PEOPLE'S DEMOCRATIC REPUBLIC OF ALGERIA

MINISTRY OF HIGHER EDUCATION

AND SCIENTIFIC RESEARCH

University of 20 August 1955 Skikda

Faculty of Sciences

Department of Natural and Life Sciences

Thesis submitted for the Master's degree

Field: Biological Sciences

Specialization: Applied Microbiology

Title:

Microbiological and biochemical analysis of bread in some bakeries at Skikda city

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Academic year: 2024/2025

Acknowledgements

First and foremost, I would like to thank ALLAH for guiding me to this point.

I would also like to express my gratitude to everyone who contributed to my reaching this stage, including my supervisor, **Dr. Aggoun Asma**, for proposing such an interesting topic and for her advice, insightful comments, and guidance throughout the course of my work.

I would like to express my gratitude to the members of the jury who kindly agreed to judge this modest work, **Dr. Boudjellab Zine Eddine** and **Dr. Ghanem Maya**.

I would like to express my deepest gratitude to the members of the Wilaya laboratory for their guidance, advice and assistance: **Mr. Zaid**, Also the director of the Technology Hall, **Mr. Bouchaala**, as well as the engineers.

I would also like to thank all the professors and teachers who have encouraged and supported me especially **Mr. Aouzal** from the beginning of my studies to the end of my fifth academic year.

Finally, I express my sincere and profound gratitude to all those who have been involved, directly or indirectly, in the development of this humble work.

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List of abbreviations

CFU: Colony-forming unit

d: dilution rate corresponding to the first dilution selected.

FTAM: Total mesophilic aerobic flora

GBC: Giolitti Cantoni broth

JORA: Official Journal of the Algerian Republic.

PCA: Plate Count Agar.

pH: hydrogen potential.

M1: Initial weight of the sample (before drying)

M2: Final weight of the sample (after drying)

N: number of germs per gram of product.

n1: number of plates read at the first dilution.

n2: number of plates read at the second dilution.

TSE: Tryptone Sel Eau

TPC: Total Plate Count

V: volume of inoculum applied to each plate (in ml).

VRBL: Violet Red Bile Lactose

ΣC: sum of characteristic colonies on the two selected plates.

Abstract

Bread is a commonly consumed food. Throughout its production and distribution chain, it undergoes multiple handling processes. This study was conducted on two samples of bakery bread from two bakeries, El Mouaalem and El Kasbah, in the Wilaya of Skikda, in order to assess their microbiological quality by counting the different contaminants.

The results showed that the bread was satisfactory for FMAT, *E. coli*, moulds and *S. aureus*.

This proves that both bakeries comply with manufacturing, hygiene and food safety standards.

Key words:

Bread, contaminants, microbiological quality, manufacturing standards, food safety

Résumé

Le pain est un aliment couramment consommé. Tout au long de sa chaîne de production et de distribution, il subit de multiples processus de manipulation. Cette étude a été menée sur deux échantillons de pain de boulangerie provenant de deux boulangeries, El Mouaalem et El Kasbah, dans la wilaya de Skikda, afin d'évaluer leur qualité microbiologique en comptant les différents contaminants.

Les résultats ont montré que le pain était satisfaisant pour les FTAM, *E.coli*, les moisissures et *S. aureus.*

Cela prouve que les deux boulangeries respectent les normes de fabrication, d'hygiène et de sécurité alimentaire.

Mots clés:

Pain, contaminants, qualité microbiologique, norme de fabrication, sécurité alimentaire

ملخص

الخبز هو غذاء شائع الاستهلاك. يخضع الخبز لعمليات معالجة متعددة طوال سلسلة إنتاجه وتوزيعه. أجريت هذه الدراسة على عينتين من الخبز المخبوز من مخبزين، هما مخبزة المعلم ومخبزة القصبة، في ولاية سكيكدة، من أجل تقييم جودتهما المكروبيولوجية عن طريق حساب الملوثات المختلفة .

أظهرت النتائج أن الخبز كان جيدا من حيثFTAM ، بكتيريا القولون، الفطريات و*S. aureus*.

وهذا يثبت أن المخبزتان تلتزمان بمعايير التصنيع والنظافة والسلامة الغذائية.

الكلمات المفتاحية:

الخبز، الملوثات، الجودة الميكروبيولوجية، معايير التصنيع، سلامة الأغذية

Introduction

The microbiological quality of food is an essential factor and represents a considerable challenge in ensuring a healthy and nutritious diet. The availability of healthy and nutritious food is one of the fundamental rights of human beings and an essential factor in maintaining good health (Nicklin et al., 2000).

Baked goods are an important staple food in most countries and cultures. Baked goods and cereals are a valuable source of nutrients in our diet, providing us with most of our dietary calories and about half of our nutritional needs (Saranraj and Geetha, 2012).

Bread occupies a fundamental place in the human diet. It is the traditional staple food of many cultures. In Africa, the populations of the Maghreb are the largest consumers (Kone et al., 2020).

In food microbiology, it is more important to test for the absence or presence of germs and to be able to determine whether or not the product complies with standards for human consumption (Lightfoot, 2002). Regulations concerning food safety and hygiene focused mainly on controlling the raw material through to the final product, with the aim of ensuring compliance with safety and quality standards (Becila, 2009).

This study aims to assess the microbiological quality of bread samples sold in the Skikda city by analyzing the levels of total mesophilic aerobic flora, Escherichia coli, Staphylococcus aureus, and fungi.

This thesis is structured into four interdependent chapters:

The first two chapters are purely theoretical, providing general information on commercially available bread and its microbiological quality.

The third chapter describes the materials, methods and techniques employed to detect and enumerate germs.

The fourth chapter is analytical, discussing the results of the practical study.

Chapter one:

General information about bakery bread

1.1.Definition of bakery bread

The definition of bread can be summarised as follows: The food in question is derived from kneaded and baked flour (Soumoy and Lisse, 2022).

The production of bread typically involves the utilisation of wheat flour, water, yeast and salt as fundamental ingredients. Ingredients such as wheat-free flour, sugar, enzymes, dough conditioners, vitamins and minerals may also be added to improve sensory, textural and nutritional quality.

