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Quality of Fresh Camel Meat (*Camelus dromedarius*) Sold at Retail Houses in Bechar City (Southwest of Algeria): Physicochemical and Hygienic Approaches

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ABSTRACT

Background: Meat is the first source of animal protein, its richness in essential amino acids classifies it among the noble proteins. However, due to its nutritional qualities, meat constitutes a favorable ground for microbial development and can serve as a source of foodborne pathogens for consumers. Hence this study aimed to evaluate the hygienic quality of fresh camel meat marketed in Bechar city (Southwest of Algeria).

Methods: At the butcher's shops in the Bechar El Djadid's market, the taken samples underwent analyzes of a few physicochemical and microbiological parameters. The suspected pathogenic isolates were confirmed using biochemical tests.

Result: The physicochemical parameters results showed that the samples had slightly acidic pH values ranging from 5.25 to 5.86, the temperature from 6 to 7.5°C and the total solid content (TSC) ranging from 21 to 36.6% with a moisture rate ranging from 63.4 to 75.6. However, the obtained microbiological results showed a load of *Escherichia coli* of 3.3 and 4.83 Log_{10} CFU/g for the samples S1 and S2, respectively, exceeding the threshold set by national standards. The analyzed samples had a load of *S. aureus* (CoPS) ranging from 3.78 to 5 Log_{10} CFU/g, with the presence of *Salmonella choleraesuis ssp arizonae* for the sample (S1), while both *Listeria monocytogenes* and *Pseudomonas spp* species were absent in all the analyzed samples. The lactic acid bacteria (LAB) load ranged from 2.36 to 2.74 Log_{10} CFU/g. In conclusion, four out of five analyzed samples had an unsatisfactory quality. This is the result of a lack of hygiene in one of the links in the raw material supply chain, from the slaughterhouse to the retailer, whose stakeholders must ensure cleanliness and compliance with good hygiene practices (GHP) to protect consumers against microbial risks.

Key words: Camel meat, GHP, Hygienic, Physicochemical quality.

INTRODUCTION

Although representing less than 1% of the red meat market, camel meat is the subject of growing interest among pastoralists and consumers in arid and semi-arid countries, both from an economic and a dietary point of view (Faye *et al.,* 2013; Sadoud *et al.,* 2019), where the climate negatively affects the production efficiency of other domestic livestock (Fallah *et al.,* 2008; Suliman *et al.,* 2020). In arid areas, there are pastures made from grass species of *Aristida pungens* and *Panicum turgidum* and fodder shrubs such as the many acacias. It is the camel breeding area par excellence, which occupies a preponderant place in the agricultural and social life of local populations (NEPAD-CAADP, 2006).

During the (2007-2017) decade, the Algerian camel herd increased from 286,670 heads in 2007 to 381,882 heads in 2017 (Sadoud *et al.,* 2019), a breeding potential confined to three main zones of reproduction (East, South-West and South) and distributed over 17 provinces where a rate of 83% is confined to eight (8) Saharan provinces: Tamanrasset, Adrar, Tindouf, El-Oued, Ouargla, Illizi, Ghardaia and Bechar (DESA, 2003; Senoussi *et al.,* 2017; Benyagoub, 2019). The western part of Algeria is known for its important distribution of the Rguibi breed which was originally reared by the Reguibat tribe (Cherifi *et al.,* 2017). The increase in the number of camels heads is the result of several camel breeding development programs set up by the Algerian state. Camel breeding only experienced a considerable boost starting from 2000, following the promulgation by the Ministry of Agriculture of the birth premium, which is a kind of financial assistance granted to herders for any birth of a new camel (Bedda, 2014; Sadoud *et al.,* 2019). This policy has contributed to the supply of the local market with a significant quantity of camel meat

