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# Microbiological contamination of cooked meals in collective and commercial catering of public universities of Abidjan in Côte d'Ivoire

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## ABSTRACT

In Côte d'Ivoire, the absence of legislation in university catering increases the risk of collective food poisoning. The aim of this study was to assess the level of contamination of cooked meals in university catering in the city of Abidjan. To do this, 160 cooked meals samples were taken in the two public universities of Abidjan. The search of mesophilic aerobic germs; Enterobacteriaceae and of *Staphylococcus aureus* was carried out. The results showed that in general, the microbial loads of the cooked meals analyzed were higher than the criteria required by the regulations. 40.33% of the presumptive *Staphylococcus aureus* strains tested are confirmed. 20 species belonging to 14 genera of Enterobacteriaceae were isolated from the different cooked meals. The species most frequently isolated from cooked meals is *Klebsiella pneumoniae* (19.4%) followed by *Klebsiella oxytoca* (17%) and *Serratia liquefaciens* (14.5%). In general, efforts still need to be made to improve the level of hygiene in institutional catering and commercial catering. Constant monitoring of the application of hygienic rules must be instituted, in order to prevent the occurrence of food poisoning. The use of microbiologic results of cooked meals in the universities will provide an example for similar collective catering.


**Keywords**: Food poisoning, *Staphylococcus aureus*, *Klebsiella pneumoniae*, university restaurants.

## INTRODUCTION

Food-borne illness is one of the major problems in developed and developing countries due to consumption of contaminated food or through failure of hygiene (Jain et al., 2020). Foodborne diseases comprise a broad group of illnesses caused by microbial pathogens, parasites, chemical contaminants and biotoxins. The burden of disease can be defined as the incidence and prevalence of morbidity, disability, and mortality associated with acute and chronic manifestations of diseases (WHO, 2006). More than 200 types of diseases (cholera, salmonellosis, shigellosis, typhoid and other gastroenteritis diseases) are estimated to be caused or spread by food, occasionally causing long-term health problems in vulnerable groups such as the elderly, pregnant women, children and immunocompromised people (Loukieh et al.,

 
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2018; WHO, 2019). According to WHO (2007), in developing countries up to 2 million deaths are estimated per year. Gastro-intestinal diseases are of great concern to consumers, producers and policymakers in developing countries because it remains in the top five causes of sickness and death being contributed by unsafe foods.

In recent years, more people have tended to eat outside the home, often in catering establishments, such as cafeterias, canteens, fast food outlets, bars and restaurants. Mass catering is for groups of people who share a common interest or must eat outside of the home for any reason, including work, study, leisure, and illness. This branch of the hospitality industry can be divided into the following major sectors: the cost sector (i.e., healthcare, education, schools and colleges, business and industry, and public services) and the profit sector (i.e., hotels, restaurants, fast food, cafes and takeaways, public houses, travel organizations and leisure operations) (Smith and West, 2003). The catering sector has seen an increase in technological innovation in correspondence with changes in the consumption habits of the population, transformed by many factors and the evolution of lifestyles, demographic trends, and convenient foods (Valero et al., 2016). However, several scientific studies and reviews of the literature have shown that cooked meals from a restaurant service can be the cause of many food-borne epidemics (Osimani et al., 2016a). The European Food Safety Authority (EFSA) and European Centre for Disease Prevention and Control (ECDC) (EFSA and ECDC, 2015) have recently reported that catering establishments (e.g., catering services, restaurants, hotels, pubs, bars) were identified as the most frequently reported setting for major foodborne outbreaks such as salmonellosis, listeriosis and campylobacteriosis. If in developed countries, catering is regulated by health and safety criteria (Abrahale et al., 2019), this is often not the case in developing countries (Paudyal et al., 2017). The problem is severe in developing countries due to difficulties in securing optimal hygienic food handling practices (Mengist et al. 2018). In developing countries, up to 70% of cases of diarrheal disease are associated with the consumption of contaminated food (Zeru and Kumie, 2007). The health status of the food handlers, their personal hygiene, and their knowledge and practice of food hygiene play an important role in food contamination (Mudey et al., 2010). In Côte d'Ivoire, as in several African countries, the absence of legislation in university catering increases the risk of collective food poisoning.