Bread is one of the most widely consumed foods worldwide, with a global average per capita consumption ranging from 41 to 303 kilograms per year. As such, it constitutes a primary source of energy and nutrition for humans (Villarino et al., 2016).

1.2. Bread baking settings

The production of bread is dependent on the presence of three primary ingredients: flour, yeast, and water. (Giannou et al., 2003).

1.2.1. Flour

The most significant raw material. It is the principal ingredient in the production of bread. The quality of the bread is the primary factor determining its success (Shapter, 2007).

1.2.2. Yeast

Bakers' yeast is frequently cited as the primary agent responsible for the fermentation process. This process is characterised by the generation of gases during the decomposition of carbohydrates, which results in an increase in bread volume. Furthermore, the maturation of the dough leads to the development of a distinct texture and structure. The release of aromatic substances, carbon dioxide and ethanol during this process contributes to the unique flavour of bread (Zinedine, 2004).

1.2.3. Water and salt

Water is an indispensable component in the process of dough formation and maintenance of its fluidity. It has been established that this process is also responsible for the dispersion of yeast cells and the dissolution of sugars and salts (Giannou et al., 2003).

In the context of bread production, the addition of salt during processing exerts a significant influence on the characteristics of the final product. This element is of particular importance

in determining the sensory attributes of the bread, including its taste, colour, and shelf-life. So, the various ingredients utilized in the production of bread each contribute to the formation of its structural components and aromatic compounds. However, it has been demonstrated that the final characteristics of the bread will be much more strongly impacted by the various parameters of the bread-making process (kneading and fermentation times, baking temperature, etc.) than by the quality of the ingredients according to (Jourdren, 2017).

1.3. Different stages of the bread-making process

As posited by Cauvain and Young (2011), the various processes involved in the production of bread exhibit significant variation with regard to the manner in which the ingredients constituting the dough are amalgamated.

The various stages of the bread-making process can be categorised into three primary phases: initial mixing, fermentation, and final baking. (Figure 01)

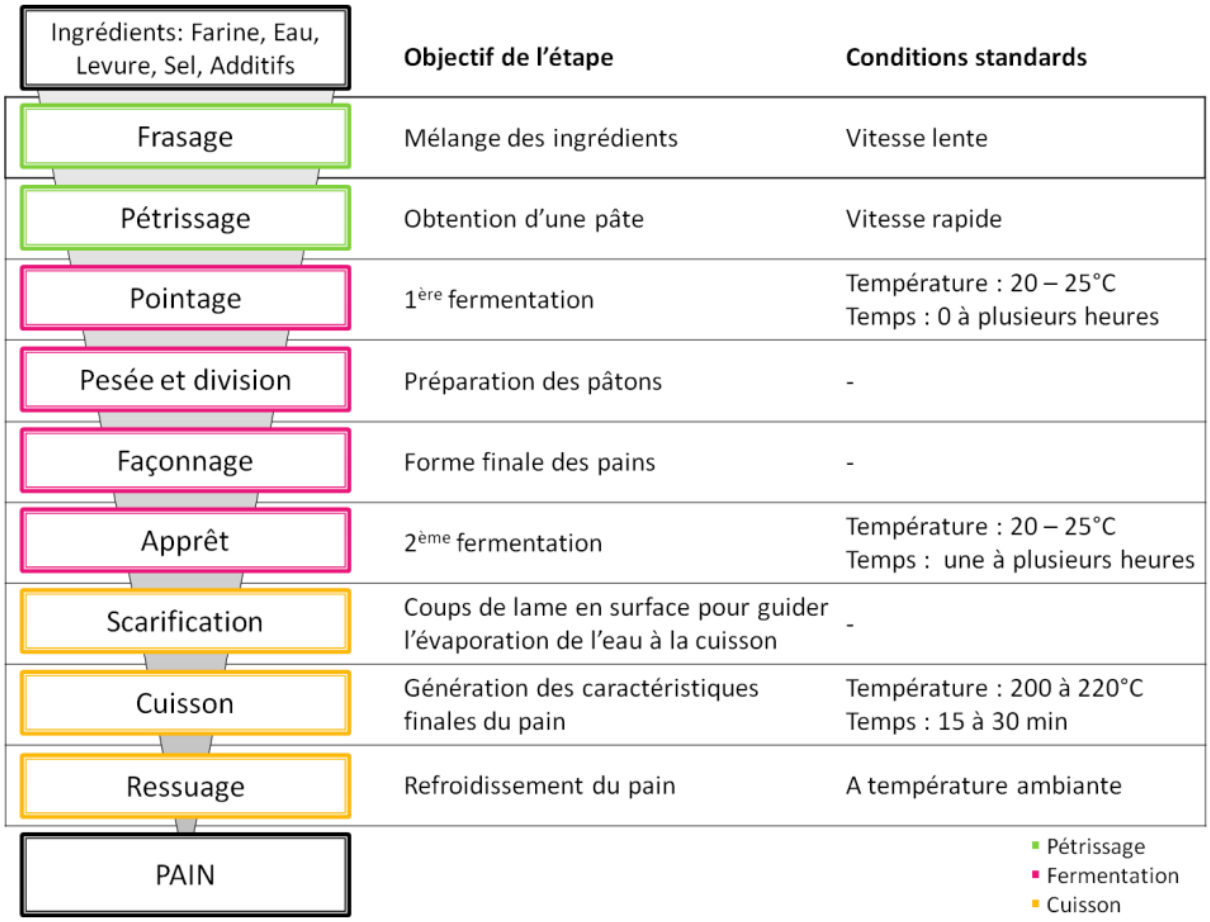


Figure 01: Stages of the bread-making process (Hammi et al., 2023)

The first step is kneading, in which the flour and water are first mixed (ground) at low speed. Then add the rest of the ingredients and mix at high speed until a dough is obtained. The dough is then left to rest during the fermentation process, which is the first stage of fermentation. The initial dough is then divided into pieces and shaped. This step gives the bread its final shape.

Next comes the second stage of fermentation, known as rising, followed by the stage of scraping the dough pieces (the baker taps the slices of dough with blades to allow the water vapour to evaporate during baking and prevent the bread from deforming), just before putting them in the oven to bake. The final stage before serving is cooling, allowing the bread to return to room temperature. This stage takes about an hour, depending on the shape of the bread. (Jourdren, 2017).