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exceeding 5400 tons (FAO, 2013), where the carcass of the male dromedary can weigh 400 kg or more, the female camel can weigh from 250 to 350 kg (Knoess, 1977; Yousif and Babiker, 1989). Due to its nutritional value and socio-economical importance, camel meat is considered a functional food, a good source of minerals, vitamins and bioactive compounds (Suliman *et al.,* 2020) making it an essential supply for a balanced food intake. Therefore, its hygiene is essential for public health, as the consumption of poor quality meats can lead to foodborne illness (Yehia *et al.,* 2021). Meat constitutes a favorable ground for microbial development, mainly proteolytic bacteria which lead to harmful changes in organoleptic properties: smell, color, texture and produce toxic substances (Fguiri *et al.,* 2021). Most bacteria grow quickly in fresh, non-acidic foods like meat, fish and vegetables, causing them to spoil. Others form spores which make them resistant to preservation techniques and resume their multiplication upon return to favorable conditions (De Reynal and Multon, 2009).

It is in this context that the present study takes place, aiming to analyze the physicochemical and the microbiological quality of some samples of fresh camel meat, from the Rguibi camel breed, marketed in the Bechar El Djadid market, a site known for its strong marketing of this product, in order to estimate the hygienic quality of the product at the level of the retail houses in Bechar city.

MATERIALS AND METHODS

The reagents and culture media used in this study consist of ingredients of uniform grade and chemicals of analytical grade or the highest purity available. The various analyzes were carried out at Mohammed TAHRI University of Bechar (Algeria) for two months from April 1st, 2021.

Sampling

The camel meat samples to be analyzed were purchased from the Bechar El Djadid market. The latter is experiencing strong marketing of this product (Table 1).

After the purchase, the sample was put in a refrigeration system (an isothermal cooler) and sent as quickly as possible to the laboratory for its analysis.

Microbiological analysis

The microbiological analyzes were carried out according to the standards established by the American Public Health Association (APHA) (Salfinger and Tortorello, 2015).

Stock solution and decimal dilution

The prepared stock solution was in the order of 10^{-1} with physiological water (0.9%) as the diluent (JORA n.38, 2014). Homogenization of the sample was held in a stomacher sterile blending bag, using a homogenizer (Seward stomacher 400 circulator, England) for 8-10 min (Fig 1).

National regulations (JORA n.39, 2017) require that the sample must be composed of five units to have a representative one (sampling plan n=5). From the stock solution, a series of decimal dilutions were prepared (up to the 10^{-5} dilution) with the same diluent.

Microbial parameters analyzed

According to national regulations (JORA n.39, 2017), the microorganisms to be searched belong to the following bacterial groups: *Escherichia coli*, *Pseudomonas sp* and *Salmonella sp*. In addition to these three bacterial parameters, we also analyzed the following parameters: Total Aerobic Mesophilic Flora (TAMF), Coagulase Positive Staphylococci (CoPS), *Listeria monocytogenes*, sulfite reducing Clostridia, yeasts and molds.

Search and enumeration of the microbial parameters mentioned above were carried out as follows:

- Search and enumeration of the total aerobic mesophilic flora were carried out by the pour plate technique on PCA (Plate Count Agar). The Petri dishes were incubated at 22 and 30°C for 72 hours.
- The total coliforms (TC) and thermotolerant or Fecal Coliforms FC (*Escherichia coli*) were isolated by the pour plate technique on MacConkey agar medium. The Petri dishes were incubated at 30 and 44°C for 24 to 48 hours.
- Search and enumeration of spores of sulfite reducing Clostridia (SRC) by the pour plate technique on Meat-Liver Sulfite Iron Agar in a tube after having exposed the stock solution to heat-shock at 80°C for 10 minutes. The tubes were incubated under anaerobic conditions at 46°C for 24 hours.
- Search and enumeration of *Pseudomonas spp* by spread plate technique on cetrimide agar. The Petri dishes were incubated at 37°C for 24 hours.
- Staphylococci were isolated using the spread plate technique on Baird-Parker agar medium. The petri dishes were incubated at 37°C for 24 hours.
- Search for *Listeria monocytogenes* was carried out in three stages:

Primary enrichment on half Frase broth, then secondary enrichment on Fraser broth and thirdly, isolation on PALCAM Listeria agar. The Petri dishes were incubated at 37°C for 24 hours.

Table 1: Sampling frequency and dates for collection of camel meat.