The aim of this study was to assess the level of contamination of cooked meals in university catering in the city of Abidjan.

## MATERIALS AND METHODS

### Sample collection

In this study, 160 food samples were taken from cooked meals for two periods over eight months. Period 1 lasted from June to September 2017 (rainy season) and period 2 from November to February 2018 (dry season) in the 2 public universities of Abidjan (NANGUI ABROGOUA University (UNA) and FÉLIX HOUPHOUËT BOIGNY University (UFHB)). In each university, two (2) restaurants were chosen: the public collective restaurant from the regional center of university works of Abidjan (Col) and a private commercial restaurant (Com) randomly chosen from among the most frequented. In each restaurant, five (5) cooked meals were selected. For each cooked meal, four (4) samples of approximately 250 g each were taken aseptically and placed in a sterile plastic bowl then stored in a cooler containing dry ice and sent to the microbiology laboratory of the Ocean Research Center (CRO) for immediate analysis (Table 1). The samples were taken on different days, so as not to take the same cooked meals.

### Preparation of culture media

The culture media used in this study were prepared according to the manufacturer's instructions.

### Sample preparation and decimal dilutions

10 g of each sample was aseptically weighed and transferred to a stomacher bag to

which 90 mL of sterile buffered peptone water was added. The sample was blended for two minutes at 230 RPM in a stomacher to produce a homogeneous sample. 1 mL of initial suspension was then diluted in 9 mL of sterile Buffered Peptone water to achieve a 10-fold dilution series.

**Bacteriological analyzes**

The enumeration of mesophilic aerobic germs was carried out on PCA medium, according to the standard NF ISO 4833-1: 2013. The search and enumeration of Enterobacteriaceae were carried out VRBG medium, according to the standard ISO 21528-2: 2004. The Gram and oxidase tests isolated 124 BG (-) strains and oxidase (-). Identification of Enterobacteriaceae species was carried out on these 124 strains using the API 20E gallery.

The enumeration of *Staphylococcus aureus* was carried out on Baird Parker medium, according to the ISO 6888-1: 1999/ Amd 1: 2003. The confirmation of *Staphylococcus aureus* was carried out on 186 presumptive strains using Gram coloration, catalase test, coagulase test, Dnase test and latex kit for Staph (LIOFILCHEM, Italy).

The number of bacterial groups on the original sample was estimated by the formula:

$N = \Sigma C/[n1 + 0.1n2)] \times d$

where:

N = number of colonies per ml or gram of sample.

ΣC = sum of all of the colonies in all plates counted.

n1 = number of plates in the lower dilution counted.

n2 = number of plates in the next higher dilution counted.

d = dilution factor corresponding to the first dilution retained.

**Data analyzes**

A single factor analysis of variance (ANOVA) and Tukey's one-way multiple comparisons were conducted to determine differences in the population means of the different bacterial species. Significant differences were considered at the 95% confidence level ($P<0.05$).

**Table 1**: Distribution of samples of cooked meals.

| | Period 1 | | | | Period 2 | | | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | UNA | | UFHB | | UNA | | UFHB | | |
| | Col | Com | Col | Com | Col | Com | Col | Com | |
| **Cooked rice** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 32 |
| **Fried fish** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 32 |
| **Attiéké*** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 32 |
| **Ivoirian sauce** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 32 |
| **Raw mixed vegetable salads** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 32 |
| **Total** | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | **160** |

*Attiéké: steamed cassava semolina; UNA: NANGUI ABROGOUA University; UFHB: FÉLIX HOUPHOUËT BOIGNY University; Com: private commercial restaurant; Col: public collective restaurant

## RESULTS

### Average bacterial load in cooked meals in university restaurants

Average bacterial loads vary from one cooked meals to another and from one restaurant to another (Table 2). The highest loads for aerobic mesophilic germs ($2.3 \times 10^6$) were found in the "attiéké" of collective restaurant (Col) of UNA during period 1. The highest loads for Enterobacteriaceae ($8.7 \times 10^5$) were found in the raw mixed vegetable salad of collective restaurant (Col) of UFHB during period 1. The highest loads for *Staphylococcus aureus* presumptive ($8.6 \times 10^4$) were found in the "attiéké" of collective restaurant (Col) of UNA during period 1.