1.4. Nutritional and microbial quality of bread:

Cereals and bakery products provide sufficient nutrients and energy for daily needs.

Bakery products meet various nutritional needs, namely protein, carbohydrates, lipids, minerals and vitamins (Saranraj and Geetha, 2012).

Bread and wheat flour account for a significant percentage of daily food consumption,

with up to fifty per cent of total energy requirements obtained from a single loaf of bread.

From a microbial perspective, it is believed that pathogenic microbes can survive for a long time instead of stopping their growth under such low water activity.

Baked food products and cereal grains that are stored under inappropriate storage conditions can contribute to the multiplication of various pathogenic microbes. Pathogenic microbes (e.g., Escherichia coli, Salmonella spp, other food spoilage microbes). In addition to bacterial growth, the growth of Mould in flour is known to significantly degrade the quality of flour and bread (Ali Zaber, 2022).

1.5. Deterioration of bread:

Shelf life is generally defined as the period during which a food product remains safe and retains the desired sensory, chemical, physical and microbiological characteristics when stored under recommended conditions (Giménez et al., 2012).

There are several types of damage:

- Microorganisms: often the main factor limiting the shelf life of products with high and medium moisture content.
- Physical: water loss and moisture gain can cause changes in texture and even promote physical and chemical deterioration.
- Chemical: characterised by lipid degradation, causing an unpleasant odour, making the product unacceptable and reducing its shelf life. (Smith et al., 2004).

There are various types of product modifications that can limit the shelf life of food. Essentially, the shelf life of a food product depends on four main factors: formulation, processing, packaging and storage conditions. All four factors are essential, but their relative importance depends on the perishability of the food product (Galić et al., 2009).

1.6. Health risk

Health risks fall into three categories:

1 - Initial contamination of raw materials and secondary products delivered during storage, manufacturing and handling.

2 - Interruption of the cold chain or inadequate cooling leading to the proliferation of microorganisms already presents in the product.

3 - Survival of microorganisms after insufficient cooking, i.e. failure to comply with the time/temperature criteria necessary to guarantee product hygiene. (Millet et Cabut, 1997)

Chapter two:

Microbiology of Bread

2.1. Sources of microorganisms in food

Food micro-organisms have three possible sources:

-It pre-existed in the raw material or in the food before any manipulation or modification

-They are introduced accidentally during the subsequent handling of food

-They are added voluntarily (Joffin et Joffin,1999). This effect can be caused by non-sterile equipment and wash water, or the skin, mouth, clothes of the handler, or dust in the air, or insects such as flies, which are very dangerous carriers of microorganisms (Ait abdelouahab, 2007).

2.2. Factors affecting microbial growth

Various factors affect the growth and survival of micro-organisms in food. These factors may be intrinsic, such as the properties of the food or the micro-organism itself, or extrinsic, such as those of the environment (Tewari and Juneja, 2008).

2.2.1. Intrinsic environment

2.2.1.1. Acidity, pH and buffering capacity

Foods with a pH below 4.6 are called highly acidic foods and those where the pH is higher than 4.6 are called low-acid foods. This limit was set because in foods with a pH below 4.6, Clostridium botulinum spores can't sporulate and produce toxin. The optimal pH for microorganism growth is close to neutrality (pH 7) and most bacteria do not develop below pH 4.6 (Tewari and Juneja, 2008).

2.2.2. Extrinsic environment

2.2.2.1. Storage temperature

Microbial content in the storage environment directly affects the shelf life of bakery products. Temperature and humidity greatly influence the production of toxins by moulds, as these microbes tend to develop mainly at 25-30 C with a relative humidity higher than 90%. The optimal cooling conditions for bread were an air temperature of 20°C (Qian et al.,2021).

2.2.2.2. Relative humidity of the environment

There is a relationship between temperature and humidity that should be borne in mind.

In general, the higher the temperature, the lower the relative humidity and vice versa.

Foods whose surface deteriorates due to Mould, yeast and certain bacteria need to be stored in conditions of low relative humidity to increase their shelf life (Dilbaghi and Sharma, 2007).

2.3. Germs responsible for the deterioration of commercial bread

2.3.1. Total aerobic mesophilic flora (FTAM)

The aerobic mesophilic flora comprises micro-organisms that form countable colonies when propagated under defined laboratory conditions (Ghafir and Daube, 2007). This group includes all micro-organisms that can grow in the presence of oxygen and at temperatures ranging from 20 to 37°C (Rachedi et al., 2021).

2.3.2. *Escherichia Coli*

Escherichia coli is a member of the Enterobacteriaceae family. They are short, motile rods with peritrichous flagella, Gram-negative, non-spore-forming and oxidase-negative. Multiplication occurs at 44°C (optimum 40°C and extremes 45.5°C). As a facultative anaerobic species predominant in the intestine and faeces, the presence of E. coli in food and water is considered a sign of faecal contamination (Salifou et al., 2013).

2.3.3. Coagulase-positive Staphylococcus aureus

Gram-positive Staphylococcus aureus is a major bacterial pathogen often involved in food poisoning due to its high carry rate on human skin and nose, its effective spread in the air, and its strong survival in the fomites (Le et al., 2021). It is immobile and positive for catalase and coagulase (Yves et al., 2003).

2.3.4. Yeasts and Moulds

Fungal spores are the main culprits of bread spoilage and bakery products (Garcia et Copetti, 2019). Yeast is a much less important cause, but the growth of one or the other can cause surface deterioration. The deterioration of perishable goods by these microbes is generally a sign that the food was simply stored for too long, (Sperber et Doyle 2009).

Chapter three:

Equipment and Method

3.1. Microbial analysis

The first bread sample was collected in the Skikda region on 04/05/2025 (Figure 02) in the municipality of Skikda Merdj-Eddib at El Mouaalem bakery, more precisely at the following geographical coordinates: 36.863574, 6.920723.