Samples	Dates of sampling
S1	April 19th, 2021
S2	April 25th, 2021
S3	May 1st, 2021
S4	May 5th, 2021
S5	May 8th, 2021

Fig 1: Camel meat sample in Stomacher bag.

- Search for *Salmonella sp* was carried out in three stages (NF V08-052, 1993): A pre-enrichment on Buffered Peptone Water (BPW), then, a selective enrichment on Vassiliadis broth (RV) and Selenite Cystine broth (SC) and finally, isolation on Hektoen agar and Salmonella Shigella agar. The Petri dishes were incubated at 37°C for 24 hours.
- Search and enumeration of yeasts and molds (Fungal Flora 'FF') were carried out by spread plate technique on Potato Dextrose Agar supplemented with lactic acid. The Petri dishes were incubated at 25°C for 3 to 5 days.
- Search and enumeration of lactic acid bacteria (LAB) were carried out by the pour plate technique (double layer) on MRS (De Man, Rogosa and Sharpe) agar medium incubated at 30°C for 72 hours.

Identification of isolates

The suspected pathogenic isolates namely *Staphylococcus aureus*, *Salmonella* spp, *Listeria monocytogenes* underwent biochemical tests, mainly: Coagulase test, catalase test, urease test, oxidase test and esculin hydrolysis test (Tille, 2018, Benyagoub *et al.,* 2018a).

Physicochemical analysis

The physicochemical analysis was limited by four parameters namely: pH measurement, temperature, determination of total solid content and moisture rate, carried out as follows:

- The pH was measured using a multi-parameter pH meter (Adwa AD 1040, Romania) (JORA n.23, 2006). The device was calibrated first.
- The temperature (T°C) of the samples was measured using an electronic thermometer.
- The total solids content (TSC) is the group of all substances which do not volatilize under specific physical conditions. Moisture content (M%) was measured using the evaporation method of a mass of meat of 10 g at 105°C for 2 to 3 hours. The process was repeated until the weight of the meat sample stabilized. The moisture content was expressed in (%) and calculated according to the following formula:

$$M(\%) = \frac{m1 - m2}{m1} \times 100$$

Where,

m1 and m2 are the masses in (g) of the sample before and after drying, respectively.

Thus, the total solids content (TSC) was calculated by the following formula (JORA n.01, 2006):

$$TSC(\%) = (100 - M)$$

Where,

M (%): Moisture content in (%).

Interpretation of microbiological analysis

The hygienic quality of the analyzed samples was judged based on the m and M contamination limits (m and M) given by the official journal (JORA n.39, 2017). Microbial parameter results were expressed as Log_{10} CFU/g and graphical presentations were plotted as a curve using Origin 2018 software.

RESULTS AND DISCUSSION

Microbiological analysis

The microbiological analysis results of camel meat samples are shown in Fig 2, 3 and 4. Fig 2 shows the load of total aerobic mesophilic flora (TAMF) and fungal flora (FF) which ranged from 3.87 to 6.48 Log_{10} CFU/g and 3.41 to 4.58 Log_{10} CFU/g, respectively. The lactic acid bacteria (LAB) load ranged from 2.36 to 2.74 Log_{10} CFU/g. Samples 2 and 3 were the most loaded among the analyzed samples.

Fig 3 shows the bacterial contaminants load (spores of sulfite reducing Clostridia and coliforms) which ranged from 3.78 to 5.11 Log_{10} CFU/g for total coliforms, while samples 1 and 2 had a fecal coliforms load of 3.3 and 4.83 Log_{10} CFU/g, respectively. However, *Escherichia coli* was absent for the samples S4, S4 and S5. Sample S3 experienced soil contamination by spores of sulfite reducing Clostridia with a load of 1.6 Log_{10} CFU/g.