No microbial load was found in Ivoirian sauce of commercial restaurant (Com) of UFHB. In general, the microbial loads of the cooked meals analyzed were higher than the criteria required by the regulations. The contamination of cooked meals in commercial restaurants (Com) is higher than that in collective restaurants (Col). The results obtained also show that there is no link between the sampling period and the microbial loads obtained for each cooked meals.

### Prevalence of *Staphylococcus aureus* strains isolated from cooked meals in university restaurants

All 186 strains tested are GRAM positive and catalase positive. 40.3% of the strains tested are both DNase +, coagulase + and positive in the latex agglutination test so confirmed *Staphylococcus aureus* (Table 3).

### Distribution of *Staphylococcus aureus* according to cooked meals in university restaurants

At NANGUI ABROGOUA University (UNA), the frequency of detection of *S. aureus* in samples from public collective restaurant (Col) and private commercial restaurant (Com) varies from 1.3 to 13.3% and 0 to 12% respectively. At FELIX HOUPHOUET BOIGNY University (UFHB), the frequency of detection of *S. aureus* in samples from Col and Com varies from 2.7 to 13.3% and 0 to 6.7% respectively (Table 4). The highest detection frequency was observed in the RTEs meals of private commercial restaurants of 2 universities. Ivoirian sauce of UNA private commercial restaurant and raw mixed vegetable salads samples have the highest detection frequency from private restaurant of UNA and UFHB respectively.

### Prevalence of Enterobacteriaceae species isolated from cooked meals in university restaurants

A total of 20 species belonging to 14 genera of Enterobacteriaceae were isolated from the different cooked meals (Table 5). The most common types of Enterobacteriaceae are *Enterobacter* (4 species), *Serratia* (3 species) and *Klebsiella* (2 species). The species most frequently isolated from cooked meals is *Klebsiella pneumoniae* (19.4%) followed by *Klebsiella oxytoca* (17%) and *Serratia liquefaciens* (14.5%) (Table 5). The highest enterobacterial prevalence was determined in private commercial restaurant (Com) of UFHB (37.1%). *Klebsiella oxytoca* was the most isolated species of raw mixed vegetable salads (12.9%) and *Escherichia coli* was only determined in Ivoirian sauce (Table 6).

