditional fermented milk and cereal food widely consumed in West Africa and now found in N'Djamena (Chad), where its production remains largely artisanal and poorly controlled. This descriptive, cross-sectional study, conducted from October 2022 to March 2023 in five districts (arrondissements) of N'Djamena, aimed to assess the microbiological quality of dégué produced and sold in the city.

Material and methods : A sociodemographic survey was carried out among 247 individuals (15 producers, 13 vendors, and 219 consumers), and 20 dégué samples (16 artisanally produced and 04 of the DJAMIL brand) were analyzed at the laboratories of the Food Quality Control Center (CECOQDA) and the IRED (Livestock Research Institute for Development).

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The analyses covered enumeration of total aerobic mesophilic flora, total coliforms, Enterobacteria, *Escherichia coli*, *Staphylococcus aureus*, *Bacillus cereus*, and yeasts/molds, as well as detection of *Salmonella* spp.

Results and Discuss: Survey results revealed an overall moderate-to-low level of food hygiene knowledge (37.24% of respondents rated as "poor"). Microbiologically, 72% of artisanal dègué samples were found non-compliant with the regulatory criteria applied, compared with only 19% of DJAMIL-brand dègué samples. Total aerobic mesophilic flora, coliforms, Enterobacteriaceae, and *Bacillus cereus* were the parameters most frequently out of standard in artisanal products. No sample, regardless of dègué type, tested positive for *Salmonella* spp.

Conclusion: These results reflect inadequate hygiene conditions in the artisanal dègué production chain in N'Djamena and highlight the need to strengthen producer training, the cold chain, and regular health inspection of this widely consumed product, particularly among children and young people.

Introduction:-

Dègué is a cereal-based dairy food that is widely consumed in Burkina Faso, Benin, Mali, Côte d'Ivoire, and Senegal. Eaten by all segments of society, it is recognized for its probiotic properties. Although it is a fermented food, fermentation in the manufacturing process only concerns the milk added to the pre-cooked lumps of millet flour. It is a beverage prepared and sold fresh on a daily basis, along road sides, near areas of activity, in markets, and in shops, by small processing units (Tankoano *et al.*, 2017). In developing countries, inadequate food hygiene can be the cause of infectious diseases (cholera, typhoid), food-borne toxi-infections and poisoning, or transient disorders in consumers (diarrhea, gastroenteritis). This is particularly true for raw milk and its traditional derivatives, which are fragile, perishable products, rich in water and nutrients (Marnissi *et al.*, 2013). One of the major constraints to promoting the dairy sector is precisely this perishability: about four hours after milking, milk already begins to deteriorate (Mutwedu *et al.*, 2018). Because of its high moisture content, the risks of infection linked to various handling steps, its near-neutral pH, and the diversity of its nutrients, milk is an excellent growth medium for many microorganisms (Mutwedu *et al.*, 2018).

Assessment of the microbiological quality of a food relies on testing for germs of hygienic interest, indicators of fecal contamination, as well as pathogenic and toxin-producing germs (Marnissi *et al.*, 2013). Microbiological quality control of food remains essential, as it prevents the marketing and consumption of dangerous or non-compliant products; this control is based on regulated analyses, governed by national or international standards that generally require the absence of any pathogenic germ or microbial toxin, as well as a low total microbial load (Guergouri, 2020). Dègué was introduced in Chad, more specifically in N'Djamena, where it is produced by individuals. It is packaged in unlabeled plastic bottles and sold mainly in shops, and is consumed by a significant portion of the population of N'Djamena. In Chad, milk production is carried out by extensive pastoral or agro-pastoral livestock farms, which mainly sell cow's milk, but also goat's and camel's milk. This production follows seasonal variations in pasture availability: the high-production season corresponds to the rainy season (July to October), while the period preceding the arrival of the rains is the most difficult (Vias Franck, 2018; Pabamé and Frédéric, 2021).

The demographic growth of the Chadian population in general, and of the city of N'Djamena in particular, has favored the development of income-generating activities linked to dairy products, including dègués. N'Djamena is indeed the largest center of milk and dairy product consumption in the country (Doutoum *et al.*, 2013). The city's supply basin relies on a set of livestock farms located within a radius of 120 km, mainly supported by cattle and dromedary herders (Koussou & Patrice, 2013). Over the past two decades, the privatization of large dairies and the abandonment of state monopolies have strengthened the competitiveness of local sectors (Gaba, 2001), favoring the emergence of small private dairy businesses (milk bars, cheese factories, and yogurt makers) whose shared vision is the promotion of local milk (Doutoum *et al.*, 2013; Vias Franck, 2018). However, the local dairy products thus marketed do not always offer consumers a formal health guarantee (Koussou, Duteurtre *et al.*, 2007). It is in this context that the present study is situated, its main objective being to assess the microbiological quality of dègués produced and sold in the municipality of the city of N'Djamena.

General background on milk and dairy products:

Milk:

Definition:

Milk is the whole product of the total and uninterrupted milking of a healthy, well-fed, and non-overworked dairy female. It must be collected cleanly and must not contain colostrum (Konte, 1999). It is also defined as the normal mammary secretion of dairy animals, obtained from one or more milkings, without any addition or removal, and intended for consumption as liquid milk or for further processing (Koussou *et al.*, 2007 ; FAO/WHO, 1999).

Production:

In Chad, milk production is carried out by extensive pastoral or agro-pastoral livestock farms, which mainly sell cow's milk, but also goat's and camel's milk, with seasonal variations linked to pasture availability (Vias Franck, 2018). Estimates put national production at 20-million-liter sin 2001. In 2002, I treached 223,475 tonnes of milk, broken down as follows: 159,300 t/year for cows, 33,000 t/year for goats, 21,800 t/year for camels, and 9,375 t/year for sheep. The system of milk and dairy product production and marketing remains, in Africa in general and in Chad in particular, of a traditional type (Doutoum *et al.*, 2013).