Fig 4 shows the bacterial pathogenic bacteria load, where the analyzed samples had a CoPS load ranging from 3.78 to 5 Log_{10} CFU/g exceeding national regulations, with the presence of *Salmonella choleraesuis ssp arizonae*, only

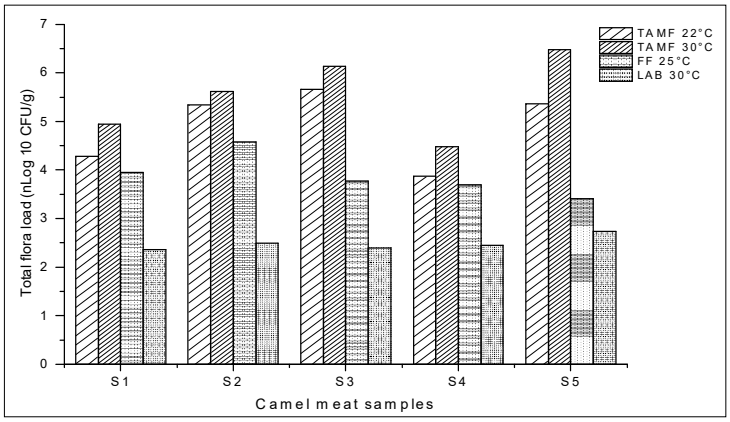

Fig 2: Total flora load of camel meat samples.

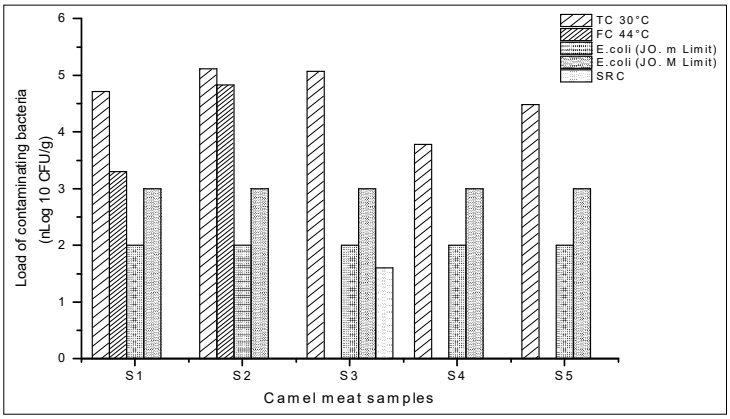

Fig 3: Bacterial contaminants load (fecal and soil origin) of camel meat samples.
JO: Official Journal; m and M: Minimum (m) and maximum (M) contamination lmit.

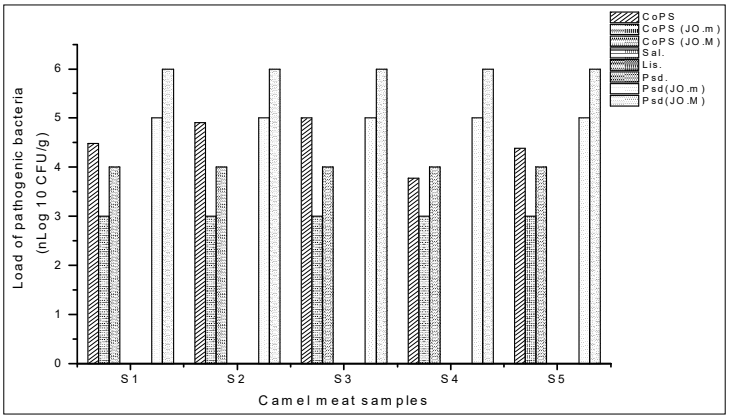

Fig 4: Pathogenic bacteria load of camel meat samples.
CoPS: Coagulase positive *Staphylococci*; Sal: *Salmonella* ssp.; Lis: Listeria monocytogenes; Psd.: *Pseudomonas* spp.;
JO: Official Journal; m and M: Minimum (m) and maximum (M) contamination lmit.

in the sample (S1) and the absence of *Listeria monocytogenes* and *Pseudomonas spp* in all the analyzed samples.

Except for the *S. aureus* species isolated on the Baird-Parker agar medium and the *Escherichia coli* species isolated on the MacConkey medium, the identification results of the strains isolated during the search for pathogenic bacteria are given in Table 2 and Fig 5 below.

Physicochemical analysis

The physicochemical analysis results of camel meat are presented in Fig 6.

According to the obtained results, the analyzed samples had slightly acidic pH values between 5.25 and 5.86, temperature values ranging from 6 to 7.5°C, while, moisture (M%) and total solids content (TSC) were ranged from 63.4 to 75.6% and 21 to 36.6%, respectively.