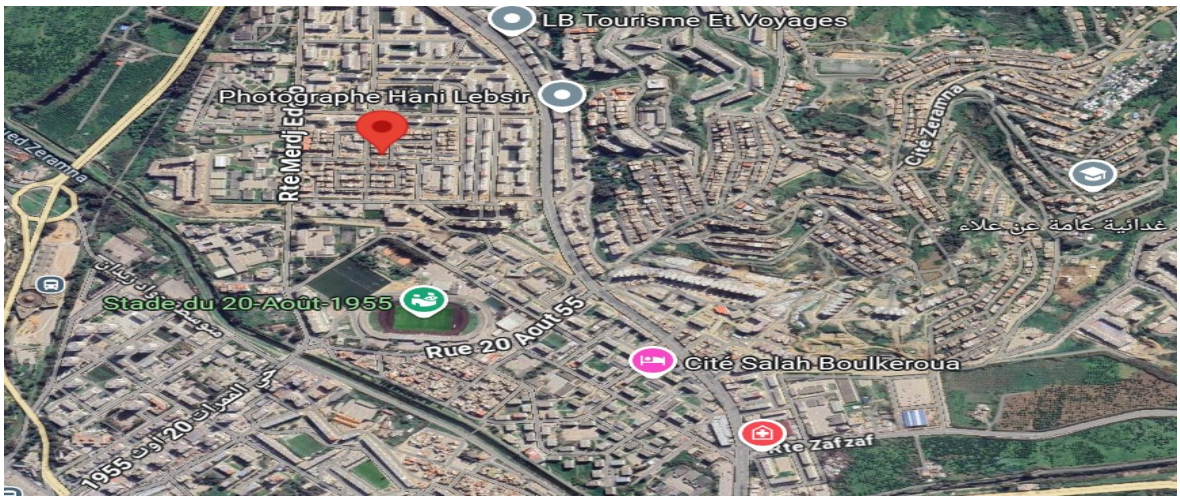


Figure 02: Geolocation of El Mouaalem bakery

The second bread sample was collected in the Skikda region on 11/05/2025 (Figure 03) in the municipality of Skikda Houari Boumediene at El Kasbah bakery, more precisely at the following geographical coordinates: 36°51'38.9"N 6°55'07.0"E

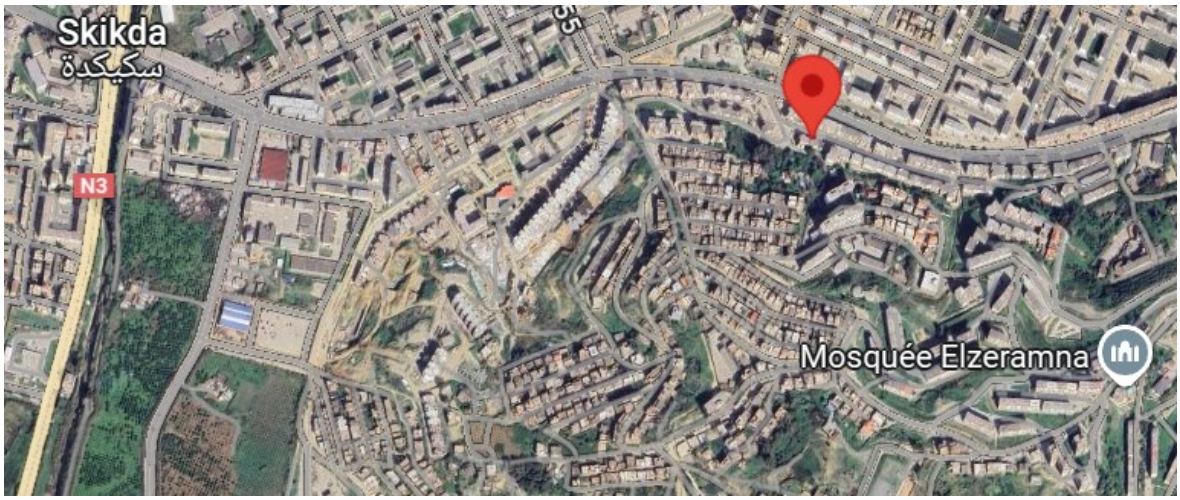


Figure 03: Geolocation of bakery El Kasbah

The experiment was conducted the same day of collection at Local Public Health Establishment of Merdj-Eddib, Kayouch Fadhila (Figure 04), more precisely at the following geographical coordinates: VW7G+9V2, Skikda (Figure 05).

Figure 04: Food bacteriology and quality control unit

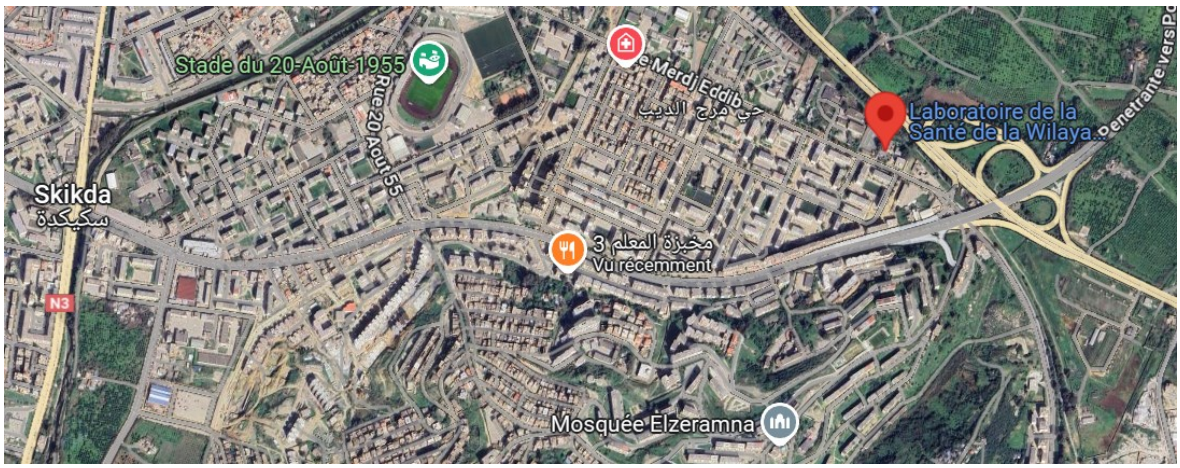


Figure 05: Geolocation of Local Public Health Establishment of Merdj-Eddib, Kayouch Fadhila

3.1.1. Preparation of stock suspension:

- Weigh 25 g of bread aseptically and cut it into small pieces.

