# Assessment of the Sanitary Quality of Ready to Eat Sesame, a Low Moisture Streets Food Form Burkina Faso

**Muller Compaoré** ( mullercompaore@yahoo.fr )
Centre de Recherche en Sciences Biologiques Alimentaires et Nutritionnelles (CRSBAN), École Doctorale Sciences et Technologies, Université Joseph KI- ZERBO 03 BP 7021 Ouagadougou 03.

**Raoul Bazié**
Centre de Recherche en Sciences Biologiques Alimentaires et Nutritionnelles (CRSBAN), École Doctorale Sciences et Technologies, Université Joseph KI- ZERBO 03 BP 7021 Ouagadougou 03.

**Marguerite Nikiéma**
Centre de Recherche en Sciences Biologiques Alimentaires et Nutritionnelles (CRSBAN), École Doctorale Sciences et Technologies, Université Joseph KI- ZERBO 03 BP 7021 Ouagadougou 03.

**Virginie Yougbaré**
Laboratoire National de Santé Publique (LNSP), 09 BP 24 Ouagadougou 09

**Réné Dembelé**
Unité de Formation et de Recherche en Sciences Appliquées et Technologies (UFR/SAT), Université de Dédougou, BP 176 Dédougou

**Dissinviel Kpoda**
Université Joseph KI- ZERBO, Centre Université de Ziniaré 03 BP 7021 Ouagadougou 03

**Elie Kabré**
Laboratoire National de Santé Publique (LNSP), 09 BP 24 Ouagadougou 09

**Nicolas Barro**
Centre de Recherche en Sciences Biologiques Alimentaires et Nutritionnelles (CRSBAN), École Doctorale Sciences et Technologies, Université Joseph KI- ZERBO 03 BP 7021 Ouagadougou 03.

---

**Research Article**

**Keywords:** Sanitary quality, Sesamum indicum, microorganisms, low moisture food, Burkina Faso

**Posted Date:** January 29th, 2021

**DOI:** https://doi.org/10.21203/rs.3.rs-140047/v1



---

**Version of Record:** A version of this preprint was published at BMC Microbiology on July 8th, 2021. See the published version at https://doi.org/10.1186/s12866-021-02269-0.

# Abstract

**Background:** Microbial contamination of edible low moisture foods poses a significant public health risk for human. In this study, the microbial quality of sweet dehulled sesame, salted dehulled sesame and the raw sesame, sold under ambient conditions were examined. The samples were collected in the cities of Burkina Faso. The first type is sweet dehulled sesame ($n_1$ = 25); the second type is salted dehulled sesame ($n_2$ = 25) and the third type raw sesame ($n_3$ = 25). Assessment of the microbial quality was based on the total aerobic mesophilic bacteria, the thermotolerant coliforms, the yeasts and moulds, the *E. coli,* and the *Salmonella* spp using ISO methods.

**Results:** The results showed the presence of microorganisms varying from 1.0 to $1.72 \times 10^5$ CFU $g^{-1}$ for thermotolerant coliforms, from 1.0 to $6{,}12 \times 10^6$ CFU $g^{-1}$ for the total mesophilic aerobic flora and from 1.0 to $8.10 \times 10^5$ CFU $g^{-1}$ for yeasts and moulds. The higher contaminations rates were mostly observed in raw sesame samples. No *E coli* or *Salmonella* pathogens were detected. Based on international standards of dehydrated foods, 50.67% of the ready to eat sesames are satisficing while 17.33% are acceptable and 32% are not satisficing.

**Conclusion:** Attention should be emphasized on the processing practices, especially in crowded places where sesames are mostly sold. The high numbers of all microbial groups in these sesame samples suggested that the production of ready to eat sesame should be improved by better hygiene. This study highlights also that ready to eat sesame might harbor a wide range of microorganisms when processes are weak of hygiene.


# Background

RTE foods are those that do not require any further processing (such as cooking) prior to consumption by the consumer [1] (1)RTE such as sesame is a very popular low-moisture foods, sold almost everywhere by ambulant vendors in all regions in Burkina Faso (Fig. 1). It is customary known as a small gift for children when parents are travelling within the country. Low-moisture foods were once thought to be relatively safe with respect to foodborne illness risk since low water activities do not permit the growth of foodborne microorganisms [2]. Recently over the years, a number of incidences relating to outbreaks caused by the presence of food-borne pathogens in low water activity ($a_w$) foods have increased [3] ; [4]. It is thought that microorganisms were not able to grow in a dry condition. However, pathogens can become sheltered in such dry food and cause public health issues. According to [4] foods with $a_w$  0.85 are considered as low moisture food and include cereals and many others dry food as grains and seeds (e.g., sesame, melon, pumpkin, linseed).

Sesame processing is still at the traditional stage in Burkina Faso. It is run by artisanal and semi-artisanal processors who are individuals, companies, associations and some pastries [5]. These processed products are generally sweet dehulled sesame croquettes, salted dehulled sesame seeds and raw sesame seeds. According to the International Marketing – Management Consulting Group [6], sesame is consumed in the raw state (26%), in cookies form (35%), as ingredients for cooking (25%), as oil (6%) and as pastry ingredient (6%). Although, the majority of the national sesame production is export oriented, there is few data about the quality of processed sesame for local consumption. Hygiene conditions are poor when foods are produced in non-industrial establishments, mainly due to the fact that the necessary infrastructure for technologically adequate processes is not available [7]. Sugar either salt decreases $a_w$ of the product thereby inhibiting microbial growth [8]. Sesame seeds are usually dehulled and roasted before use; this improves their functional properties, releases more flavor and color, and improves their sensorial quality [9]. Also, dehulling removes relatively high amounts of antinutritional oxalic acid and fiber contained in the testa (seed coat), resulting in lighter-colored, less bitter-tasting seeds [9]. From these dehulled sesames, the products are obtained by caramelization in sugar or by soaking the seeds in salty water before roasting. These processed are usually done manually. Published papers highlighted that there is potential health risk associated with initial contamination of foods by pathogenic bacteria as well as subsequent contamination by vendors during preparation and through post-cooking handing and cross contamination [10] ; [11]. The purpose of this study was to assess the microbiological quality of three types of edible sesame sold in the street of fourteen (14) provinces. The microorganisms of interest were those that can decrease the quality of sesame and cause public health issue and those that can withstand high concentration of sugar and salt. These microorganisms include thermotolerants coliforms, Salmonellas, *E. coli* and yeasts and moulds.