The dromedary is of significant socio-economic importance in many arid and semi-arid regions of the world and its milk and meat constitute an important component of the human diet in these areas (Benyagoub and Ayat, 2015; Abrhaley and Leta, 2018). Camel meat is known for its nutritional and therapeutic properties, hence the importance of this study which aimed to estimate the hygienic quality of fresh camel meat sold at the market of Bechar El Djadid (Bechar, Southwest of Algeria).

According to the literature data, camel meat is considered a healthy food, it contains 64 to 78% water, 18.6 to 22.8% protein, 1.1 to 10.5% fat and 1 to 1.4% ash, with a cholesterol level lower than that of other farm animals and it is rich in polyunsaturated fatty acids (Fallah *et al.,* 2008; Kadim *et al.,* 2008; Eskandari *et al.,* 2013). The latter is an important factor in reducing the risk of cardiovascular disease (avoiding atherosclerosis), controlling obesity and reducing the risk of cancer and the diseases that are often linked to the consumption of saturated fat (Abrhaley and Leta, 2018).

Besides nutritional characteristics, therapeutic properties are attributed to camel meat in many cultures around the world for cures and remedies of many ailments such as seasonal fever, sciatica, shoulder pain, asthma, freckle removal and improved performance. Compared to meats from other domestic animal species, the lower level of pollutants in camel meat's diet is well noted (Abrhaley and Leta, 2018).

For the analyzed physicochemical parameters, the pH of the samples was slightly acidic ranging from 5.25 to 5.86.

This result was similar to the results obtained by Eskandari *et al.* (2013) and Touati (2017) where the pH values varied between 5.4 and 5.78 and from 5.53 to 5.67, respectively, for camel meat after 24 hours of slaughter. According to Eskandari *et al.* (2013), young camels had higher pH values than older ones; this may be due to lower glycogen stores in young animals. Additionally, the slower degradation of glycogen and subsequent accumulation of lactic acid in camels is attributed to their unique ability to starve for a long time (Eskandari *et al.,* 2013).

Table 2: Identification of presumed pathogenic bacteria contained in 25 g of camel meat.

B. parameter / Sample	*Salmonella spp*	*L. monocytogenes*
S1	+ve (*S. choleraesuis ssp arizonae*)	-ve (*Kluyvera spp*)
S2	-ve (*Enterobacter sakazakii, Escherichia coli)*	-ve
S3	-ve (*Enterobacter sakazakii, Proteus vulgaricus)*	-ve
S4	-ve (*Citrobacter freundii*, *Proteus vulgaricus, Serratia odorifera*)	-ve
S5	-ve (*Proteus penneri*)	-ve (*Moellerella wisconsensis*)

B. parameter: Bacterial parameter, Sample: Camel meat samples; +ve: A positive culture for a presumed isolate; -ve: A negative culture for a presumed isolate.