Chemical composition:

The chemical composition of milk varies mainly according to factors linked to the animal (genetics, physiological stage, health status) or to the environment (season, feeding, milking) (FAO, 1995, Béninga, M.B., 2011).

Dairy products:**Definition:**

A dairy product is a product obtained through some treatment of milk, which may contain food additives and other ingredients functionally necessary for its processing (FAO/WHO, 1999). These are products derived exclusively from milk, it being understood that substances necessary for their manufacture may be added, provided they do not replace, in whole or in part, any of the constituents of milk. However, the local dairy products marketed do not always offer a formal health guarantee (Duteurtre *et al.*, 2007).

Classification:

Dairy products are classified into several categories: curdled milk, cheeses, yogurts, and fermented milks (Breiz, 2020). Skimmed curdled milk (rouaba) results from the total or partial churning of whole milk after fermentation, or from skimming when it is not churned; it is clearly distinguished from fermented whole milk (rayib, or "local yogurt" as a loose term) (Duteurtre & Atteyeh, 2000). Fermented milk is obtained through the action of suitable, viable, active, and abundant microorganisms, resulting in a reduction of pH with or without coagulation (Codex Alimentarius, 2011); yogurt is a specific form of it, fermented exclusively by *Lactobacillus bulgaricus* and *Streptococcus thermophilus*, but not all fermented milks are yogurts (Breiz, 2020).

Microorganisms in milk and dairy products:

Owing to its composition, milk is a very favorable substrate for the development of microorganisms. When these multiply in it, they cause alterations harmful to product quality (degradation of constituents, release of undesirable compounds, defects in taste, odor, or texture) and can impair the growth of the lactic acid bacteria essential for fermentation. Strict adherence to good manufacturing and hygiene practices is therefore essential to guarantee good-quality food (Carlos, 2020). Indicators of fecal contamination, such as coliforms and *Escherichia coli*, are bioindicators classically used to reveal unclean handling practices (Deltenserie *et al.*, 2002; Tourette, 2002). Contamination can be biological, chemical, or physical in nature; from a microbiological standpoint, the consequences vary greatly depending on whether the germs involved are spoilage organisms (yeasts, molds) or pathogens, the latter representing a greater public health concern (Deltenserie *et al.*, 2002).

Value of testing for microorganisms in dairyproducts:

Testing for germs of hygienic interest makes it possible to assess the level of contamination of foodstuffs and the nature of their microflora, as part of both official controls and the self-checks carried out by producers (Marnissi *et al.*, 2013; Carlos, 2020). On the pathogenic side, *Listeria monocytogenes* and *Salmonella* spp. are among the germs systematically tested for in raw milk, heat-treated milk, and dairy products (Deltenserie *et al.*, 2002). Nutritionally, contamination by proteolytic or lipolytic germs leads to the denaturation of proteins and vitamins, hence the value of rigorous microbiological assessment in preserving the nutritional qualities of the product (Carlos, 2020).

Dègué:**Definition and origin:**

In the Bambara language, "dègué" refers to small granules (2 to 3 mm) made from cereal flour (sorghum, millet, fonio) pre-cooked by steaming, as well as to the culinary preparation made of these granules mixed into sweetened yogurt or curdled milk (Cruz *et al.*, 2020). It is also defined as a traditional dish based on millet and fermented milk (Ny, Baba-Moussa *et al.*, 2009). Originating in West Africa, dègué is a Bambara dish (a people of Mali) widely eaten across a region encompassing Senegal, Guinea, Côte d'Ivoire, and the rest of West Africa; It is generally consumed as a snack rather than at the end of a meal.

Sales channels and prices in Chad:

In N'Djamena, dègués are sold at the homes of the women who process them, in shops in the various districts, at kiosks, along streets, and through street vending from small coolers. Their shelf life ranges from two to three days when refrigerated (17-18°C); in the absence of electricity, the rise in temperature accelerates spoilage, which can occur as early as two days for "light" dègués and three days for more "substantial" ones. The product is sold individually, at a price of 250 FCFA for a 33 cl bottle and 500 FCFA for a 75 cl bottle.

Ingredients and preparation:

The ingredients used in making dègué include powdered milk, curdled milk or yogurt (plain or vanilla), millet semolina, powdered sugar, vanilla sugar, water, butter, and casta (a starch-based thickener). Preparation involves two main steps: fermentation of the milk (a mixture of powdered milk, lukewarm water, and yogurt, with casta added, then incubated for a maximum of 8 hours in a warm, dry place, otherwise the mixture reverts to a liquid state), and steaming of the millet semolina (25 minutes), which is then cooled and mixed with the butter and the sweetened, vanilla-flavored milk preparation, before being refrigerated and served very cold, sometimes with raisins added (Koussou & Patrice, 2013).

Material and Methods:-**Study site:**

This descriptive, cross-sectional study with an analytical aim was conducted from October 2022 to March 2023 in five districts of N'Djamena, the capital of Chad, the most populous city. It mainly focused on the microbiological analysis of dègués, carried out at the food microbiology laboratory of the Food Quality Control Center (CECOQDA). Chad is a country with an agro-pastoral vocation where a third of the rural population lives exclusively from livestock farming and agriculture (Pabamé & Frédéric, 2021). The country has a large ruminant herd, with national milk production estimated at 220,000 tonnes per year (Koussou & Patrice, 2013).

Figure 1: Map of study area

Biological material:

The biological material used in the study consisted of dègués produced and marketed locally, in two forms: artisanally produced dègués (unlabeled) and dègués of the DJAMIL commercial brand.

Survey:-

A cross-sectional survey was conducted in five districts of N'Djamena among dègué producers, sellers, and consumers, in order to gather socio demographic information as well as data on manufacturing processes, the storage and sale conditions of the product. In total, 247 people out of 384 planned were surveyed, comprising 15 producers, 13 sellers, and 219 consumers

Sampling Method :-

the sampling of dègué was random and systematic. It covered 60 samples (artisanal and DJAMIL brand) collected from shops selected on the basis of their high customer numbers in three districts of N'Djamena (5th, 6th, and 7th). Only 20 samples were analyzed because of limited resources. The geographic distribution of sampling area is shown on the map in Figure 1.