## Methods

# Samples collection and storage

Samples of three different categories of processed edible sesame (Fig. 2) were collected in some crowed cities, road and major streets of Burkina Faso. Sampling was carried out in duplicate according to the production batches in fourteen (14) provinces (Fig. 3). Sample were transferred aseptically in sterile plastics bags, sealed and stored at room temperature prior for analyses. Sampling of salted sesame and raw sesame was carried out in duplicate according to the production batches and then vigorously mixed to obtain a homogeneous sample of at least 50 g. Sweet dehulled sesame was also sampled in duplicate according to the production batches and then crashed in sterile bag with Bag Mixer, Interscience France for 2 minutes to obtain a homogeneous sample of at least 50 g. The following samples were collected:

- Sweet dehulled sesame ($n_1$ = 25);
- Salted dehulled sesame ($n_2$ = 25) and
- Raw sesame ($n_3$ = 25)

The processing steps and parameters of ready-to-eat sesame were obtained through a ten-minute interview with sesame processors in order to establish the production diagram (Fig. 4).

# Microbial Analysis of the Samples

Twenty-five (25) grams of each sesame sample were homogenized into 225 mL of sterile buffered peptone water (Liofilchem diagnostic, Italy). Further tenfold serial dilutions were made with in sterile buffered peptone water. Duplicate plates were made for each sample at each dilution under ISO 6887 standard methods. Microbial counts were expressed as colony-forming units per gram of sesame (CFU $g^{-1}$)

- *Total aerobic mesophilic bacteria*, were counted among all the sesame samples onto standard plate count (PCA) agar (Conda Pronadisa, Spain) under NF ISO 4833: 2003. Plates were incubated at 30 ± 1°C for 72 h. After incubation the number of colonies was counted on the plate with less than 300 colonies.

- *Thermotolerant coliforms* known to be an indicator of fecal contamination were counted onto standard violet red bile lactose (VRBL) agar (Conda Pronadisa, Spain) incubated at 44.5 ± 0.5°C for 24 to 48 hours under NF V08-017:1980. Only the Petri dish containing less than 150 colonies were considered.

- *Escherichia coli* was identified through the IMViC test from thermotolerant coliforms. Suspected colonies were selected and subcultured on Nutrient Agar at 37°C for 24 hours. Pure cultures grown on Nutrient Agar were used for Oxidase test and determination of IMViC pattern (indole, methyl red, Voges Proskauer and citrate utilization test) following Standard Procedures for food Analysis. Positives clones were transferred into Levine BBL™ Eosin Methylene Blue Agar (EMB) Agar France, which was incubated at 37 ± 1°C for 24 hours. *Escherichia coli* ATCC 8739 was uses as positive control for all samples.

- *Salmonella spp.* was investigated according to the standard - Horizontal method for detection of *Salmonella* spp ISO 6579:2007. Briefly, the non-selective enrichment was done by adding 25 g of each sesame sample into 225 mL buffered peptone water incubated at 37°C for 18 to 20 hours. The selective enrichment step was performed onto both tetrathionate (Müller-Kauffman) (Liofilchem diagnostic, Italy) and Rappaport Vassiliadis Soy (Difco laboratories) broths incubated respectively at 37 ± 1°C and 42 ± 1°C for 18 to 20 hours. A brilliant green at 0.95% was added to the selective media Tetrathionate broth in order to inhibit the growth of Gram-positive bacteria. Isolations were performed onto Xylose Lysine Deoxycholate (HiMedia Laboaratories, India) and *Salmonella-Shigella* (HiMedia Laboaratories, India) agars. Suspected colonies were purified on nutrient agar and then submitted to API 20E (BioMérieux) test for biochemical confirmation. *Salmonella typhimurium* (ATCC 14028) and *Salmonella enteritidis* (ATCC 13076) was used as positive control. The Key biochemical tests including the fermentation of glucose, negative urease reaction, lysine decarboxylase, negative indole test, H2S production, and fermentation of dulcitol [12].

- *Yeasts and moulds* were counted onto standard yeast extract glucose chloramphenicol (YGC) agar (HiMedia Laboaratories, India) incubated at 25 ± 1°C for 5 days following ISO 7954:1988. The growth of moulds was checked every day in order to avoid invading colonies. Considered Petri dish for bacterial counting were less than 150 colonies.

# Statistical analysis

Statistical analysis was done using IBM SPSS Statistics Version 20.0.0. The mean value and standard deviation were calculated from the obtained data in each sesame sample group. Comparison test were done to determine whenever there were significant differences ($P \leq 0{,}05$) within these types of sesame samples. Values obtained in the counts were transformed to decimal logs.

# Criteria of appreciation

There are no Burkinabe standards to assess the quality of processed sesame. therefore, the criteria assigned to dehydrated plant products formulated by [13] have been used. The criteria decreed by the government of Québec concerning nuts, dried fruits, fruit powder, nut paste have been also considered [14]. The Table 1

## Results

The enumeration ($\log_{10}$ CFU $g^{-1}$) of microorganisms such as total flora, thermotolerants coliforms, yeast and mould as well as the presence or absence of *Salmonella* and *E. coli* obtained following assessment of seventy-five sesame samples are shown in the Table I.

The results showed the presence of microorganisms independently of the sample nature. Thermotolerant coliforms were found in samples as follow: 44% in sweet dehulled sesame, 16% in salted dehulled sesame and 68% in raw sesame. The means concentration was 6.79 x$10^3$; 1.70 x10; 1.84 x$10^4$ CFU $g^{-1}$ (respectively for sweet dehulled sesame, salted dehulled sesame and raw sesame). The thermotolerant coliforms column independently of the sample type, showed that 43 samples (57.3%) out of 75 sesame samples had zero coliforms. The majority of these sample belong to the salted dehulled sesame (28%), followed by Sweet dehulled sesame (18.67%) and raw sesame (10.66%).

92% of the samples have shown a presence of microorganisms. The total aerobic mesophilic flora varies from 3x10 to 6.12x105 CFU $g^{-1}$. The means concentrations of the total aerobic mesophilic flora were 5.5 x$10^4$; 4.5 x$10^3$; 2.5 x$10^5$ CFU $g^{-1}$ respectively for sweet dehulled sesame, salted dehulled sesame and raw sesame. When a deep look is taken, it can be notice that the six sample which showed zero microorganisms in the total aerobic mesophilic flora come from the salted dehulled sesame. Therefore, concerning the flora, the two other types of sesame showed the presence of microorganisms in all the analyzed samples with high loads in the raw sesame samples.

The total aerobic mesophilic flora seems to have the high number of microorganisms in these 3 types of sesame samples as compare to the thermotolerant coliforms and the yeasts and moulds.