**Table 2**: Average bacterial load in cooked meals in university restaurants (CFU/g).

| cooked meals | Bacteria | Period 1 | | | | Period 2 | | | | Criteria |
|---|---|---|---|---|---|---|---|---|---|---|
| | | UNA | | UFHB | | UNA | | UFHB | | |
| | | Col | Com | Col | Com | Col | Com | Col | Com | |
| **Cooked rice** | MAG | (1.9±1.5)X10$^{5aa}$ | (7.7±1.2)X10$^{5aa}$ | (1.8±3.2) X10$^{4ba}$ | (4.4±7.6)X10$^{5aa}$ | (1.7±1)X10$^{6ca}$ | (1.4±1.2)X10$^{6ca}$ | (3.6±4)X10$^{5aa}$ | (1.3±1.2)X10$^{6da}$ | $10^6$ |
| | Ent | (5.4±4.2)X10$^{3ab}$ | (1.7±2.9)X10$^{4bb}$ | 0$^{cb}$ | (5.6±9.7)X10$^{3ab}$ | (3.4±3.5)X10$^{3ab}$ | (1.3±2.2)X10$^{3ab}$ | (3.9±5.5)X10$^{4bb}$ | (6.2±4.4) X10$^{3ab}$ | $10^2$ |
| | *S. aureus* pr | (7±7.5) X10$^{3ab}$ | (2.5±3.7)X10$^{4bb}$ | 0$^{cb}$ | 0$^{cc}$ | (1.7±3)X10$^{4bc}$ | 0$^{cc}$ | (2±2.1)X10$^{4bb}$ | (1.1±2)X10$^{4bc}$ | $10^3$ |
| **Fried fish** | MAG | (6.8±1.1)X10$^{5aa}$ | (1.1±1.3)X10$^{5aa}$ | (1±1.8)X10$^{4ba}$ | (5.2±6.7)X10$^{5aa}$ | (1.6±1.3)X10$^{6ca}$ | (1.3±1.1)X10$^{6ca}$ | (1.8±9.5)X10$^{5aa}$ | (8±1.3)X10$^{5ad}$ | $10^8$ |
| | Ent | 0$^{ac}$ | (4.9±8.5)X10$^{3bc}$ | 0$^{ab}$ | (2.8±4.9)X10$^{3bb}$ | (5.5±7.2)X10$^{3bb}$ | (1.2±1.2)X10$^{4cd}$ | (7±4.5)X10$^{3bc}$ | 0$^{ae}$ | $10^2$ |
| | *S. aureus* pr | (2.7±0.4)X10$^{3ab}$ | (4.7±8.1)X10$^{3ac}$ | 0$^{bb}$ | 0$^{bc}$ | 0$^{bd}$ | (8.1±1.6)X10$^{4cd}$ | (1±0.9)X10$^{4cb}$ | (1.7±1.7)X10$^{4cc}$ | $10^3$ |
| **Attiéké** | MAG | (2.3±3)X10$^{6ad}$ | (4.9±0.9)X10$^{4bb}$ | (1.4±1.4)X10$^{6ac}$ | (1.4±1.7)X10$^{6ad}$ | (2±1.9)X10$^{6aa}$ | (2.8±5.9)X10$^{5ce}$ | (3±7.2)X10$^{4bb}$ | (1.6±1.3)X10$^{6aa}$ | $10^6$ |
| | Ent | (1.4±1.9)X10$^{5aa}$ | (4.3±4.7)X10$^{4bb}$ | (7.6±9.2)X10$^{4ba}$ | (8.1±2.8)X10$^{3cb}$ | (1.1±9.2)X10$^{3cb}$ | (3.9±2.2)X10$^{4bd}$ | (2.2±0.7)X10$^{4bb}$ | (3.6±4.2)X10$^{4bc}$ | $10^2$ |
| | *S. aureus* pr | (8.6±1.2)X10$^{4ae}$ | (4.5±1.5)X10$^{4ab}$ | (3.1±6.4)X10$^{3bd}$ | (7.8±1)X10$^{4ae}$ | 0$^{cd}$ | (3.9±5.5)X10$^{4ad}$ | (3±0.6) X10$^{4ab}$ | (2.9±7)X10$^{3bb}$ | $10^3$ |
| **Ivoirian sauce** | MAG | (6±8.9)X10$^{5aa}$ | (1.2±1.7)X10$^{5aa}$ | (4.9±2.4)X10$^{5ae}$ | 0$^{bc}$ | (2±1.1)X10$^{6ca}$ | (9.6±1.1)X10$^{5ae}$ | (1.6±1.4)X10$^{6cd}$ | (1.2±1.2)X10$^{6ca}$ | $10^6$ |
| | Ent | 0$^{ac}$ | (6.3±1.1)X10$^{3bc}$ | 0$^{ab}$ | 0$^{ac}$ | 0$^{ad}$ | (5±5.9)X10$^{3bb}$ | (4.7±0.8)X10$^{4cb}$ | 0$^{ae}$ | $10^2$ |
| | *S. aureus* pr | (2.7±1.9)X10$^{4ae}$ | (5.1±3.6)X10$^{4ab}$ | 0$^{bb}$ | 0$^{bc}$ | 0$^{bd}$ | 0$^{bc}$ | (4.9±8.6)X10$^{4ab}$ | (2.3±0.3)X10$^{4ac}$ | $10^3$ |
| **Raw mixed vegetable Salad** | MAG | (1.1±1.2)X10$^{6ad}$ | (9.3±1.2)X10$^{5ba}$ | (1.4±1.3)X10$^{6ac}$ | (1.3±1.3)X10$^{6ad}$ | (8.2±1.5)X10$^{5be}$ | (5.7±7.9)X10$^{4cd}$ | (5.9±7.1)X10$^{5ba}$ | (8.8±6.7)X10$^{5bd}$ | $10^8$ |
| | Ent | 0$^{ac}$ | (3.9±6.8)X10$^{2bd}$ | (8.7±1.2)X10$^{5ce}$ | (7.4±5.1)X10$^{3db}$ | 0$^{ad}$ | (6.9±1.2)X10$^{4ed}$ | (1.4±1.2)X10$^{4eb}$ | (4.4±4.7)X10$^{4ec}$ | $10^2$ |
| | *S. aureus* pr | (6.6±3.6)X10$^{3ab}$ | (4.3±3)X10$^{4bb}$ | (2.6±1.6)X10$^{4ba}$ | (3.9±6.6)X10$^{3ab}$ | 0$^{cd}$ | (1.1±2)X10$^{3ab}$ | (2.4±3.3)X10$^{4bb}$ | (1.1±1)X10$^{4bc}$ | $10^3$ |