Sample size for survey was determined using the following formula : $n = z^2 \times p(1 - p) / d^2$

This formula determines the number of people n to be surveyed, based on the margin of error m that can be tolerated for a response proportion p.

n = sample size;

z = confidence level (for a 95% confidence level, z = 1.96);

p = estimated proportion of the population (p = 0.5);

d = acceptable margin of error (5%)

We have chosen a confidence level of 95% and a margin of error of 5%. This gave :

$n = (1.96)^2 \times (0.5)(1-0.5) / (0.05)^2 = 384.16$, or 384 people to be surveyed.

Strict aseptic rules were observed during collection to avoid any contamination and to limit any increase in the initial microbial load. The samples were then transported under ice in an isothermal container and transported to the laboratory in a cooler condition and storage at 4°C for analysis.

Microbiological analyses:

Microbiological analyses covered the enumeration of total mesophilic aerobic flora (ISO 4833, 2013) on PCA medium (Oxoid CM 0463), yeasts and molds (NF ISO 21527-2, 2008) on Sabouraud Dextrose Agar (Oxoid CM

0041) supplemented with chloramphenicol (0.05 g/l), total coliforms (NF ISO 4832, V 08-015, 2006) on VRBL and *Escherichia coli* (NF ISO 16649-2, 2001) on TBX media (Oxoid CM 0107), *Bacillus cereus* on MYP medium, *Staphylococcus aureus* (NF EN ISO 6888-1, 2018) on Baird-Parker agar (Oxoid CM 0275) supplemented with egg yolk and potassium tellurite and *Salmonella* spp. on XLD and Hektoen agars, in accordance with standard NF ISO 6579 (2021). Each sample was analyzed in triplicate.

Data treatment:

Data from the field survey and the microbiological analyses were entered and organized into tables and graphs using Microsoft Word and Excel 2019.

Results:-

Sociodemographic characteristics of respondents:

The survey covered a total of 247 people out of 384 planned, including 149 men and 98 women, giving a sex ratio of 0.65. The 3-19 age group was the most represented (58.3%), followed by the 20-30 age group (29.2%). In terms of education level, nearly half of respondents (49.4%) had a primary-school level, and the majority (51.0%) were pupils/schoolchildren, reflecting the significant weight of young consumers in the sample (Tables I and II).

Table I: Distribution of respondents by sex and age group

Table II: Distribution of respondents by education level and profession

Table III: Distribution of respondents by district(arrondissement)

Table III shows that the various categories surveyed are more strongly represented in the 7th district (38.05 %).

Table IV: Distribution of respondents by level of food hygiene knowledge.

The results in Table IV show that nearly a third of respondents (37.24%) have a level of knowledge deemed poor regarding food hygiene, which constitutes a potential risk factor for contamination throughout the *dègué* production, distribution, and consumption chain.

Distribution of samples analyzed:-

A total of 60 *dègué* samples were collected, split into two categories: 38 artisanally produced (unlabeled) samples and 22 DJAMIL brand samples, collected from four sampling areas spread across three districts. Only 20 samples (16 artisanal and 04 DJAMIL *dègués*) were analyzed.

Table V: Number of samples per sampling site

Microbiological quality of artisanally produced *dègués* :-

Table V presents the results of the microbiological analyses carried out on a representative subset of 16 artisanal *dègué* samples, expressed in CFU/g and compared to the microbiological criteria adopted for each germ tested. A significant proportion of samples exceeded the thresholds set for total mesophilic aerobic flora (TMAF), total coliforms, Enterobacteria, *Escherichia coli*, and *Bacillus cereus*, with several values far exceeding the upper limit of quantification ($> 1.5 \times 10^5$ to $> 3 \times 10^6$ CFU/g).

Table VI: Results of microbiological analyses of artisanal *dègués* (CFU/g):-

Figure 2: Concentration of germs in artisanal *dègués* sold in shops

NC: Non Compliance and C: Compliance

Analysis of the figure 2 shows that artisanal *dègués* have a higher-than-normal microbial load.

Figure 3: Overall contamination results for artisanal production *dègués*

NC: Non Compliance and C: Compliance

The overall assessment of the microbiological quality of artisanal *dègués* (Figure 3) shows 72% non-compliant samples (non-compliant with at least one microbiological criterion) versus 28% compliant samples, reflecting a worrying level of contamination in this production sector.

Microbiological quality of DJAMIL brand *dègués*:

Table VII presents the results obtained for the DJAMIL brand *dègué* samples. Unlike the artisanal products, most of the parameters tested were below the microbiological criteria adopted, with the occasional exception of TMAF (samples Ar5A_E1, Ar6D_E1, and Ar6M_E1) and yeasts/molds (samples Ar6M_E1 and Ar7C_E4).

Table VII: Results of microbiological analyses of DJAMIL *dègués* (CFU/g)

Figure 4: Germ's concentration in DJAMIL *dègués* produced and sold in shops

NC: Non-Compliance and C: Compliance

Analysis of figure 4 shows that DJAMIL products have a compliant microbial load, except for FAMT and moulds/yeasts.

Figure 5: Overall contamination results for DJAMIL dègués
NC: Non-Compliance and C: Compliance

The overall assessment of DJAMIL brand dègués (figure 5) shows 19% non-compliant samples versus 81% of samples compliant with the microbiological criteria. It should be noted that the percentages of compliance and non-compliance shown in **figures 4 and 5** represent the weighted averages of the respective percentages of bacteria in **figures 2 and 3**.

Regardless of the type of dègué analyzed (artisanal or DJAMIL), no sample showed the presence of *Salmonella* spp. in 25 g of sample.