# Pathogens detection

Although thermotolerant coliforms were detected in 32 samples (42.7%), *Escherichia coli* neither *Salmonella* spp, were not detected in any of the 75 analyzed samples.

## Yeast and moulds

Concerning the yeast and mould, 22 samples (29.3%) out of the 75 showed zero microorganisms whose 15 (20%) belong to salted dehulled sesame and 7 (9.3%) to sweet dehulled sesame. All the raw sesame sample gave at least 10 CFU $g^{-1}$ yeasts and moulds. The means concentrations in this group were 7.7 $x10^2$; 4.0 x10; 3.6 $x10^4$ CFU $g^{-1}$ respectively for sweet dehulled sesame, salted dehulled sesame and raw sesame. Different morphologies were observed and the predominant morphologies of yeast and mold were showed in Fig. 5.

The maximum loads in thermotolerant coliforms, in total flora and in yeasts and molds were observed with the same sample of Sweet dehulled sesame and raw sesame. In the case of salted dehulled sesame, three different samples carried these maximum values.

Table 1
Microbiological counts of three types of ready to eat sesame (log10 CFU g − 1)

| | *Thermotolerant coliforms* | | | *Total aerobic mesophilic bacteria* | | | *Yeasts and moulds* | | | *Salmonellas* spp | *E. coli* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Counts | | | Counts | | | Counts | | | Prsc/Abs/25g | Prsc/Absg |
| Samples | **DW** | **DS** | **RS** | **DW** | **DS** | **RS** | **DW** | **DS** | **RS** | **DW, DS, RS** | **DW, DS, RS** |
| **1** | ▯1.0 | ▯1.0 | 3.97 | 3.18 | 3.70 | 5.11 | 2.00 | **2.48**[a] | 3.79 | Abs | Abs |
| **2** | ▯1.0 | ▯1.0 | ▯1.0 | 3.00 | 3.30 | 3.93 | ▯1.0 | 2.00 | 2.85 | Abs | Abs |
| **3** | ▯1.0 | ▯1.0 | ▯1.0 | 3.90 | ▯1.0 | 3.74 | 2.85 | ▯1.0 | 2.48 | Abs | Abs |
| **4** | 4.93 | ▯1.0 | 4.93 | 5.18 | 3.30 | 5.03 | 3.91 | ▯1.0 | 3.73 | Abs | Abs |
| **5** | ▯1.0 | ▯1.0 | 3.23 | 3.00 | ▯1.0 | 4.37 | ▯1.0 | ▯1.0 | 2.85 | Abs | Abs |
| **6** | 3.30 | ▯1.0 | 3.26 | 3.93 | 3.18 | 3.98 | ▯1.0 | ▯1.0 | 2.85 | Abs | Abs |
| **7** | 2.00 | **2.30**[a] | ▯1.0 | 3.18 | 3.30 | 4.31 | ▯1.0 | ▯1.0 | 2.90 | Abs | Abs |
| **8** | 2.48 | ▯1.0 | 3.92 | 2.48 | ▯1.0 | 4.51 | 2.00 | ▯1.0 | 2.90 | Abs | Abs |
| **9** | 3.51 | 2.02 | 4.39 | 3.67 | 3.30 | 5.79 | 2.41 | 2.00 | 3.89 | Abs | Abs |
| **10** | 3.42 | 1.90 | **5.24**[a] | 3.55 | 2.00 | **6.52**[a] | 2.30 | ▯1.0 | **5.91**[a] | Abs | Abs |
| **11** | ▯1.0 | 1.60 | 3.71 | 2.48 | 2.48 | 3.93 | ▯1.0 | 2.00 | 3.41 | Abs | Abs |
| **12** | ▯1.0 | ▯1.0 | 4.51 | 2.95 | 3.16 | 5.23 | 1.18 | 1.00 | 3.39 | Abs | Abs |
| **13** | ▯1.0 | ▯1.0 | 4.60 | 3.29 | 3.66 | 5.13 | 1.40 | ▯1.0 | 4.55 | Abs | Abs |
| **14** | **4.54**[a] | ▯1.0 | ▯1.0 | **6.79**[a] | 4.37 | 6.01 | **3.98**[a] | 1.65 | 3.03 | Abs | Abs |
| **15** | ▯1.0 | ▯1.0 | 3.23 | 2.78 | 3.48 | 3.88 | 1.00 | ▯1.0 | 2.56 | Abs | Abs |
| **16** | ▯1.0 | ▯1.0 | 3.28 | 2.98 | **4.77**[a] | 3.45 | ▯1.0 | 1.48 | 1.78 | Abs | Abs |
| **17** | 2.77 | ▯1.0 | 3.58 | 4.72 | 3.15 | 5.12 | 0.70 | 2.26 | 4.10 | Abs | Abs |
| **18** | ▯1.0 | ▯1.0 | 1.90 | 3.79 | ▯1.0 | 3.85 | 0.70 | ▯1.0 | 2.37 | Abs | Abs |
| **19** | ▯1.0 | ▯1.0 | ▯1.0 | 3.45 | ▯1.0 | 3.46 | 1.88 | ▯1.0 | 2.39 | Abs | Abs |
| **20** | ▯1.0 | ▯1.0 | 1.00 | 4.11 | ▯1.0 | 3.00 | 1.74 | ▯1.0 | 1.70 | Abs | Abs |
| **21** | ▯1.0 | ▯1.0 | 4.86 | 2.80 | 1.70 | 5.16 | ▯1.0 | ▯1.0 | 2.65 | Abs | Abs |
| **22** | 3.83 | ▯1.0 | ▯1.0 | 5.53 | 2.45 | 4.54 | 1.18 | 1.18 | 2.51 | Abs | Abs |
| **23** | ▯1.0 | ▯1.0 | ▯1.0 | 4.35 | 3.52 | 4.85 | 1.18 | 2.06 | 2.45 | Abs | Abs |
| **24** | 3.79 | ▯1.0 | ▯1.0 | 4.95 | 2.11 | 4.00 | 1.48 | ▯1.0 | 2.00 | Abs | Abs |
| **25** | 4.44 | ▯1.0 | 2.61 | 4.76 | 1.48 | 5.34 | 1.00 | ▯1.0 | 2.48 | Abs | Abs |
| Average | 3.83 | 1.23 | 4.26 | 4.74 | 3.65 | 5.39 | 2.89 | 1.6 | 4.55 | Abs | Abs |

*a = maximum value in each sample group; minimum value = ▯1.0; Prcs: presence Abs: absence*

Table 2
Appreciation criteria of samples

| | m (CFU/g) | M (CFU/g) |
|---|---|---|
| Total aerobic mesophilic bacteria [a] | $3.10^4$ | $3.10^5$ |
| Thermotolerants coliforms [a] | $10^2$ | $10^3$ |
| *E. coli* [a, b] | 10 | $10^2$ |
| Yeasts and moulds [a] | $10^3$ | $10^4$ |
| *Salmonella* [a, b] | Absence /25g | |
| [a, b] Criteria (a = [13]; b = [14] ) | | |

# Discussion

Food quality has always been a concern to human being especially in developing countries. The results of the present study showed that the three types of ready-to-eat sesame (sweet dehulled sesame, salted dehulled sesame and raw sesame) harbor microorganisms such as total flora, thermotolerant coliforms and yeast and mould up to 72% in sesame sweet dehulled sesame, 44% in salted dehulled sesame and 89.33% in raw sesame.