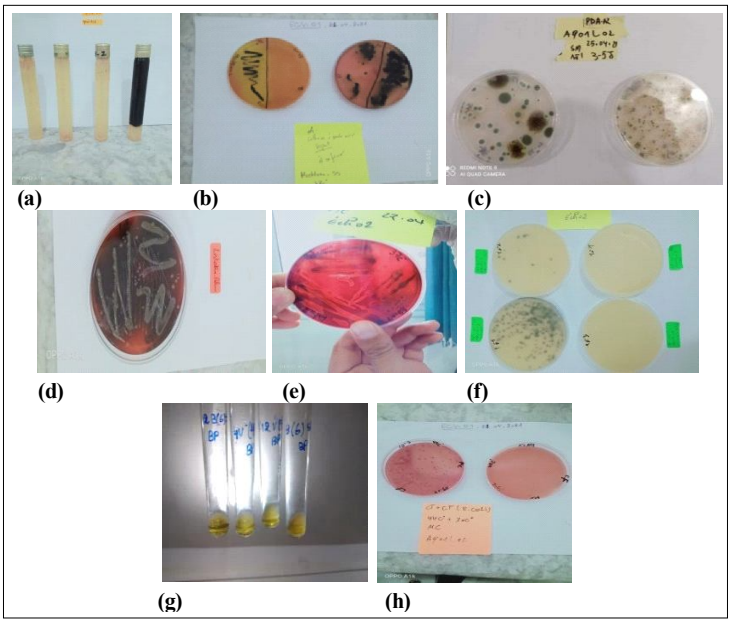

Fig 5: Isolation and identification of microbial strains contaminating fresh camel meat (Original, 2021).
(a): Spores of sulfite reducing clostridia; (b): *Salmonella sp*; (c): Fungal Flora; (d): Presumed *Listeria sp* (S3); (e): Presumed *Listeria sp* (S2); (f): *Staphylococcus aureus* (CoPS); (g): Coagulase test; (h): Total and fecal coliforms (S1).

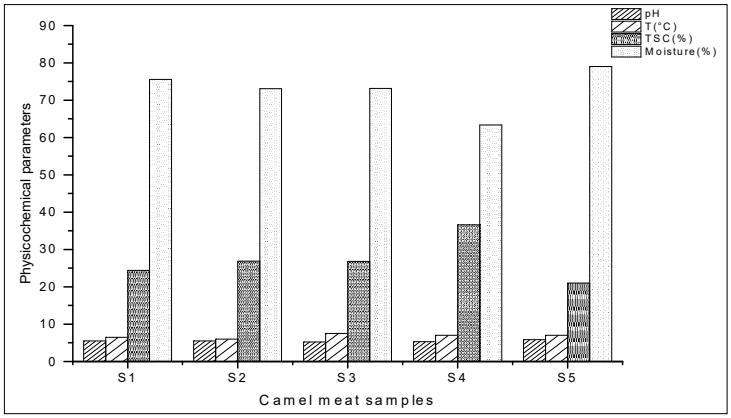

Fig 6: Physicochemical parameters of the camel meat samples.

The moisture content was ranging from 63.4 to 75.6%. These values corroborate what was reported by Touati (2017) where the average value of the moisture content was 74.91%, with a dry matter rate ranging from 21.56 to 26%. According to literature data, camel meat contains significantly less fat and more moisture compared to other farm animals (Fallah *et al.,* 2008). These variations are at the origin of several factors linked on the one hand to the age and the camel species such as the state of health of the dromedary, the physiological variations, the feeding conditions and on the other hand linked to the environment of the samples, namely the type of muscle, the lipid content and the storage conditions (Touati, 2017).

The microbiological analysis results indicate that the total flora for three samples (S2, S3 and S5) exceeds the load recommended by the international standard set at 5 Log_{10} CFU/g. The aerobic plate count 'APC' is a measure of the microbial quality of the meat. Any exceeding of this load could be a spoilage indicator (Tegegne *et al.,* 2019). These results are in agreement with the results obtained by Fallah *et al.* (2008), where the load of APCs was 5.08 Log_{10} CFU/g. Moreover, the Fungal Flora (FF) load ranged from 3.41 to 4.58 Log_{10} CFU/g corroborates the results obtained by Fallah *et al.* (2008); Tegegne *et al.* (2019) which were 4.11 and 4.95 CFU/g, respectively. Regarding the lactic acid bacteria 'LAB', the analyzed samples had loads ranging from 2.36 to 2.74 Log_{10} CFU/g. These results were lower than those given by Fallah *et al.* (2008), where the LAB load found was 3.6 Log_{10} CFU/g and this was probably due to the freshness of the camel meat.