Table I: Distribution of respondents by sex and age group

Sociodemographic variables		Producers	Sellers	Consumers	Total	Percentage (%)
Sex						
Male		05	11	133	149	60,32
Female		10	02	86	98	39,67
Total		15	13	219	247	
Age [years]						
[3 - 19]		01	03	140	144	58,29
[20 - 30]		09	06	57	72	29,15
[31 - 45]		05	04	22	31	12,55
Total		15	13	219	247	

Table II: Distribution of respondents by education level and profession

Sociodemographic variables		Producers	Sellers	Consumers	Total	Percentage (%)
Education level						
Higher		01	02	24	27	10,93
Secondary		06	04	69	79	31,98
Primary		03	00	119	122	49,39
No schooling		05	07	07	19	07,69
Total		15	13	219	247	
Profession						
Civil servants		01	00	14	15	06,07
Students		02	03	49	54	21,86
Schoolchildren		00	00	126	126	51,01
Unemployed		05	06	17	28	11,33
Housewives		07	04	13	24	09,71
Total		15	13	219	247	

Table III: Distribution of respondents by district (arrondissement)

Category of respondents	Producers	Sellers	Consumers	Total	Percentage (%)
Districts					
1 st	02	01	25	28	11,33
5 th	01	01	22	24	09,71
6 th	05	07	43	54	21,86
7 th	07	03	84	94	38,05
9 th	00	01	45	47	19,03
Total	15	13	219	247	

Table IV: Distribution of respondents by level of food hygiene knowledge.

Category of respondents	Producers	Sellers	Consumers	Total	Percentage (%)
Hygiene knowledge					
Bad	06	07	79	92	37,24
Average	04	02	89	95	38,46
Good	05	04	51	60	24,29
Total	15	13	219	247	

Table V: Number of samples per sampling site

District (Ar) / Samples	5 th (Am-riguébé)	6 th (Dembé)	6 th (Moursal)	7 th (Chagoua)	Total
Artisanal dègués	10	07	15	06	38
Djamil dègués	05	04	08	05	22
Total	15	11	23	11	60

Table VI: Results of microbiological analyses of artisanal dègués (CFU/g)

Germ	TMAF	Total coliforms	Enterobacteria	E. coli	S. aureus	B. cereus	Yeasts/molds	Salmonella spp.
Criteria> Samples	$\leq 5.10^4$	$\leq 10^2$	$\leq 10^2$	≤ 10	$\leq 10^2$	$\leq 10^2$	$\leq 10^3$	Absent /25g
Ar5A_E1	$\leq 4,9.10^4$	< 10	< 10	< 10	$\leq 4,6.10^3$	$< 10^2$	$\leq 4,9.10^4$	Absent
Ar5A_E2	$7,8.10^5$	$2,5.10^4$	$5,4.10^4$	$> 1,5.10^4$	$4,6.10^3$	$> 1,5.10^5$	4.10^2	Absent
Ar5A_E3	$2,5.10^5$	$2,8.10^4$	$4,3.10^4$	$> 1,5.10^4$	$4,6.10^3$	$> 1,5.10^5$	5.10^2	Absent
Ar5A_E4	$3,5.10^4$	$2,8.10^2$	$2,2.10^2$	< 10	$4,6.10^3$	$< 10^2$	$1,2.10^3$	Absent
Ar6D_E1	$9,7.10^5$	$9,5.10^4$	$1,2.10^5$	$> 1,5.10^4$	$4,6.10^3$	$> 1,5.10^5$	6.10^2	Absent

Ar6D_E2	$> 3.10^6$	$1,7.10^4$	$2,1.10^4$	$> 1,5.10^4$	$1,4.10^3$	$> 1,5.10^5$	< 40	Absent
Ar6D_E3	$2,5.10^5$	$> 1,5.10^5$	$> 1,5.10^5$	< 40	$1,4.10^3$	< 40	$3,2.10^3$	Absent
Ar6D_E4	$6,4.10^5$	$8,3.10^4$	$8,3.10^4$	$> 1,5.10^4$	$1,4.10^3$	$> 1,5.10^5$	4.10^2	Absent
Ar6M_E1	$> 3.10^6$	$1,2.10^2$	$> 1,5.10^5$	$> 1,5.10^4$	$1,4.10^3$	$> 1,5.10^5$	$> 1,5.10^5$	Absent
Ar6M_E2	$> 3.10^5$	$3,8.10^3$	$> 1,5.10^5$	4.10^1	$< 10^2$	$> 1,5.10^5$	$> 1,5.10^5$	Absent
Ar6M_E3	$> 3.10^6$	$1,3.10^5$	$> 1,5.10^5$	$> 1,5.10^5$	$4,6.10^3$	$> 1,5.10^5$	$> 1,5.10^5$	Absent
Ar6M_E4	$> 3.10^6$	7.10^1	$> 1,5.10^5$	10^2	$< 10^2$	$> 1,5.10^5$	$> 1,5.10^5$	Absent
Ar7C_E1	$> 3.10^6$	< 10	$> 1,5.10^5$	$3,2.10^3$	$< 10^2$	$> 1,5.10^5$	$> 1,5.10^5$	Absent
Ar7C_E2	$> 3.10^6$	$> 1,5.10^5$	$> 1,5.10^5$	$> 1,5.10^4$	$1,2.10^3$	$> 1,5.10^5$	2.10^3	Absent
Ar7C_E3	$> 3.10^6$	$> 1,5.10^5$	$> 1,5.10^5$	$> 1,5.10^4$	$1,4.10^3$	$> 1,5.10^5$	3.10^3	Absent
Ar7C_E4	$> 3.10^6$	$5,1.10^4$	$> 1,5.10^5$	$> 1,5.10^4$	$< 10^2$	$> 1,5.10^5$	$> 1,5.10^5$	Absent

Table VII: Results of microbiological analyses of DJAMIL dègués (CFU/g)