Raw sesame had the highest counts of thermotolerants coliforms, total aerobic mesophilic bacteria and yeast and mould as compared to dehulled sweet and dehulled salted sesame. The means were 4.26 $log_{10}UFC.g^{-1}$; 5.39 $log_{10}UFC.g^{-1}$ and 4.55 $log_{10}UFC.g^{-1}$ respectively for thermotolerants coliforms, total aerobic mesophilic bacteria and yeast and mould. Raw sesame was followed by sweet dehulled on which the means of thermotolerants coliforms, total aerobic mesophilic bacteria and yeast and mould were respectively 3.83 $log_{10}UFC.g^{-1}$; 4.74 $log_{10}UFC.g^{-1}$ and 2.89 $log_{10}UFC.g^{-1}$. The lower contaminated was salted dehulled sesame with the average of 1.23 $log_{10}UFC.g^{-1}$; 3.65 $log_{10}UFC.g^{-1}$ and 1.6 $log_{10}UFC.g^{-1}$ respectively for thermotolerants coliforms, total aerobic mesophilic bacteria and yeast and mould. Based on recommended microbiological criteria for dehydrated foods use in this study [13] [14] (Table 2); 50.67% of the ready to eat sesame are satisficing while 17.33% are acceptable and 32% are not satisficing. The discrepancies between the numbers of microorganisms of these three types of ready-to-eat sesame may reflect differences of food handler's hygiene management and the final product conservation. The flowchart of ready-to-eat sesame processing (Fig. 4) showed clearly that no heating step is involved in the production of raw sesame. This is what probably justifies its high load in microorganisms and which makes it one of the most contaminated and risky foods. [15] found out an average of 4.53 $log_{10}UFC.g^{-1}$ ($3.4x10^4$); 4.83 $log_{10}UFC.g^{-1}$ ($6.9x10^4$); 4.36 $log_{10}UFC.g^{-1}$ ($2.3x10^4$) respectively for coliforms, aerobic plate counts and yeast and mould while assessing the microbial quality of tahini (Sesame Paste) in Lebanon. In the other hand, [16] found out an average of 1.44 $log_{10}UFC.g^{-1}$ (2.8x10); 4.63 $log_{10}UFC.g^{-1}$ ($4.3x10^4$); 3.88 $log_{10}UFC.g^{-1}$ ($7.6x10^3$) respectively for coliforms, aerobic plate counts and yeast and mould while assessing the microbiological and chemical quality of tahini halva in Turkey. The obtained results in this study are slightly different of these two-research finding. Indeed, all these products are sesame-based product and the presence of microbes according to [15] has been attributed to a number of reasons including, the microbial quality of sesame seeds, poor hygiene and sanitation, and improper processing and storage conditions.

Published papers reported that sesame-based products such as Tahini and Halva (Helva) has been linked to salmonella infections outbreak [16] ; [17] ; [18]. The causes of these contaminations are mainly due to contaminated ingredients or unhygienic processing. It believed that contamination of sesame based products is deeply linked to the quality of the raw materials. [19] exhibited 24.6% of salmonella contamination of raw sesame submitted to exportation from 2007 to 2017 in

Burkina Faso. According to [5], in Burkina Faso, sesame based products processing is run by artisanal and semi-artisanal processors who are individuals, companies, associations and some pastries.

Therefore, there is a need as stipulated by the [17] to design and to setup proper Hazard Analysis Control Critical Point (HACCP) system and Good Manufacturing Practices (GMP) as the contributing factors for reduction of microbial contamination in low-moisture foods.

Indeed, the processing methods used to transform raw sesame into dehulled sweet and dehulled salted sesame should normally reduce drastically the microorganism population. We can hypothesize that the presence of microorganisms could then be linked to post contaminations. Our hypothesis was clearly confirming by the presence of thermotolerant coliforms in 32 out of 75 samples (42.70%) including heat treated sesame. Most of them were found particularly in 89,33% of the raw sesame samples (17 out of 25). The presence of thermotolerants coliforms indicates the presence of fecal material from warm-blooded animals [20]. The thermotolerants coliforms (fecal coliforms) group is restricted to organisms that grow in the gastrointestinal tract of humans and other warm-blooded animals and includes members of at least 3 genera: Escherichia. Klebsiella, and Enterobacter [21]. The process used to obtain the three types of ready-to-eat sesame involved some critical points as showed in Fig. 4 in red color. These critical points could be the ways through which microorganisms could reach the final product and cause public health issue. Controlling these critical points is essential to improve the quality of the final product. During the processing of sweet and salted dehulled sesame, a large amount of sugar and salt were added to give the sweet taste and dirt but also to improve the conservation of these products. Even thought, some sesame samples seem to have high number of microorganisms. According to [4], the addition of large amounts of salt or sugar can also be regarded as a simulated drying process, as it results in a reduction of the amount of water available for microbial growth. The dehulled sweet sesame after caramelization undergoes a manual kneading operation in order to give the desired shapes (circles, heart, lozenge…) to the final products (Fig. 4). This could be one of the reasons for its high coliform load. Sanitation and personal hygiene, especially during home-based food processing, needs improvement. According to [22], the tendency at present is to market dried fruits in the packaged form, the principal chances for contamination after drying would be from the hands of the person filling the package, if filling is done by hand, or from the package itself. Furthermore, there is a variation between the sesame samples in terms of visual quality. Some are more grilled, more sweet or more salted within the same group of samples. This suggested a lack of quality standards in sesame processing conditions. Therefore, it seems necessary to setup and respect Good Manufacturing practices (GMP), Good Hygiene Practices (GHP) and Good Standard Processing (GSP) by training the actors as the processing system of this field still artisanal.