Values with different letter are significantly different for p>0.05. The first letters correspond to the significance on the same line and the second letters correspond to the significance on the same column. UNA: NANGUI ABROGOUA University; UFHB: FÉLIX HOUPHOUËT BOIGNY University; Col: public commercial restaurant; Ent: Enterobacteriaceae; MAG: mesophilic aerobic germs; *S. aureus* pr: *Staphylococcus aureus* presumptive; Com: private collective restaurant.

**Table 3**: Prevalence of *Staphylococcus aureus* strains isolated from cooked meals in university restaurants.

| Tests | Positive strains N(%) | Negative strains N(%) |
|---|---|---|
| Coloration GRAM | 186 (100) | 0 |
| Catalase | 186 (100) | 0 |
| Dnase | 75 (40,3) | 111 (59,7) |
| Coagulase | 75 (40,3) | 111 (59,7) |
| Agglutination au latex | 75 (40,3) | 111 (59,7) |
| ***Staphylococcus aureus* confirmed** | **75 (40,3)** | **111 (59,7)** |

**Table 4**: Distribution of *Staphylococcus aureus* according to cooked meals in university restaurants N (%).

| Cooked meals | *Staphylococcus aureus* confirmed N (%) | | | | |
|---|---|---|---|---|---|
| | UNA | | UFHB | | Total N(%) |
| | Com | Col | Com | Col | |
| **Cooked rice** | 2 (2.7) | 1 (1.3) | 5 (6.7) | 1 (1.3) | **9 (12)** |
| **Ivoirian sauce** | 11 (14.6) | 9 (12) | 2 (2.7) | 5 (6.7) | **27 (36)** |
| **Attiéké** | 1 (1.3) | 0 | 2 (2.7) | 0 | **3 (4)** |
| **Raw mixed vegetable salads** | 7 (9.3) | 6 (8) | 8 (10.7) | 4 (5.3) | **25 (33.3)** |
| **Fried fish** | 5 (6.7) | 1 (1.3) | 3 (4) | 2 (2.7) | **11 (14.7)** |
| **Total N (%)** | **26 (34.6)** | **17 (22.6)** | **20 (26.8)** | **12 (16)** | **75 (100)** |

UNA: NANGUI ABROGOUA University; UFHB: FÉLIX HOUPHOUËT BOIGNY University; Com: private collective restaurant; Col: public commercial restaurant.

**Table 5**: Enterobacteriaceae species identified.

| Genera | Species | Number | Percentage of occurence (%) |
|---|---|---|---|
| *Klebsiella* | *Klebsiella pneumoniae* | 24 | 19,4 |
| | *Klebsiella oxytoca* | 21 | 17 |
| *Serratia* | *Serratia liquefaciens* | 18 | 14,5 |
| | *Serratia odorifera* | 4 | 3,2 |
| | *Serratia rubidaea* | 1 | 0,8 |