Germ	TMAF	Total coliforms	Enterobacteria	E. coli	S. aureus	B. cereus	Yeasts/molds	Salmonella spp.
Criteria>Samples	$\leq 5.10^4$	$\leq 10^2$	$\leq 10^2$	≤ 10	$\leq 10^2$	$\leq 10^2$	$\leq 10^3$	Absent /25g
Ar5A_E1	$> 3.10^6$	< 10	< 10	< 10	$< 10^2$	$1,8.10^3$	$< 10^2$	Absent
Ar6D_E1	$7,6.10^5$	< 10	< 10	< 10	$< 10^2$	$< 10^2$	$< 10^2$	Absent
Ar6M_E1	$> 3.10^6$	< 10	< 10	< 10	$< 10^2$	< 10	$1,5.10^5$	Absent
Ar7C_E1	$1,4.10^4$	< 10	< 10	< 10	$< 10^2$	< 10	$7,5.10^3$	Absent

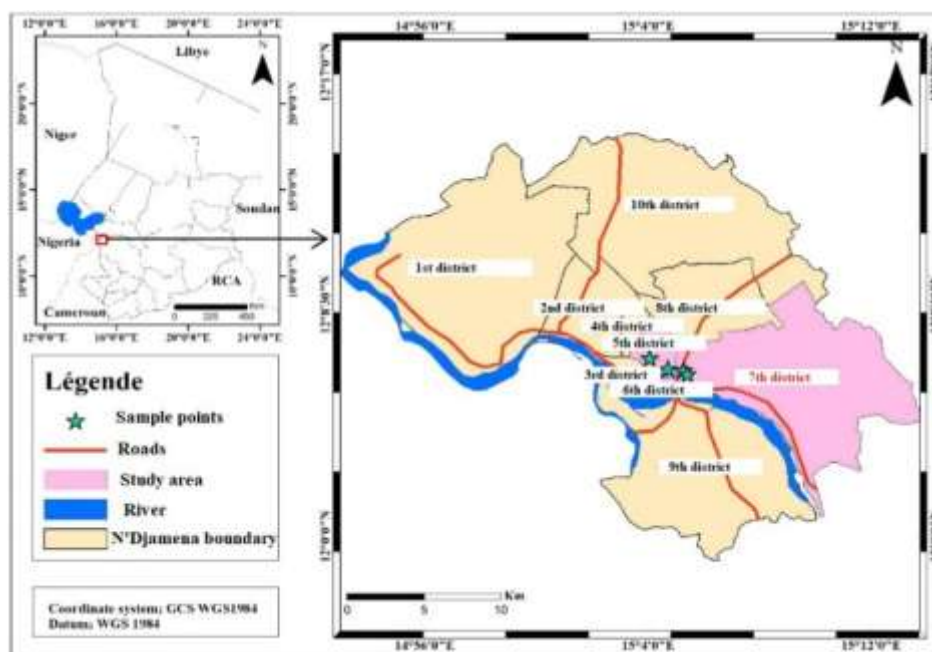
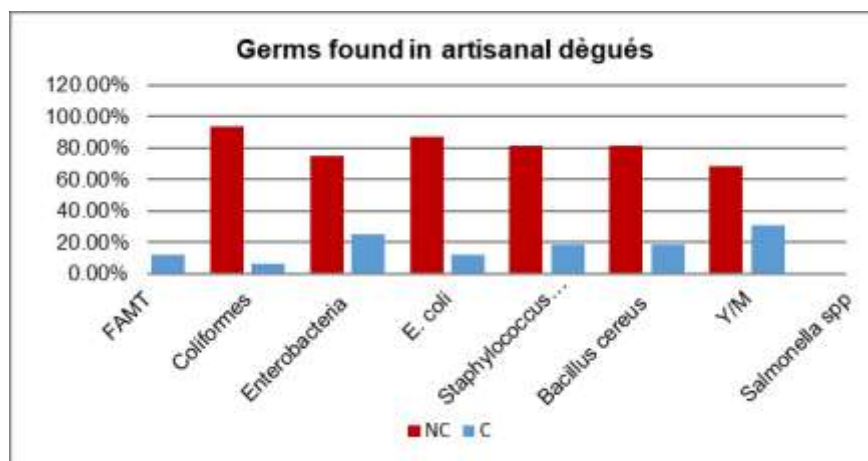
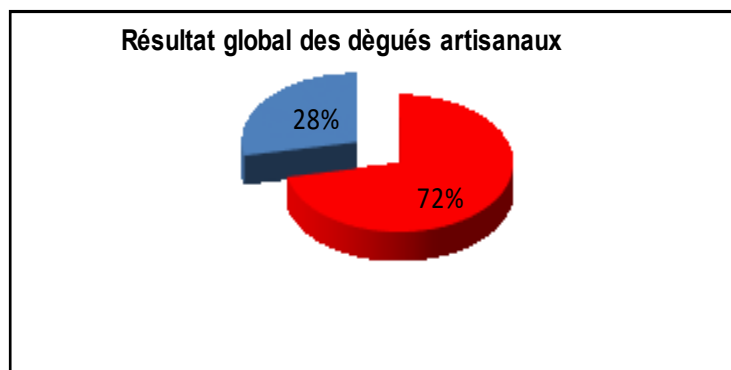


Figure 1: Map of study area

Figure 2: Concentration of germs in artisanal dègués sold in shops
NC: Non-compliant and C: CompliantFigure 3: Overall contamination results for artisanal production dègués
NC: Non-compliant and C: Compliant