In general, survival, growth and multiplication of microorganisms in food depend on various factors which may be classified simply into those that are intrinsic or associated with the food material and those that are extrinsic or associated with the environment surrounding the food [23]. Therefore, all materials used for processing should be clean immediately in order to ensure the quality of the next production as the total aerobic mesophilic bacteria is high in almost all the sample (92%) and varies from 3x10 to 6.12x105 CFU $g^{-1}$. Aerobic mesophilic bacteria are fermentative bacteria involved in food degradation and contribute to lowered the merchantable quality of food.

The presence of possible pathogenic organisms in these foodstuffs suggest a potential public health hazard to consumers. Fortunately, no *Salmonella* spp neither *E. coli* were found in any of our samples. It was expected to find those pathogens in the raw samples as no heating step are involved in this process. Biochemical tests used to confirm suspected *E. coli* was found to be some Klebsiella and Enterobacter species. Further molecular investigations are deeply needed to understand why no *Salmonella* spp neither *E. coli* were not found even in high load of thermotolerants coliforms. Indeed, raw sesame and sesame-based products are known to harbor sometimes *Salmonella* species. Previous studies on food quality in Burkina Faso raised the circulating pathogens such as *E. coli, Salmonella and Campylobacter*. [24] ; [25] highlight the presence of *S. enterica*, *Campylobacter* and *E. coli* in raw meat, poultry feces and carcasses in while [26] raised *E. coli* and *Salmonella* strains in milk and [27] isolated *E. coli* in Organic Waste Products from Cattle's Markets.

Statistical analysis revealed that there is correlation between the three different parameters (p-value $\leq$ 0.05) and the strength of this correlation, according to Pearson were 46.3%, 47.7% and 75.4% respectively between the total aerobic mesophilic bacteria and yeasts and moulds; between total aerobic mesophilic bacteria and the thermotolerant coliforms and finally between the thermotolerant coliforms and yeasts and moulds.

Sesame is a dehiscent dry food that low moisture allowed it to be store at ambient temperature without any treatment. In the absence of sesame safety standards, weak conditioning systems can favor microbial growth to unacceptable levels even supplement such as sugar have been added.

# Conclusion

Ready-to-eat sesame is produced and sold everywhere in Burkina-Faso by women processors associations. This business provides them some revenues to fight poverty. However, he presence of high rate of microorganism in these street food sesames which showed 32% of not satisficing not only point out the contamination rate due to intrinsic or extrinsic factors, but also highlight the high risk poses by these foods to consumers specifically in crowdy places. In regard of these results, we believed that we have to change the way we look at sesame safety in Burkina Faso because they can be a vehicle for microorganism's transportation. The importance of better organization of this field, adequate training for food handlers and their managers; in the view to decrease contamination rate is therefore emphasized.

# Abbreviations

RTE: Ready-To-Eat; CFU: Colony Forming Unit; IMViC: Indole, Methyl red, Vogues-Proskauer, Citrate; DW: Sweet dehulled sesame, DS: Salted dehulled sesame, RS: Raw sesame.

# Declarations


### Acknowledgments

The authors gratefully thank the Laboratoire National de Santé Publique (LNSP) staff, the Laboratory of Molecular Biology, Epidemiology and Foodborne/Waterborne Bacteria and Virus Surveillance (LaBESTA)/University Joseph KI-ZERBO of Ouagadougou. They also thank the sesame processors associations and all sesame street vendors


### Authors' contributions

MKAC: Conceptualization, Investigation, formal analysis, result analysis, writing-review& editing. RSB: Investigation, writing-review. MEMN: Formal analysis, result analysis, writing-review. VMY: investigation, writing-review. RD: Result analysis, writing-review. DSK: Result analysis, writing-review. EK: Conceptualization, supervision, review. NB: Conceptualization, supervision, Director of thesis, review. All authors have helped in revision and approved the final manuscript.


### Funding

Not applicable.


### Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

### Ethics approval and consent to participate

Not applicable.

### Consent for publication

Not applicable.

### Competing interests

The authors declare that they have no competing interests.

## References


1. Finn S, Condell O, Mcclure P, Amézquita A, Fanning S. Mechanisms of survival , responses , and sources of Salmonella in low-moisture environments. 2013;4(November):1–15. Available from: doi: 10.3389/fmicb.2013.00331
2. Grasso EM, Grove SF, Halik LA, Arritt F, Keller SE. Cleaning and sanitation of Salmonella-contaminated peanut butter processing equipment. Food Microbiol [Internet]. 2015;46:100–6. Available from: http://dx.doi.org/10.1016/j.fm.2014.03.003
3. Ijabadeniyi OA, Pillay Y. Microbial Safety of Low Water Activity Foods : Study of Simulated and Durban Household Samples. J Food Qual [Internet]. 2017;2017:7. Available from: https://doi.org/10.1155/2017/4931521
4. Beuchat LR, Komitopoulou E, Beckers H, Betts RP, Bourdichon F, Fanning S, et al. Low-water activity foods: Increased concern as vehicles of foodborne pathogens. J Food Prot [Internet]. 2013;76(1):150–72. Available from: doi:10.4315/0362-028X.JFP-12-211
5. Yameogo SF. La filière sésame au Burkina Faso: Analyse rétrospective de 1990 à 2017. Ouagadougou; 2018.
6. IMCG. Analyse de la chaine de valeur du sesame au Burkina Faso. 2018;211. Available from: https://europa.eu/capacity4dev/file/95184/download?token=wTbcr5xC
7. Stagnitta P V., Micalizzi B, Stefanini De Guzmán AM. Prevalence of some bacteria yeasts and molds in meat foods in San Luis, Argentina. Cent Eur J Public Health [Internet]. 2006;14(3):141–4. Available from: https://doi.org/10.21101/cejph.b0244
8. Jones M, Arnaud E, Gouws P, Ho LC. Effects of the addition of vinegar , weight loss and packaging method on the physicochemical properties and microbiological profile of biltong. 2019;156(May):214–21. Available from: 10.1016/j.meatsci.2019.06.003
9. Elleuch M, Bedigian D, Zitoun A. Sesame (Sesamum indicum L.) Seeds in Food, Nutrition, and Health. In: Nuts and Seeds in Health and Disease Prevention [Internet]. 2011. p. 1029–36. Available from: doi: 10.1016/B978-0-12-375688-6.10122-7
10. Bryan F, Michanie S, Alvarez P, Paniagua A. Critical control points of street-vended foods in dominican republic. J Food Prot [Internet]. 1988;51:373–83. Available from: https://doi.org/10.4315/0362-028X-51.5.373
11. Nicolas B, Abdoul R. B, Aly S, Amadou T. OC, Jules IA, Alfred S. T. Hygienic status assessment of dish washing waters, utensils, hands and pieces of money from street food processing sites in Ouagadougou (Burkina Faso). African J Biotechnol [Internet]. 2006;5(11):1107–12. Available from: https://doi.org/10.5897/AJB06.118
12. Odumeru JA, León-velarde CG. Salmonella Detection Methods for Food and Food Ingredients. 2000;(Williams 1981):374–92. Available from: doi: 10.5772/29526
13. Joseph-Pierre Guiraud. Microbiologie alimentaire. 2003rd ed. RIA, editor. Dunod. Paris, France: RIA; 2003. 652 p.
14. Couture G, Goulet-Grondin F, Dumont MM, Samson J. Lignes directrices et normes pour l'Interprétation des resultats analytiques en microbiologie alimentaire [Internet]. 2019th ed. Gouvernement du Québec, editor. Québec: Bibliothèque nationale du Québec; 2019. 58 p. Available from: http://www.mapaq.gouv.qc.ca/fr/Publications/recueil.pdf
15. Alaouie Z, Hallal N, Alkhatib A, Khachfe HM. Assessing the Microbial Quality of Tahini ( Sesame Paste ) in Lebanon. Glob Heal. 2017;6(c):20–5.