| | | | |
|---|---|---|---|
| *Enterobacter* | *Enterobacter cloacae* | 14 | 11,3 |
| | *Enterobacter aerogenes* | 11 | 8,9 |
| | *Enterobacter amnigenus* | 1 | 0,8 |
| | *Enterobacter asburia* | 1 | 0,8 |
| *Pantoea* | *Pantoea spp* | 11 | 8,9 |
| *Acinetobacter* | *Acinetobacter baumanni* | 6 | 4,8 |
| *Escherichia* | *Escherichia coli* | 2 | 1,6 |
| *Shigella* | *Shigella spp* | 2 | 1,6 |
| *Kluyvera* | *Kluyvera spp* | 2 | 1,6 |
| *Cronobacter* | *Cronobacter spp* | 1 | 0,8 |
| *Citrobacter* | *Citrobacter koseri* | 1 | 0,8 |
| *Buttiauxella* | *Buttiauxella agrestis* | 1 | 0,8 |
| *Burkholderia* | *Burkholderia cepacia* | 1 | 0,8 |
| *Raoultella* | *Raoultella ornithinolytica* | 1 | 0,8 |
| *Rahnella* | *Rahnella aquatilis* | 1 | 0,8 |
| | **Total** | **124** | **100** |

**Table 6**: Distribution of Enterobacteriaceae species according to cooked meals cooked in university restaurants N (%).

| | **Enterobacteriaceae species** | **UNA** | | **UFHB** | | **Total** |
|---|---|---|---|---|---|---|
| | | **Col** | **Com** | **Col** | **Com** | |
| **Cooked rice** | *Pantoea spp* | 0 | 1(0.81) | 0 | 1(0.81) | 2(1.61) |
| | *Acinetobacter baumannii* | 1(0.81) | 0 | 1(0.81) | 0 | 2(1.61) |
| | *Serratia liquefaciens* | 0 | 0 | 0 | 3(2.42) | 3(2.42) |
| | *Serratia odorifera* | 0 | 0 | 1(0.81) | 0 | 1(0.81) |
| | *Klebsiella oxytoca* | 1(0.81) | 1(0.81) | 0 | 0 | 2(1.61) |
| | *Kluyvera spp* | 0 | 0 | 1(0.81) | 0 | 1(0.81) |
| | *Klebsiella pneumoniae* | 0 | 2(1.61) | 0 | 2(1.61) | 4(3.22) |
| **Fried fish** | *Raoultella ornithinolytica* | 0 | 0 | 0 | 1(0.81) | 1(0.81) |
| | *Pantoea spp* | 0 | 2(1.61) | 0 | 0 | 2(1.61) |
| | *Enterobacter cloacae* | 0 | 3(2.42) | 1(0.81) | 0 | 4(3.22) |
| | *Serratia liquefaciens* | 0 | 1(0.81) | 0 | 1(0.81) | 2(1.61) |
| | *Klebsiella pneumoniae* | 2(1.61) | 3(2.42) | 1(0.81) | 1(0.81) | 7(5.64) |
| **Attiéké** | *Rahnella aquatilis* | 0 | 1(0.81) | 0 | 0 | 1(0.81) |
| | *Burkholderia cepacia* | 0 | 1(0.81) | 0 | 0 | 1(0.81) |