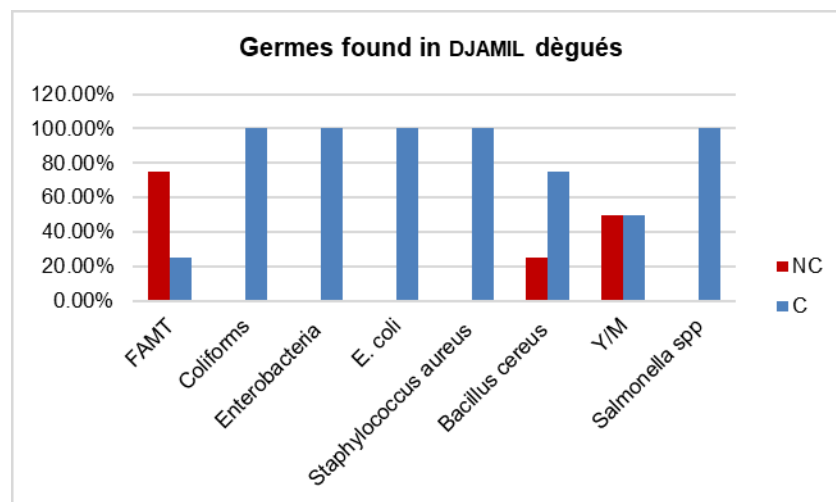


Figure 4 : Germs concentration in DJAMIL dègués produced and sold in shops
NC: Non-compliant and C: Compliant

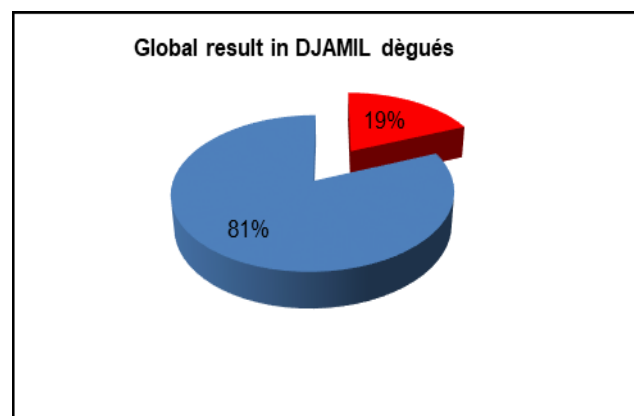


Figure 5: Overall contamination results for DJAMIL dègués
NC: Non-compliant and C: Compliant

Discussion:-

The results of the microbiological analyses of artisanal and DJAMIL dègués show that the germs tested for (TMAF, *E. coli*, *Staphylococcus aureus*, coliforms, *Bacillus cereus*, yeasts/molds, Enterobacteria) largely exceeded the acceptable standard for each germ in dègués from artisanal production, whereas results were more variable for the DJAMIL brand. Our results exceed the acceptable microbiological criteria for foodstuffs set for each of the above-mentioned germs (Division de la sécurité alimentaire ([DSA], 2018); *Salmonella* strains, on the other hand, were not found in either type of dègué.

Total mesophilic aerobic flora (TMAF) exceeded a concentration of 5×10^4 CFU/g in 87.50% of artisanally produced dègué samples, versus 75% for DJAMIL dègués (table VI and VII). These results corroborate those of a study conducted in Chad on the physicochemical and hygienic quality of bush milk and local dairy products sold in N'Djamena's milk bars, which likewise classified the samples as unsatisfactory for TMAF (Grimaud *et al.*, 2007; Koussou & Patrice, 2013). The same observations have been reported in Algeria (Hamiroune *et al.*, 2016) and in Benin (Carlos, 2020). The presence of TMAF in dègué reflects the overall hygienic quality of the production chain; the poor hygiene conditions observed in the handling of bottles, processing, and equipment use were evidently not sufficiently controlled.

Coliforms, absent from DJAMIL dègué, reflect the application of certain hygiene rules by this producer. Although some hygiene conditions have been improved, others remain uncontrolled, as shown by artisanal dègué, in which coliforms were detected at a frequency of 93.75% above 10^2 CFU/g (table VI and VII). The presence of coliforms in

the samples indicates a source of environmental contamination; the presence of dogs and other carnivores in the environment around cows can, in particular, constitute a source of contamination of utensils. Similar observations have been reported by studies conducted in Algeria and Cameroon (Maïworé *et al.*, 2018).

Staphylococcus aureus is a bacterium commonly found in humans and animals. Staphylococci are heat-resistant and are not destroyed by cooking; their presence in food represents a risk to human health, as certain strains of *S. aureus* produce enterotoxins whose ingestion causes food-borne toxi-infection (Brisabois *et al.*, 1997). This bacterium was identified at a concentration above 10^2 CFU/g in 81.25% of samples, contamination generally resulting from food handling by carriers of the bacterium, or from already-contaminated milk (table VI and VII). This result is consistent with a study on the prevalence of enterotoxigenic *Staphylococcus aureus* in dègué sold in three municipalities of Abidjan, Côte d'Ivoire (Ny, Yao *et al.*, 2009). It is none the less higher than the 70% reported by Maïworé *et al.* (2015), but remains lower than the 90% abnormal presence noted in a study conducted in Burkina Faso in 2018 (Millogo *et al.*, 2018).

Escherichia coli is a normal commensal of the human and animal gut, accounting for about 80% of the aerobic intestinal flora; it is found in very large numbers in feces, from where it spreads into the environment (soil, water). Its presence in food always indicates fecal contamination, whether direct contamination or, for heat-treated products, post-treatment contamination linked to processing equipment or personnel. *E. coli* was detected in artisanal dègué in 87.50% of cases (table VI and VII), at values above the 10 CFU/g limit recommended by the food safety division (DSA, 2018), which is consistent with the findings of a study conducted in Burkina Faso (Millogo *et al.*, 2018).

Bacillus cereus is naturally found in soil; its presence in processed foods results from contamination of raw materials (for example the cereals used to make dègué) as well as from the resistance of its spores to heat treatments and manufacturing processes. During cooling, these spores can germinate, allowing *Bacillus cereus* to multiply in the food and produce toxins there (Anses, 2021). Our study revealed the presence of *Bacillus cereus* in 81.25% of artisanally produced dègués (table VI and VII), exceeding the standard limit of 10^2 CFU/g, whereas no *Bacillus cereus* was detected in DJAMIL dègué, reflecting a better choice of raw materials in its processing.