16. Kahraman T, Issa G, Ozmen G, Buyukunal S. Microbiological and chemical quality of tahini halva. Br Food J [Internet]. 2010;112 Iss 6:608–16. Available from: http://dx.doi.org/10.1108/00070701011052691
17. Ontario Agency for Health Protection and Promotion. Case Study : Pathogens and spices [Internet]. 2015th ed. Ontario QP for, editor. ©Queen's Printer for Ontario; 2016. 1-40 p. Available from: https://www.publichealthontario.ca/-/media/documents/c/2016/case-study-spices.ashx?la=fr
18. Cagri-Mehmetoglu A. Food safety challenges associated with traditional foods of Turkey. Food Sci Technol [Internet]. 2018;38(1):1–12. Available from: doi: 10.1590/1678-457x.36916
19. Compaoré KAM, Virginie MY, René D, Fulbert N, Kabré E, Nicolas B. Retrospective study of the contamination of exported sesame by Salmonella species from 2007 to 2017 in Burkina Faso. African J Agric Res [Internet]. 2020 Aug 31;16(8):1141–7. Available from: doi: 10.5897/AJAR2020.14917
20. Bitton G. Microbial indicators of fecal contamination : Application of microbial source tracking [Internet]. Department of Environmental Engineering Sciences University of Florida; 2005. Available from: http://saublesewer.devuna.com/Documents/20050610 FSA Microbial Source Tracking Report.pdf
21. Andrews W. Manuals of food quality control, Chapter 4 - Microbiological analysis. 1992.
22. Clague JA. Studies on the microbiology of dried foods. Doctoral Dissertations 1896 - February 2014. 910. https://scholarworks.umass.edu/dissertations_1/910; 1935. 65 p.
23. Opinion S. Scientific Opinion on the risk posed by pathogens in food of non-animal origin . Part 1 ( outbreak data analysis and risk ranking of food / pathogen. 2013;11(1). Available from: doi: 10.2903/j.efsa.2013.3025.
24. Kagambèga A, Haukka K, Siitonen A, Traoré AS, Barro N. Prevalence of Salmonella enterica and the hygienic indicator Escherichia coli in raw meat at markets in Ouagadougou, Burkina Faso. J Food Prot [Internet]. 2011;74(9):1547–51. Available from: doi:10.4315/0362-028X.JFP-11-124
25. Kagambèga A, Thibodeau A, Trinetta V, Soro DK, Sama FN, Bako É, et al. Salmonella spp . and Campylobacter spp . in poultry feces and carcasses in Ouagadougou , Burkina Faso. 2018;(June):1601–6. Available from: doi: 10.1002/fsn3.725
26. Bagré TS, Kagambèga A, Bawa HI, Bsadjo G. Antibiotic susceptibility of Escherichia coli and Salmonella strains isolated from raw and curds milk consumed in Ouagadougou and Ziniaré , Burkina Faso. 2013;(June 2014). Available from: doi: 10.5897/AJMR2014.6632
27. Bako E, Traore KA, Bagre TS, Ibrahim HB, Bouda SC, Juste I, et al. Characterization of Diarrheagenic Escherichia coli Isolated in Organic Waste Products ( Cattle Fecal Matter , Manure and , Slurry ) from Cattle ' s Markets in Ouagadougou , Burkina Faso. 2017; Available from: doi:10.3390/ijerph14101100