- Pour the bread into a bottle containing 225 ml of TSE to obtain the stock suspension (10^{-1}). The steps are clearly shown in (Figure 06).

Figure 06: Preparation of stock suspension

3.1.2. Preparation of dilutions:

- Add 1 ml of the stock suspension (10^{-1}) to 9 ml of TSE and mix.

- Take 1 ml of this dilution (now 10^{-2}) and add it to 9 ml of TSE, then mix. (Figure 07)

- Repeat the operation to obtain the following dilutions (10^{-3}, etc.).

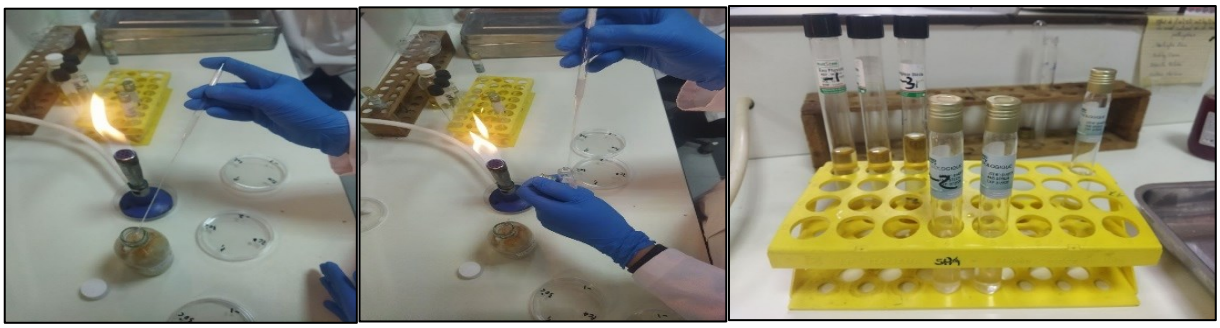


Figure 07: Preparation of dilutions

3.1.3. Enumeration of coliforms, thermotolerant coliforms and *Escherichia coli:*

-Inoculate 2 series of dishes with 1 ml of the different dilutions

-Spread the inoculum (1 ml) drop by drop over the entire surface of the plate

-Pour a layer of VRBL agar ≈ 15ml, cooled to a temperature of ≈ 45±1 °C

-Mix and allow to solidify (Figure 08)

-Incubate one set of plates 24-48h at 37 °C for total coliforms

-Incubate the other series at 44 °C to test for thermotolerant coliforms and *Escherichia coli*.

-Count the number of red colonies that grow in mass, and note the corresponding dilutions and temperatures

-Count plates with a number between 10 and 150.

Figure 08: Seeding into the mass

3.1.4. Detection and enumeration of moulds

Medium used: Sabouraud + chloramphenicol

-Inoculate plates with Sabouraud + chloramphenicol

-Spread the inoculum using a rake pipette

-Incubate Sabouraud plates with lid up for 3 to 5 days at 25°C

Count colonies:

Mould: velvety appearance

3.1.5. Total mesophilic aerobic flora (FMAT)

-Inoculate petri dishes with 1 ml of the different dilutions

-Spread the inoculum (1 ml) dropwise over the entire surface of the dish

-Pour in PCA agar ≈ 15 ml cooled to ≈ 45°C. Mix and leave to solidify (Figure 09)

-Incubate plates lid down 72±3h at 30°C

-Count the number of lenticular and pinhead colonies growing in mass and note the corresponding dilutions. Take into account plates with a number between 15 and 300.

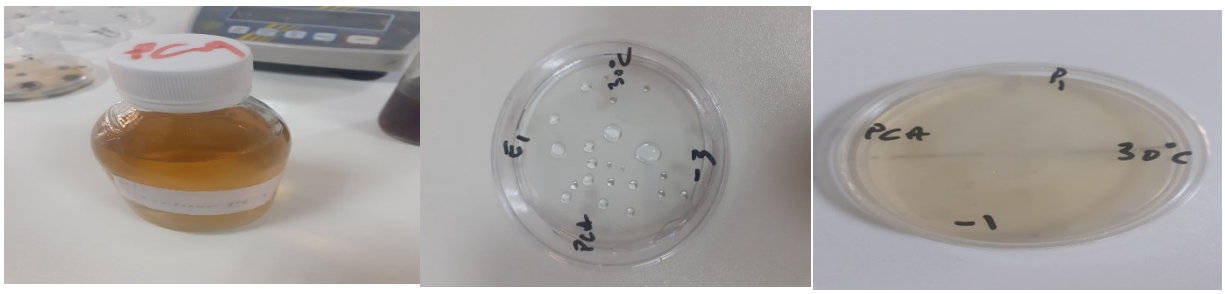


Figure 09: Preparation of plates with PCA

3.1.6. Detection and enumeration of Coagulase-positive Staphylococci:

- Medium: Giolitti Cantoni broth (GBC).

- Inoculate the tubes with 0.1 ml of the dilutions and incubate for 24-48 hours at 37°C.

- After incubation, the presence of turbidity or precipitation in the tubes with a color change of the medium to black indicates the growth of Staphylococci.

- Confirm the colonies by Catalase (bubbles with H_2O_2) and Coagulase (coagulum in rabbit plasma) tests.

Interpretation of results:

- Catalase positive and coagulase positive: *Staphylococcus aureus.*

- Catalase positive and coagulase negative: *Staphylococcus epidermidis* or other coagulase-negative Staphylococci.

3.2. Physico chemical experiment:

A sample of bread was taken from two bakeries El Mouaalem and El Kasbah, the experiment was conducted in the laboratory of the Technology Hall at the University of Skikda 20 August 1955 (Figure 10).

Figure 10: Laboratory of the Technology Hall at the University of Skikda 20 August 1955

3.2.1. Moisture Content

The moisture content is determined by the weight loss, expressed as a percentage, after drying for 1 hour in an oven set at 105°C, under atmospheric pressure, until a constant weight is reached.

3.2.1.1. Materials:

- Aluminum crucible or metal container
- Analytical balance with **0.01 g** precision
- Thermostatic oven set to **105°C**

3.2.1.2. Protocol:

1. **Initial Weighing**: Weigh **5 g** of ground and homogenized bread sample (M1).