Yeasts and molds were found, respectively, in 68.75% of non-compliant samples for artisanal production (versus 31.25% compliant) and in 50% of non-compliant samples for DJAMIL dègué (versus 50% compliant). These results may reflect non-compliance with hygiene rules with in processing households, notably poor hygiene of the utensils used during milking and a poorly controlled production environment. Our results corroborate those of Maïworé *et al.* (2018). Finally, in light of our results, no presence of *Salmonella spp.* Was noted in the samples analyzed, regardless of the type of dègué (table VI and VII). This result is consistent with that obtained by Carlos (2020) in Benin, as well as with that of a study conducted in Algeria on the bacteriological quality of raw cow's milk, which reports the same conclusions (Sara & Lakhdar, 2021).

Taken together, these results confirm a clear contrast between the artisanal sector, marked by wide spread microbial contamination and high non-compliance rates (72%) (figure 2 and 3), and the DJAMIL sector, whose more controlled manufacturing practices (choice of raw materials, equipment hygiene) translate into a markedly lower non-compliance rate (19%) (figure 4 and 5). This finding is consistent with the survey's sociodemographic data, which reveal a mixed level of food hygiene knowledge among a significant proportion of producers, sellers, and consumers (37.24% rated as having poor knowledge)(table III and IV), as well as the profile of dègué consumers, who are mostly children and young people in school (58.3% aged 3-19; 51.0% pupils/schoolchildren)(table I and II) — a population particularly vulnerable to food-borne toxi-infections. These elements, combined with the precarious storage conditions mentioned above (frequent breaks in the cold chain, short shelf lives), point to a set of risk factors that should be addressed as a priority in the artisanal sector.

Conclusion:-

This study aimed to assess the microbiological quality of dègués produced and sold in the municipality of N'Djamena. It revealed significant microbial contamination of artisanally produced dègués, with 72% of samples non-compliant with the microbiological criteria adopted, compared with only 19% for DJAMIL brand dègués, whose more standardized manufacturing process appears to better control contamination risks. Total mesophilic aerobic flora, coliforms, Enterobacteria, *Escherichia coli*, and *Bacillus cereus* are the parameters most frequently out of standard in the artisanal sector, reflecting short comings in good hygiene practices during milk collection, processing, packaging, and storage of the product. The absence of *Salmonella spp.* in all samples is, however, a likely reassuring finding.

In light of these findings, it appears necessary to strengthen the awareness and training of dègué producers and sellers in good food hygiene practices, to improve the cold chain throughout the distribution circuit, to establish regular health monitoring of this sector, given the importance of its consumption by children and young people in N'Djamena. Further studies, covering a larger number of samples and including testing for other pathogens (notably *Listeria monocytogenes*), would help to better characterize the health risks associated with the consumption of dègué in Chad.

Disclosure (artificial intelligence):

The authors certify that they have no conflicts of interest/competing interests. The authors hereby declare that no generative AI technology such as large language models (Chat GPT, COPILOT, etc.) and text-to-image generators was used in the writing or revision of this manuscript.

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Conflicts of interest:

The authors declared that no conflict of interest exists.

References:-

1. Codex Alimentarius. Lait et produits laitiers. 2e édition, FAO/OMS, 2011, 226p.
2. Anses. (2021). *Bacillus cereus*. 2–5p.
3. Béninga, M. B. (2011). Caractérisation chimique et minérale des grains de mil [*pennisetum glaucum* (L .) R . Br .] de Côte d ' Ivoire. International Journal of Biological and Chemical Sciences, 5(October), 2039–2044.
4. Breiz, A. (2020). Guide pratique des achats publics à l'attention des acteurs de la lière lait. www.bretagne.bzh
5. Brisabois, A., Hennechart-collette, C., & Garin-bastuji, B. (1997). Les germes pathogènes dans le lait et les produits laitiers : situation en France et en Europe. February 2018.
6. Carlos, A. T. J. (2020). Technologie de production et de qualité microbiologique du Dègué, une boisson fermentée et commercialisée dans les rues de Cotonou au Bénin. <https://biblionumeric.epac-uac.org:9443/jspui/handle/123456789/1923>
7. Cruz, J.-F., Hounhouigan, D. J., & Havard, M. (2020). La transformation des grains. In La transformation des grains. <https://doi.org/10.35690/978-2-7592-2784-6>
8. Delcenserie, V., China, B., Gavini, F., Beerens, H., & Daube, G. (2002). Proposition pour un nouveau standard indicateur de la contamination d'origine fécale dans les aliments: Le genre *Bifidobacterium*. Annales de Médecine Veterinaire, 146(5), 279–293.
9. Division de la Sécurité Alimentaire (DSA). (2018). Critères microbiologiques applicables aux denrées alimentaires: Lignes directrices pour l'interprétation. Ministère de la Santé, 352p, 1–57.
10. Doutoum, A. A., Tidjani, A., Balde, M., Tidjani, S. M. T., Abdelaziz Arada, I., Sylla, K. S. B., Seydi, M. G., & Toguebaye, B. S. (2013). Identification of lactic bacteria of milk quail in Chad. Journal of Applied Biology and Biotechnology, 1(4), 7–15.
11. Duteurtre, G., & Atteyeh, A. (2000). Le lait à Moundou, témoin de l'intégration marchande des systèmes pastoraux au sud du Tchad. Revue d'élevage et de Médecine Vétérinaire Des Pays Tropicaux, 53(3), 299. <https://doi.org/10.19182/remvt.9728>
12. FAO/OMS. (1999). Norme générale codex pour l'utilisation de termes de laiterie. CODEX STAN 206-1999. In Codex Alimentarius (pp. 1–4).
13. FAO, & L'agriculture. (1995). Le lait et les produits laitiers dans la nutrition humaine - Laites d'animaux laitiers. FAO : Alimentation et Nutrition, 271 pp.
14. Gaba, E. N. (2001). Les « bars laitiers » de N ' Djamena (Tchad).
15. Guergouri. (2020). TP n =° 01 : Analyse microbiologique de lait et de jus de fruits pasteurisés Mode opératoire : 2019–2020.
16. Hamiroune, M., Berber, A., Boubekeur, S., & Smar, O. (2016). Évaluation de la qualité bactériologique du lait cru bovin à divers stades de la chaîne de production laitière dans des fermes en Algérie. 35(3), 1–24.
17. Konte, M. (1999). Le lait et les produits laitiers. 221, 1–25.
18. Koussou, M. O., Grimaud, P., & Mopaté, L. Y. (2007). Evaluation de la qualité physico-chimique et hygiénique du lait de brousse et des produits laitiers locaux commercialisés dans les bars laitiers de N'Djamena au Tchad.