# Figures

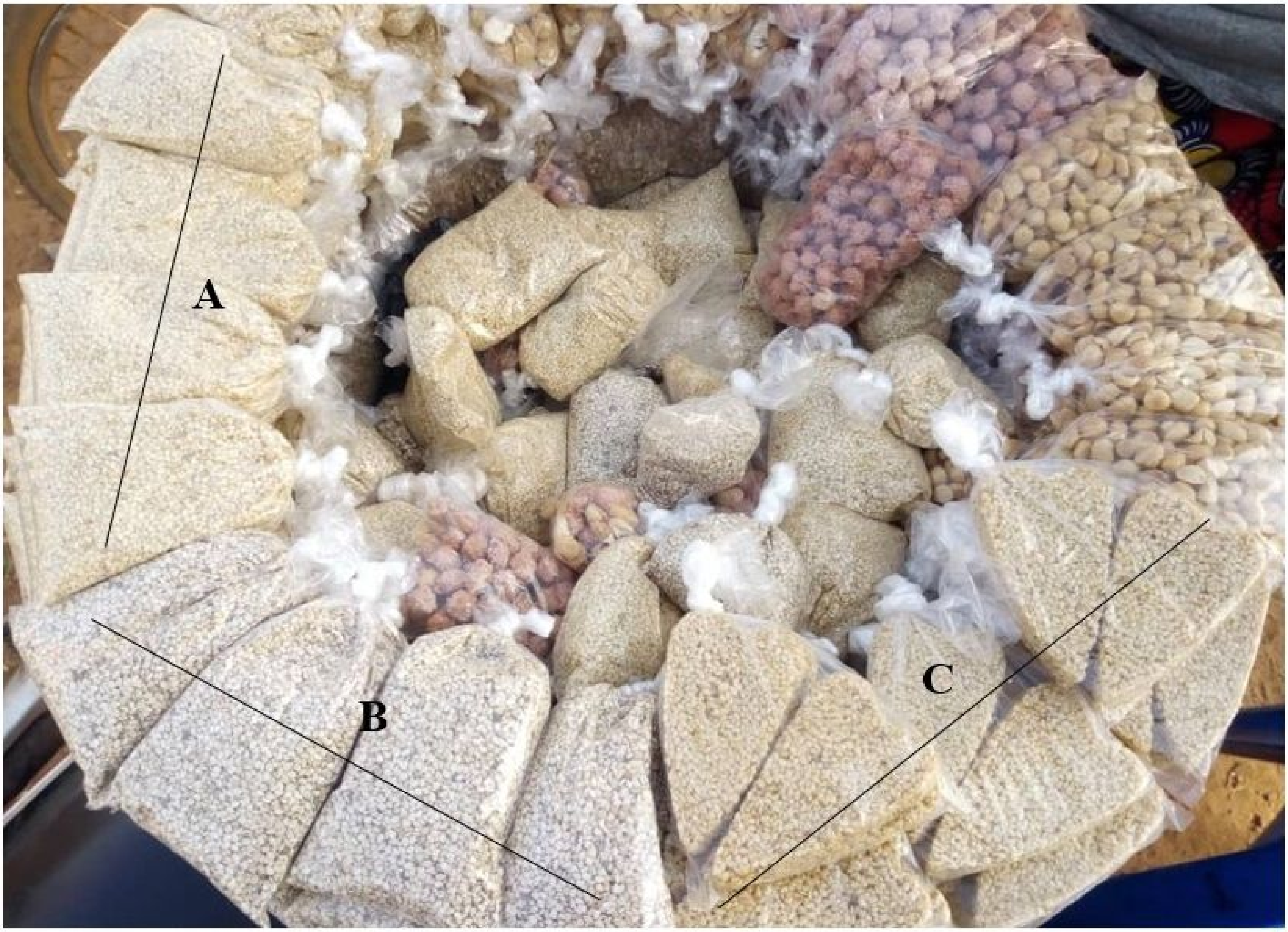
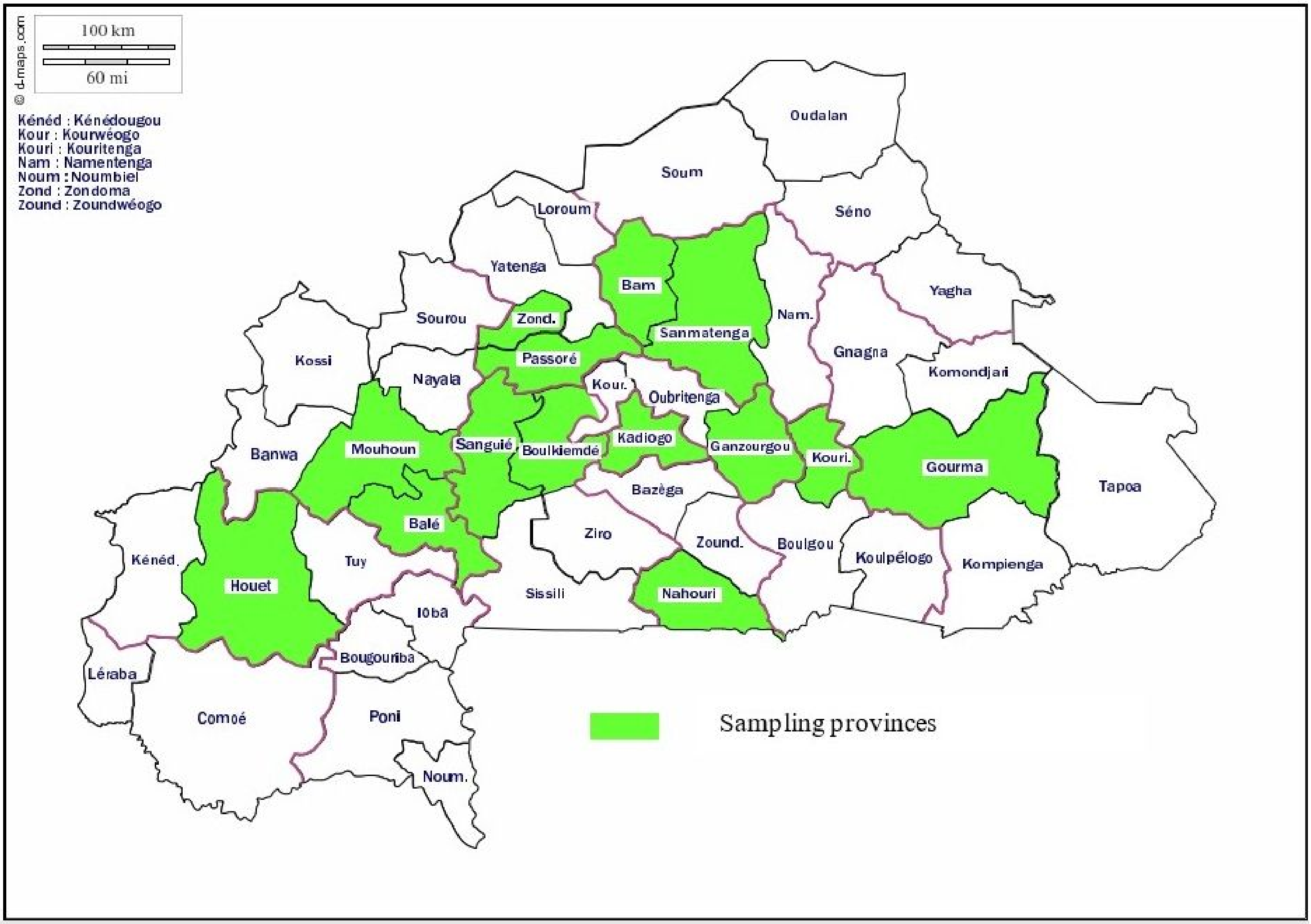



**Figure 1**

Street vendor set: A= Salted dehulled sesame; B= Raw sesame; C= Sweet dehulled sesame. Black line indicated the limit of each sample