   (Figure 11)

2. **Drying in Oven**: Place the sample in a crucible and heat in the oven at **105°C** for **1 hour**.

3. **Cooling & Final Weighing**: Remove the sample, let it cool in a **desiccator**, then weigh it again (M2).

4. **Moisture Content Calculation (%)**: Moisture content (%) is calculated using the following formula:

Moisture Content (%) = ((M1 - M2) / M1) × 100

Where:

- **M1** = Initial weight of the sample (before drying)
- **M2** = Final weight of the sample (after drying)

Figure 11: Weight of 5 g of each sample from the two bakeries

3.2.2. pH Measurement

The pH value of bread is determined by extracting an aqueous solution and measuring its acidity or alkalinity using a pH meter (Figure 11).

3.2.2.1. Materials:

- pH meter calibrated with buffer solutions
- Distilled water
- Beaker (250 mL)
- Magnetic stirrer (optional)

- Filtration system (if needed)

3.2.2.2. Protocol:

Preparation of the sample: Weigh 10 g of ground bread and mix it with 100 mL of distilled water.

Stirring: Let the mixture stand for 30 minutes, stirring occasionally to ensure proper extraction of soluble components.

Filtration: If the suspension contains too many particles, filter it through Whatman paper to obtain a clearer solution.

pH measurement: Insert the pH meter probe into the solution and record the pH value. **(Figure 12)**

Calibration check: Before and after measuring, rinse the electrode with distilled water and calibrate the device using buffer solutions (pH 4.0 and 7.0) to ensure accuracy.

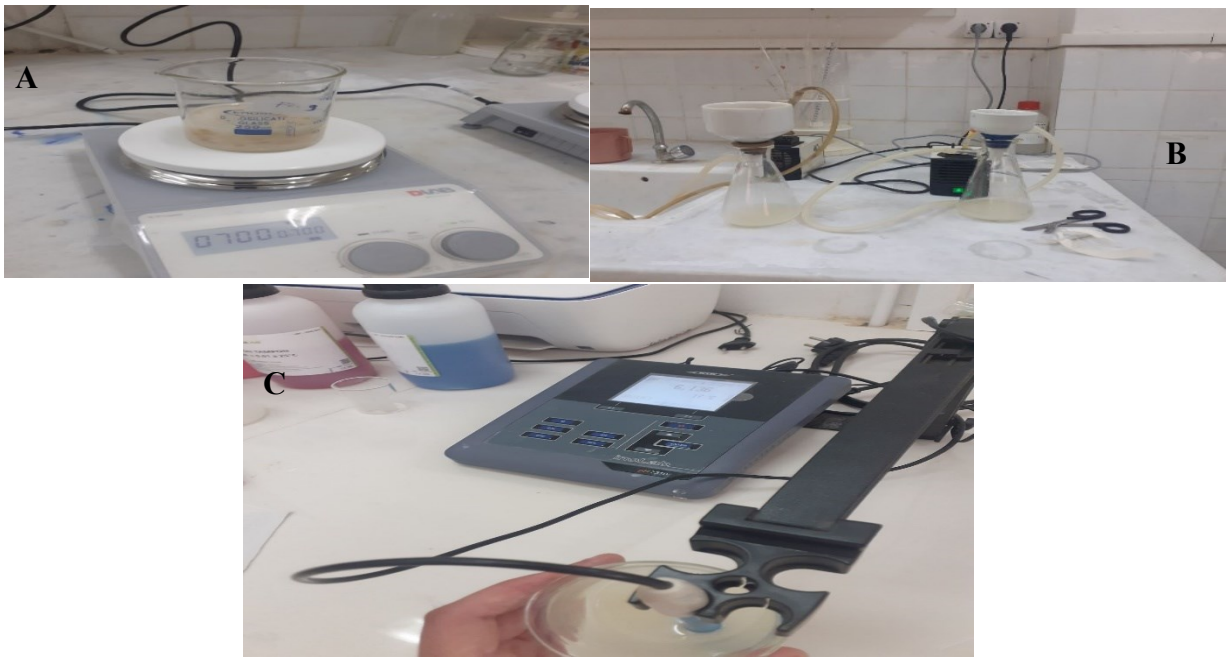


Figure 12: pH measurement

3.3. Interpretation of results:

$$N = \frac{\sum c}{\mathrm{V(n1 + 0{,}1n2)d}}$$

N = number of germs per gram of product.

ΣC = sum of characteristic colonies on the two selected plates.

V = volume of inoculum applied to each plate (in ml).

d = dilution rate corresponding to the first dilution selected.

n1 = number of plates read at the first dilution.

n2 = number of plates read at the second dilution.

3.3.1. Interpretation method:

3.3.1.1. Microbiological analysis:

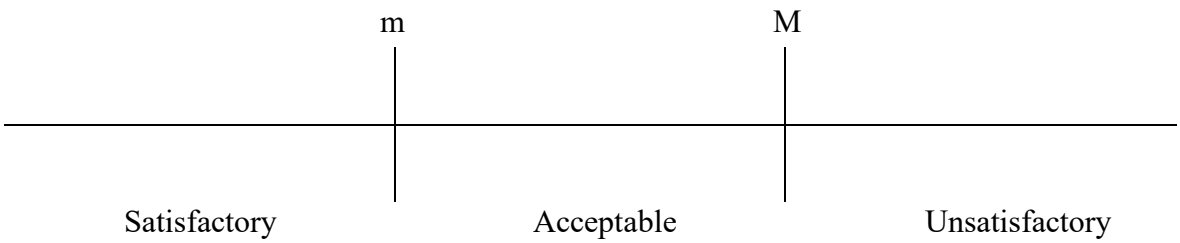
The results of the microbiological analysis were interpreted according to the Algerian standards. These evaluation criteria were established by ministerial decree on 2 July 2017 and published in the Official Journal of the People's Democratic Republic of Algeria No. 39.

Table 01: Microbiological Analysis Results of Bakery Products According to Algerian Standards (Ministerial Decree No. 39, July 2, 2017)

Germs	FMAT	*Escherichia coli*	Moulds	Staphylococci
m	10^3	3	10^2	10^2
M	10^4	30	10^3	10^3
norm	JORDAP	JORDAP	JORDAP	JORDAP

According to Mutsch (2015), the microbiological criterion is a set of qualitative and quantitative elements defining the essential microbiological characteristics expected of a given product that can be achieved through appropriate interventions. The table shows the microbiological criteria used for this study.