The analyzed samples had a total coliform load ranging from 3.78 to 5.11 Log_{10} CFU/g and the fecal coliform obtained results exceeded the threshold set by national regulations for the samples (S1 and S2) and the other three samples were fecal coliforms-free. The total coliforms results were higher than that analyzed by Fallah *et al.* (2008) (3.78 to 5.11 Log_{10} CFU/g vs. 3.61 Log_{10} CFU/g). In fact, concerning the hygienic quality of the camel meat, it was found that our samples remain more hygienic than Fellah *et al.*'s (2008) sample, where the *Escherichia coli* species was detected in all camel meat samples at t=0 up to 6 days of storage and even better than that obtained by Tegegne *et al.* (2019) where the average load of the fecal coliforms (FC) for the camel meat samples sold at retail was 6.17 Log_{10} CFU/g. Tegegne *et al.* (2019) noted that the *S. aureus* and *E. coli* O157: H7 load was higher in retail meat than in slaughter carcasses. This confirms the common lack of hygiene at the level of the retail houses and the high detection rate of fecal coliforms is an indication of contamination at the slaughterhouse through intestinal contents and unsanitary handling of meat or the effectiveness of sanitary measures deemed unsatisfactory in retail stores (Latifou Belco *et al.,* 2017; Tegegne *et al.,* 2019). The *S. aureus* load was higher than that obtained by Fallah *et al.* (2008) (from 3.78 to 5 Log_{10} CFU/g vs. 3.8 Log_{10} CFU/g). This indicates exogenous contamination often at the origin of the skin of the animal itself, the body or hands of the handler, the equipment or tool used both at the slaughterhouse or in retail houses level (Latifou Belco *et al.,* 2017; Fguiri *et al.,* 2021), then for the pathogenic species *L. monocytogenes*, our results which were negative and remain hygienically better than the results obtained by Fallah *et al.* (2008) and Tegegne *et al.* (2019) (3.91 Log_{10} CFU/g and 11 CFU/g, respectively), Nevertheless, when exposed to excessive temperatures and with sufficient time, L. *monocytogenes* can multiply exponentially to a level where high-risk groups are particularly threatened upon consumption of the undercooked camel meat (Buchanan *et al.,* 2017; Tegegne *et al.*, 2019).

The analyzed samples were *Pseudomonas spp*-free. However, the results obtained by Fallah *et al.* (2008) revealed a load of *Pseudomonas spp* of 3.33 Log_{10} CFU/g. Furthermore, the detection of *Salmonella spp* in one sample (S1) corroborates the results obtained by Fallah *et al.* (2008), where *Salmonella sp* was isolated from two (2) samples of unirradiated camel meat and one sample of irradiated camel meat (1.5 kGy). According to Yehia *et al.* (2021), zoonotic microbes, such as *Enterococcus sp*, *Staphylococcus aureus* and *Campylobacter spp*. and many other food-borne pathogens contaminate meat and the gastrointestinal tract of food-producing animals, as a reservoir of microbial contaminants, can harbor many of these pathogens, that can contaminate meat during processing in a slaughterhouse, leading to subsequent human illness.

The studies carried out by Rahimi *et al.* (2010); Abrhaley and Leta (2018), revealed that few reports are indicating a lower prevalence of different microorganisms in camel meat compared to other farm animal species namely lamb, goat and beef, or the availability of natural antagonists against pathogenic species.

The contamination of the revealed fecal origin, which exceeded the threshold set by national regulations, was probably the result of a lack of hygiene in one of the links in the raw material supply chain (slaughterhouse), local, transport, handling and storage condition, where the role of inspection services such as the communal office of hygiene and inspectors from the trade department and laboratories of CACQE 'Algerian Center for Quality and Packaging Control' in public health and hygiene, prevention against food poisoning, water-borne disease, zoonoses and other health problems remain quite important and must ensure cleanliness and respect of good hygiene practices to prevent consumers from all the risks associated with the consumption of a product that does not comply with the regulations and established standards (CAC/RCP-3, 1997; Benyagoub *et al.,* 2018b).

CONCLUSION

Despite the absence of pathogenic bacteria such as *Listeria monocytogenes* and *Pseudomonas spp* in our samples, the microbiological quality of the analyzed camel meat samples was poor or even unsatisfactory due to the high level of fecal contamination (origin-coliforms) and CoPS. This

requires rigorous hygiene measures to improve the microbial quality of camel meat. Therefore, good hygienic practices as sanitary measures should be taken at all stages (mainly air, water and knives used to slaughter), in slaughterhouses and retail houses and a strict slaughter process should be followed to improve the overall quality and safety of camel meat available in Bechar El Djadid market.

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Conflict of interest: None.

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