| | | | | | | |
|---|---|---|---|---|---|---|
| | *Pantoea spp* | 0 | 5(4.03) | 0 | 0 | 5(4.03) |
| | *Serratia liquefaciens* | 1(0.81) | 1(0.81) | 0 | 0 | 2(1.61) |
| | *Klebsiella oxytoca* | 0 | 2(1.61) | 0 | 1(0.81) | 3(2.42) |
| | *Klebsiella pneumoniae* | 0 | 0 | 0 | 1(0.81) | 1(0.81) |
| **Ivoirian sauce** | *Serratia rubidaea* | 0 | 0 | 0 | 1(0.81) | 1(0.81) |
| | *Citrobacter koseri* | 0 | 1(0.81) | 0 | 0 | 1(0.81) |
| | *Enterobacter amnigenus* | 0 | 1(0.81) | 0 | 0 | 1(0.81) |
| | *Cronobacter spp* | 0 | 1(0.81) | 0 | 0 | 1(0.81) |
| | *Shigella spp* | 0 | 1(0.81) | 0 | 1(0.81) | 2(1.61) |
| | *Escherichia coli* | 0 | 1(0.81) | 0 | 1(0.81) | 2(1.61) |
| | *Acinetobacter baumannii* | 0 | 1(0.81) | 0 | 0 | 1(0.81) |
| | *Enterobacter aerogenes* | 0 | 1(0.81) | 0 | 2(1.61) | 3(2.42) |
| **Raw mixed vegetable salads** | *Enterobacter cloacae* | 0 | 1(0.81) | 0 | 0 | 1(0.81) |
| | *Serratia odorifera* | 0 | 0 | 0 | 1(0.81) | 1(0.81) |
| | *Serratia liquefaciens* | 0 | 2(1.61) | 0 | 0 | 2(1.61) |
| | *Klebsiella oxytoca* | 0 | 0 | 0 | 1(0.81) | 1(0.81) |
| | *Klebsiella pneumoniae* | 0 | 2(1.61) | 0 | 2(1.61) | 4(3.22) |
| | *Pantoea spp* | 0 | 2(1.61) | 0 | 0 | 2(1.61) |
| | *Acinetobacter baumannii* | 0 | 1(0.81) | 1(0.81) | 1(0.81) | 3(2.42) |
| | *Enterobacter asburia* | 0 | 1(0.81) | 0 | 0 | 1(0.81) |
| | *Enterobacter aerogenes* | 0 | 0 | 6(4.84) | 2(1.61) | 8(6.45) |
| | *Enterobacter cloacae* | 0 | 0 | 3(2.42) | 6(4.84) | 9(7.26) |
| | *Serratia odorifera* | 0 | 0 | 0 | 2(1.61) | 2(1.61) |
| | *Serratia liquefaciens* | 0 | 1(0.81) | 6(4.84) | 2(1.61) | 9(7.26) |
| | *Kluyvera spp* | 0 | 1(0.81) | 0 | 0 | 1(0.81) |
| | *Buttiauxella agrestis* | 0 | 1(0.81) | 0 | 0 | 1(0.81) |
| | *Klebsiella pneumoniae* | 0 | 1(0.81) | 2(1.61) | 5(4.03) | 8(6.45) |
| | *Klebsiella oxytoca* | 0 | 2(1.61) | 5(4.03) | 8(6.45) | 15(12.09) |
| | **Total** | 5 (4.03) | 45(36.29) | 28 (22.58) | 46 (37.1) | 124 (100) |

UNA: NANGUI ABROGOUA University; UFHB: FÉLIX HOUPHOUËT BOIGNY University; Com: private collective restaurant; Col: public commercial restaurant.

## DISCUSSION

The cooked meals from collective and commercial restaurants of Universities NANGUI ABROGOUA and FELIX HOUPHOUËT BOIGNY were contaminated by mesophilic aerobic germs (MAG), coagulase positive Staphylococci and Enterobacteriaceae. The presence of mesophilic aerobic germs in cooked meals is a microbiological indicator which makes it possible to assess the overall bacterial load present in a food or on a surface. According Djibrine et al. (2018), although the strong presence of total aerobic plate count does not inevitably imply the presence of pathogenic bacteria, it could mean that the ecology of the food is possibly conducive to development of pathogenic bacteria. The presence of MAG is a food health indicator, but also of the sales environment. Neglect of hygiene rules in the handling and / or preparation of food could increase this contamination. The average loads obtained in RTE meals served in collective and commercial restaurants are all greater than $10^5$ CFU/g with more contamination in commercial restaurants than in collective restaurants. This finding could be explained by the low-skilled workforce recruited from commercial restaurants. In general, commercial restaurants have no legal existence. The staff employed are underqualified and therefore poorly paid. They have little or no knowledge of Good Hygiene Practices (GHP) and Good Manufacturing Practices (GMP) (Degnon et al. 2018). This choice of personnel is not linked to a mismatch of available skills, but to a workforce mobilization strategy (Amar and viney, 2002).