The results are interpreted according to a 3-class plan, based on the reference criteria of m according to the jordap No. 39:



If the results of the five repetitions are less than m, the product is satisfactory.

If the results of one repetition are equal to m, the product is acceptable.

If the results of two repetitions are equal to m, the product is unsatisfactory.

If the results of one repetition are equal to M, the product is unsatisfactory.

We call the number of results equal to m: c.

3.3.1.2. Physicochemical analysis:

3.3.1.2.1. Moisture content:

• A well-balanced loaf has a moisture content of between 13% and 60%.

• If the moisture content is too high (> 60%), there may be a risk of microorganism growth.

3.3.1.2.2. pH measurement:

• Well-fermented bread has a pH between 5.0 and 6.5.

• If the pH is below 5, there may be excessive fermentation.

Chapter four

Results

And

Discussion

4.1. Microbial analysis

4.1.1. El Mouaalem bakery

The microbial testing results for the bakery El Mouaalem are presented across five trials, focusing on various parameters, including FMAT (Food Microbial Activity Test), Coagulase-positive Staphylococci, *Escherichia coli*, and Moulds.

4.1.1.1. Results of FMAT

The FMAT values recorded across the trials ranged from 3900 in R1 to 430 in R5, indicating variations in microbial activity within the bakery's products. The highest FMAT value, 3900, was observed in trial R1, suggesting a peak in microbial activity at that point, while the lowest value, 430, was noted in R5, signaling a decrease in microbial activity in that particular sample (Table 02).

Table 02: FMAT results for El Mouaalem bakery

Inoculum	PCA
R1	3900
R2	890
R3	506
R4	796
R5	430

PCA: Plate Count Agar

4.1.1.2. Results of coliforms, thermotolerant coliforms and *Escherichia coli*

The results for *Escherichia coli* were also uniform, showing a value of 0 in every trial. This implies that no contamination by *E. coli* was detected, highlighting the bakery's adherence to microbiological safety standards in this regard (Table 03) (Figure 13).

Table 03: Results of *Escherichia coli* testing at El Mouaalem Bakery

Inoculum	VRBL 37	VRBL 44	*E. coli*
R1	0	0	0
R2	0	0	0
R3	0	0	0
R4	0	0	0
R5	0	0	0

VRBL: Violet Red Bile Lactose

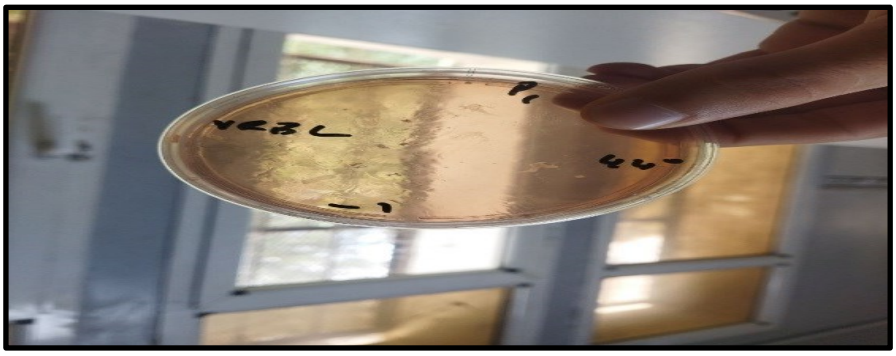


Figure 13: *Escherichia coli* test results from the bakery El Mouaalem

4.1.1.3. Results of Coagulase-positive Staphylococci

For the Coagulase-positive Staphylococci parameter, the results were consistent across all five trials, with a count of 0 in each case. This indicates the absence of Coagulase-positive Staphylococci in all the tested samples, suggesting that the bakery's products were free from this pathogen (Table 04) (Figure 14).

Table 04: Results of Coagulase-positive Staphylococci testing at El Mouaalem bakery

Inoculum	Giolitti BC	Catalase	Coagulase
R1	0	0	0
R2	0	0	0
R3	0	0	0
R4	0	0	0
R5	0	0	0

Figure 14: Results of Coagulase-positive Staphylococci testing for El Mouaalem bakery

4.1.1.4. Results of moulds

Lastly, the Moulds parameter also showed zero presence in all five trials, with a count of 0 in each case. This result suggests that Mould contamination was not detected in any of the samples, further affirming the microbiological quality of the bakery's products (Table 05).

Table 05: Results testing of Moulds for El Mouaalem bakery

Inoculum	Moulds
T medium	0
T diluent	0
R1	0
R2	0
R3	0
R4	0
R5	0

4.1.2. Bakery El Kasbah

The microbial testing results for the bakery El Kasbah are presented across five trials, focusing on various parameters, including FMAT (Food Microbial Activity Test), Coagulase-positive Staphylococci, *Escherichia coli*, and Moulds.

4.1.2.1. Results of FMAT

The results from the microbial experiment at the bakery El Kasbah show varying levels of FMAT (Food Microbial Activity Test) across the five trials, with values recorded as 159, 76, 40, 128, and 100, respectively, for trials R1 through R5. These varying values suggest fluctuations in the microbial activity within the bakery's products. The highest FMAT value of 159 was recorded in trial R1, whereas the lowest value of 40 was seen in trial R5, indicating some degree of microbial activity reduction over the course of the trials (Table 06).

Table 06: FMAT analysis El Kasbah bakery

Inoculum	PCA
R1	159
R2	128
R3	100
R4	76
R5	40

PCA: Plate Count Agar

4.1.2.2. Results of Coagulase-positive Staphylococci

In terms of the presence of Coagulase-positive Staphylococci, all trials (R1 to R5) showed a count of 0, meaning no detectable Coagulase-positive Staphylococci were found in any of the samples. This result indicates that the bakery's products were free from this specific pathogen throughout the testing period (Table 07).