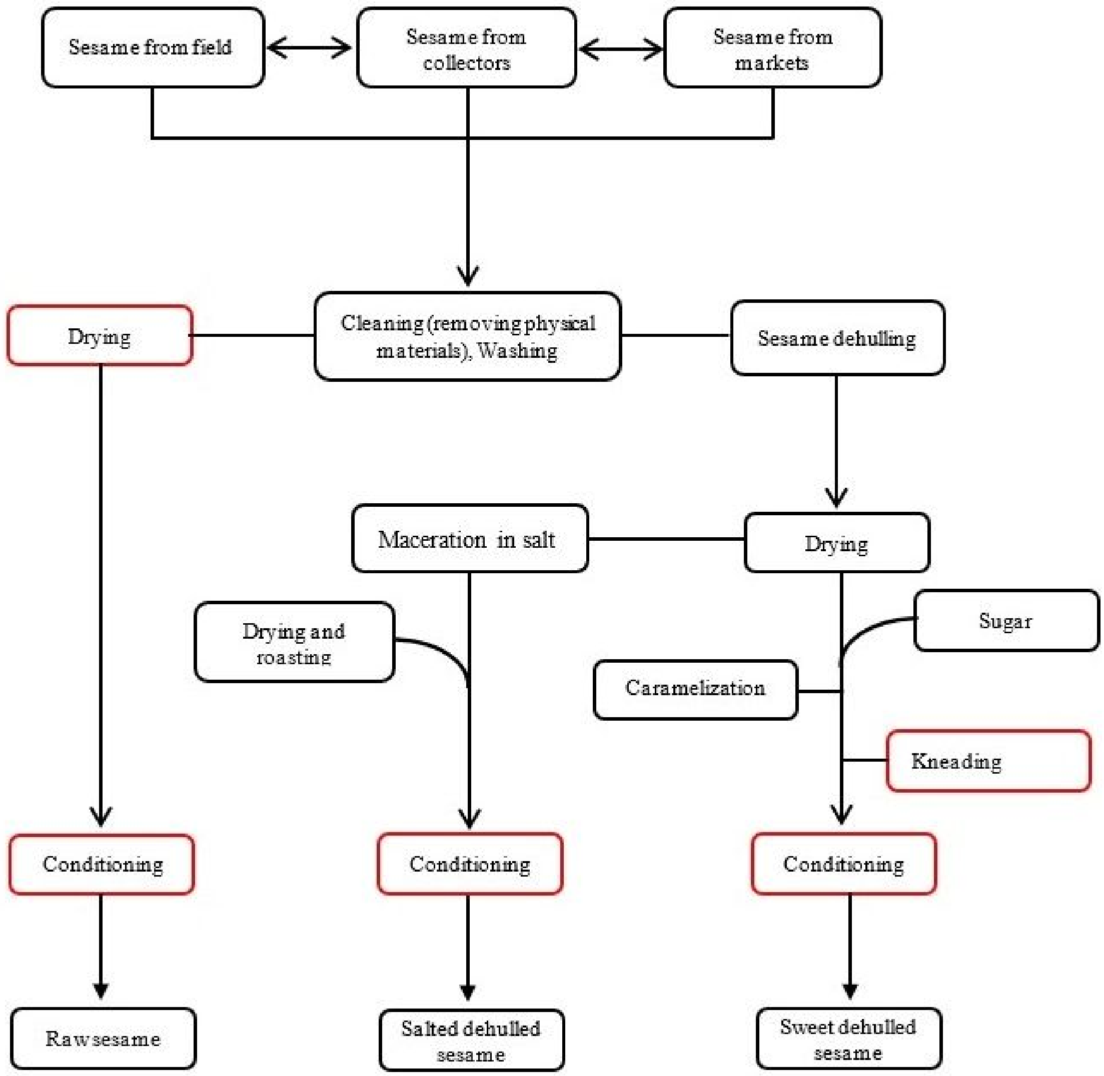

### Figure 2

The three different categories of processed edible sesame (A= Salted dehulled sesame; B= Raw sesame; C= Sweet dehulled sesame)




## Figure 3

Source : https://www.d-maps.com/carte.php?num_car=25733&lang=fr Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.




## Figure 4

ready-to-eat sesame processing flowchart. Red color indicates critical points

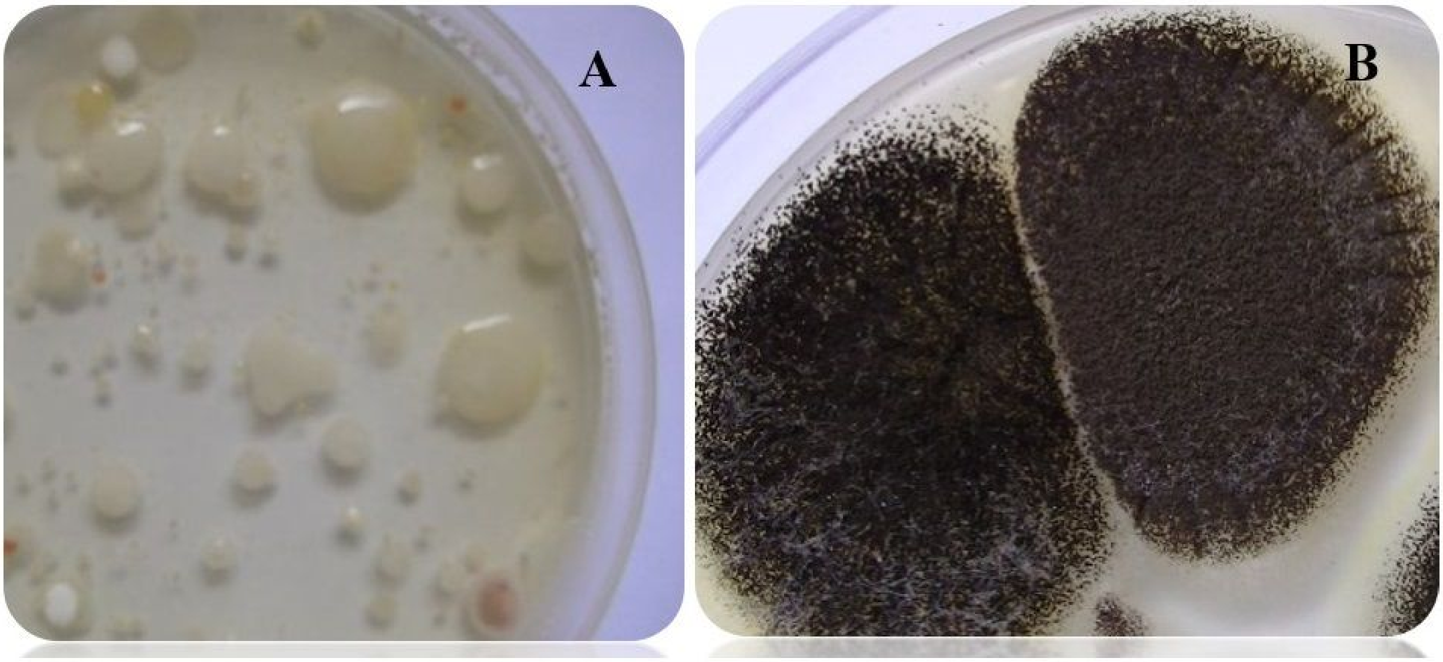



Figure 5

predominant morphologies of yeast and mold encountered. 5A: yeast colonies; 5B: molds colonies