Revue d'élevage et de Médecine Vétérinaire Des Pays Tropicaux, 60(1–4), 45.

<https://doi.org/10.19182/remvt.9976>

19. Koussou, M., & Patrice, G. (2013). L'organisation des circuits d'approvisionnement en lait de la ville de N'Djamena (Tchad). 4653–4664.
20. Maïworé, J., Baane, M., & Amadou, A. T. (2018). Influence des conditions de la traite sur les qualités physico-chimiques et microbiologiques du lait cru collecté à Maroua , Cameroun Résumé Abstract. 14(4), 235–248.
21. Marnissi, B. El, Belkhou, R., Ouali, A. El, & Bennani, L. (2013). Caractérisation microbiologique et physicochimique du lait cru et de ses dérivés traditionnels Marocains (Lben et Jben) Microbiological and physicochemical characterization of raw milk and some Moroccan traditional dairy derivatives (Lben and Jben). 8, 100–111.
22. Millogo, V., Sissao, M., & Ouédraogo, A. (2018). Qualité nutritionnelle et bactériologique des échantillons de quelques produits laitiers locaux de la chaîne de production au Burkina Faso Nutritional and bacteriological quality of some local dairy products samples of Burkina Faso ' production chain. 12(February), 244–252.
23. Mutwedu, V. B., Basengere, R., Ayagirwe, B., Ganza, O. B., Aksanti, C. B., Matendo, R., Bisimwa, E. B., Karume, K., Balezi, Z., & Mushagalusa, N. (2018). Effets des techniques de transformation sur la qualité du fromage blanc traditionnel « Mashanza » produit au Sud-Kivu , RD Congo. 38(1), 6097–6110.
24. NF ISO 4833, Microbiologie des aliments, Méthode horizontale pour le dénombrement des micro-organismes, Technique de comptage des colonies à 30°C sur PCA, 19p, 2003.
25. NF ISO 21527-2, Microbiologie des aliments, Méthode horizontale pour le dénombrement des levures et moisissures, Partie 2 : technique par comptage des colonies dans les produits à activité d'eau inférieure ou égale à 0,95, 9p, 2008.
26. NF ISO 4832 (V 08-015), Microbiologie des aliments, Méthode horizontale pour le dénombrement des coliformes, Méthode par comptage des colonies obtenues à 37°C, 6p, 2006.
27. NF ISO 4832 (V08-060), Microbiologie des aliments, Dénombrement des coliformes thermotolérants par comptage des colonies obtenues à 44°C, Biokar diagnostics Violet Red Bile Agar (VRBA), 4p, 2009.
28. NF EN ISO 6888-1/A1, Microbiologie des aliments, Méthode horizontale pour le dénombrement des staphylocoques à coagulase positive (*Staphylococcus aureus* et autres espèces), Partie 1 : Technique utilisant le milieu gélosé de Baird-Parker, Amendement 1 : Inclusion des données de fidélité, 18p, 2004.
29. ISO 6579, Microbiology of food and animal feeding stuffs, Horizontal method for the detection of *Salmonella* spp, Fourth edition, 34p, 2021.
30. Ny, Z., Baba-Moussa, L., Yao, C., Bouhoua, L. G., Sanni, A., & Loukou, Y. G. (2009). Prévalence de *Staphylococcus aureus* enterotoxinogène dans le « dégué » vendu dans trois communes de la ville d'Abidjan, Côte d'Ivoire. Microbiologie et Hygiène Alimentaire, 21(62), 41–44.
31. Pabamé, S., & Frédéric, R. (2021). Adapter l'accès aux ressources agro-pastorales dans un contexte de mobilité et de changement climatique pour l'élevage pastoral au Tchad (ACCEPT) Mécanismes de Prévention et de Gestion des Conflits dans les Zones d'Intervention du Projet ACCEPT. www.iram-fr.org
32. Rachedi, M. (2020). TP : Recherche d'une contamination d'origine fécale . « Recherche et dénombrement des coliformes totaux et fécaux » Dénombrement des coliformes en milieu liquide Mode opératoire.
33. Sara, R., & Lakhdar, B. (2021). La qualité bactériologique de lait cru de la vache (Mémoire de master). Université Mohamed Khider - Biskra, Algérie
34. Tankoano, A., Diop, M., Lingani, H., Kaoré, D., & Savadogo, A. (2017). Les aspects technologiques, microbiologiques et nutritifs des aliments fermentés à base de lait et de mil en Afrique de l'Ouest. International Journal of Advanced Research, 5(8), 1509–1526. <https://doi.org/10.21474/IJAR01/5211>
35. Tourette, I. (2002). Filières laitières en Afrique et points critiques pour la maîtrise des Dangers Des Laites Et Produits Laitiers. https://agritrop.cirad.fr/511356/1/document_511356.pdf
36. Vias Franck, G. (2018). Etat des filières laitières dans les 15 pays de la CEDEAO, de la Mauritanie et du Tchad Annexe 2 : Fiche Burkina Faso. 32, 41.