Table 07: Results of Coagulase-positive Staphylococci testing for El Kasbah bakery

Inoculum	Giolitti BC	Catalase	Coagulase
R1	0	0	0
R2	0	0	0
R3	0	0	0
R4	0	0	0
R5	0	0	0

4.1.2.3. Results of Total coliforms and *Escherichia coli*

The same result was observed for *Escherichia coli*, as all trials reported a count of 0, suggesting that there was no contamination by *E. coli* in the samples tested (Table 08).

Table 08: Detection Results of Total Coliforms and *Escherichia coli* for El Kasbah Bakery

Inoculum	VRBL 37	VRBL 44	*E. coli*
R1	0	0	0
R2	0	0	0
R3	0	0	0
R4	0	0	0
R5	0	0	0

VRBL: Violet Red Bile Lactose

4.1.2.4. Results of moulds

For the Moulds parameter, the results shown in Table 09 were equally clear, with all trials showing a count of 0. This indicates the complete absence of Mould contamination in the bakery's products, further affirming the microbiological safety of the samples.

Table 09: Results testing of Moulds for El Kasbah bakery

Inoculum	Moulds
Medium witness	0
Diluent witness	0
R1	0
R2	0
R3	0
R4	0
R5	0

4.2. Results of physicochemical analysis of the two bakeries

4.2.1. Moisture content:

The moisture content experiment results for the two bakeries, B1 (El Mouaalem bakery) and B2 (El Kasbah bakery), show the weight before and after drying, along with the calculated moisture content percentage for each sample, the values are shown in detail in Table 10. For bakery B1, the weight before drying was 5 grams, and after drying, it was reduced to 3.61 grams. This resulted in a moisture content of 27.8%. This value indicates that 27.8% of the initial weight was due to moisture content that evaporated during the drying process. For bakery B2, the initial weight was also 5 grams, and after drying, the weight decreased to 3.90 grams. The moisture content for bakery B2 was calculated to be 22%. This shows that a smaller proportion of the initial weight in B2 was moisture compared to B1, indicating that B2 had a lower moisture content in its product

Table 10: Moisture content results for the two bakeries

	B1	B2
Weight before drying (g)	5	5
Weight after drying (g)	3.61	3.90
Moisture content %	27.8	22

B1: El Mouaalem bakery**, B2:** El Kasbah bakery

4.2.2. pH

The pH experiment results for the two bakeries, El Mouaalem (B1) and El Kasbah (B2), show distinct pH values in Table 11. The pH of the sample from bakery El Mouaalem (B1) was recorded at 6.136, while the sample from bakery El Kasbah (B2) showed a pH of 5.999. The values indicate a slightly more alkaline environment in the product from bakery B1 compared to B2.

Table 11: The pH results for the two bakeries

	B1	B2
pH	6.136	5.999

B1: El Mouaalem bakery**, B2:** El Kasbah bakery

Discussion

The results from the microbial quality, moisture content, and pH analyses of bakery products from El Mouaalem (B1) and El Kasbah (B2) provide valuable insights into their safety and quality. The low microbial counts, combined with moderate moisture levels and near-neutral pH values, indicate favorable conditions for food safety and shelf stability.

The FMAT values recorded for B1 and B2 (3900, 890, 506, 796, 430) are significantly lower than those reported in studies involving contaminated bakery items. For instance, total plate counts (TPC) in certain bread samples have reached up to 1.39×10^6 CFU/g, whereas commercial varieties typically range between 10–395 CFU/g in crusts and up to 310 CFU/g in crumbs (Ali et al., 2023; Sowmya et al., 2023; Lima et al., 2023; György et al., 2024; Noshirvani et al., 2024). These findings suggest that both bakeries maintain effective hygiene practices aligned with accepted food safety standards.

In terms of pathogenic indicators, the absence of Coagulase-positive Staphylococci, Escherichia coli, and moulds in both samples is a strong indicator of microbiological safety. These microorganisms are frequently associated with foodborne illness and spoilage (Ali et al., 2023; Sowmya et al., 2023; Lima et al., 2023; György et al., 2024; Noshirvani et al., 2024), and their non-detection confirms compliance with safety regulations. This aligns with prior research emphasizing the importance of pathogen-free bakery goods (Gill et al., 2020).

The moisture content of B1 (27.8%) and B2 (22%) falls within the typical range reported in the literature (13.6%–60%) (Ali et al., 2023; Sowmya et al., 2023; Lima et al., 2023; Smith et al., 2004). Moisture plays a key role in product stability and spoilage risk—higher levels often correlate with increased mold growth. Both samples exhibit moderate moisture levels, which help limit microbial proliferation and extend shelf life.

The pH values for B1 (6.136) and B2 (5.999) fall within the usual range for bakery products (5.0–6.5) (Arepally et al., 2022; Smith et al., 2004; Ali et al., 2023; Sowmya et al., 2023; Lima et al., 2023). A slightly alkaline to neutral pH supports extended shelf life without encouraging the growth of harmful pathogens, contributing positively to overall product quality.

Together, these results confirm that both bakeries produce safe, well-preserved goods that meet or exceed established microbiological standards (Ali et al., 2023; Sowmya et al., 2023; Lima et al., 2023; György et al., 2024; Noshirvani et al., 2024). Nonetheless, continuous monitoring and improvements in post-baking handling and packaging are recommended to maintain product integrity over time (György et al., 2024; Noshirvani et al., 2024; Ali et al., 2023; Sowmya et al., 2023; Lima et al., 2023).

Based on the results obtained, we conclude that the Algerian state strictly and rigorously monitors the quality of this product, especially after the recent coronavirus pandemic, when monitoring was intensified, methods were improved, and awareness campaigns were conducted for bakeries to comply with safety, quality, and hygiene standards in order to obtain safe, healthy, and high-quality bread for consumers. to the requirements of Algerian society.

Conclusion

The aim of this study was to assess the quality of bread consumed in our city by examining certain criteria that indicate whether bread is healthy and meets hygiene and safety requirements through microbiological analysis by looking for (FMAT, Moulds, *Escherichia coli* and *Staphylococci*) and physicochemical analyses.

The results of the analyses carried out on two samples from two well-known bakeries (El mouaalem and El Kasbah) in the city of Skikda showed that the bread meets Algerian hygiene and safety standards, which indicates that the monitoring committee is fulfilling its role to the fullest.

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