Staphylococci are indicators of manual contamination. *S. aureus* is heat sensitive so it is destroyed during pasteurization or cooking of food. Its presence in these foods could be explained by the handling of foods or utensils that could be unsanitary. These results are in agreement with those of the work of Spicer (2003). Indeed, this author reported that the presence of *S. aureus* in foods heated and handled after cooking is an indication of human contamination (lack of hygiene). It can also indicate poor storage conditions. Most often, food is contaminated during preparation by a healthy carrier or staff with an infected wound (Kouamé-Sina et al. 2019). If the food is left at room temperature for several hours, *S. aureus* will multiply in the food. The presence of *S. aureus* in the foods analyzed in this study could also be due to cross and initial contaminations at different stages of food development as also indicated by several authors (Barro et al., 2002; Ilboudo et al., 2009). According to them, the safety and hygienic quality of the dishes served to consumers depend on the initial contamination of the raw materials. According to Le loir et al. (2010), the presence of *S. aureus* in food would be due to the fact that this bacterium is commensal of the skin and mucous membranes of humans. Humans lodge it through the skin, hair, mouth and nostrils, which are the main routes of contamination of food by this bacterium during handling either by scratching the skin, sneezing, hair poorly retained, bracelets, watches, jewelry, etc. Regulation 2073/2005 / EC suggests that staphylococcal enterotoxins can be produced from a load greater than $10^5$ CFU/g of coagulase positive Staphylococci in food. The staphylococcal loads obtained in this work are below this value; which explains why the students did not show signs of food poisoning after consuming these foods. However, a high level of *Staphylococcus aureus* was found in raw mixed vegetable salads and ivoirian sauces samples of two university restaurants. The observations during the various samples revealed that in the collective restaurants, the staff is provided with caps, sometimes gloves and free of jewelry; unlike commercial restaurants where staff do not wear caps or gloves. This would justify the low rate of contamination in collective restaurants compared to commercial restaurants.

The presence of enterobacteria in ready-to-eat meals reflects a failure of the hygiene system in place at the restaurants of the two universities. The sanitary quality of the food sold in these spaces is thus called into question. One of the causes of this failure could be undercooked food, regularly reported by students, but also observed during sample collection, especially at collective restaurant meals. These results are similar to those of Elder et al. (2000), who revealed in their work that several epidemics directly caused by a species of enterobacterium have been reported,

52% of which are attributed to undercooked foods. Another cause is that food is cooked long hours in advance, especially in commercial restaurants, and stored in inadequate conditions, favoring microbial contamination, before being served to students. These results are in agreement with those of several authors like Barro et al., (2002); Mensah et al., (2002) who concluded that cereals with their sauces and certain legumes after cooking, they are sold for long hours under precarious hygienic conditions, exposing them to microbial and physical contamination. Another cause would be the reheating time of cooked food long before. When these foods are reheated, the temperature does not exceed 60°C and the reheating time does not exceed 30 minutes. These conditions are favorable for the proliferation of Enterobacteriaceae which can withstand temperatures of 100°C for 2 hours. The utensils in which the meals are served, the presence of waste near catering sites, the often full bins that are not emptied quickly, are all reasons that could justify the presence of Enterobacteriaceae in these ready-to-eat meals. Indeed, the latter observed these same factors of contamination and proliferation of Enterobacteriaceae in ready-to-eat meals at the collective restaurant of the University of Dakar (Senegal). The presence of Enterobacteriaceae can also be explained by the method of preparation which does not respect the rules of hygiene and by the ingredients used for the preparation of the meals, which can be contaminated during handling because Enterobacteria are commensal bacteria of the human and animal digestive system and are frequently found in the environment. These results corroborate with those of Mélanie (2006) and Soré et al. (2020), who also suspected the method of preparation and the ingredients used for the preparation of "padek" and salads respectively to explain the presence of Enterobacteriaceae in this food.

## Conclusion

This study found that the average loads of microorganisms obtained in meals are high and above the norm. The contamination of cooked meals in commercial restaurants is higher than that in collective restaurants. The presence of these germs responsible for food poisoning in cooked meals is a staff hygiene failure. Negligence or ignorance of hygiene rules by staff exposes students to collective food poisoning. In general, efforts still need to be made to improve the level of hygiene in institutional catering and commercial catering. Constant monitoring of the application of hygienic rules must be instituted, in order to prevent the occurrence of food poisoning. The use of microbiologic results of cooked meals in the universities will provide an example for similar collective catering.

## COMPETING INTERESTS

The authors have declared that there is no competing interests.

## AUTHORS' CONTRIBUTIONS

AK and ACT designed the subject and performed the microbiological analyzes. AES collected the data and wrote the manuscript. BAZ carried out the statistical analyzes. FTMK monitored the group for all the research. AAS and RKN corrected the manuscript.

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