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# Assessment of the Quality of Sheep Meat Consumed in Some Regions of Algeria

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**Abstract:**

This study aims to evaluate the quality of sheep meat marketed in three Algerian regions (Djelfa, Tiaret and Relizane). Samples were taken randomly immediately after slaughter from a leg of lamb of the local breed, aged between six and eight months and of uniform size. The results obtained showed a water deficiency (dehydration of the three meats), a pH ranging between 5.41±0.82 and 5.64±0.2, and a good water retention capacity in the meat from Relizane compared with the meat from Djelfa and Tiaret. The levels of dry matter, minerals, lipids and proteins are fairly similar and in line with the standards set by the official Algerian journal. In the regions of Tiaret and Relizane, the microbiological quality of the meat was satisfying, while that of Djelfa was considered unsatisfactory due to an excessive concentration of faecal coliforms, which exceeded established standards. Based on these findings, we infer that slaughter conditions, handling, preservation methods and production methods (feeding during the dry season) have an impact on the quality of sheep meat.

Keywords: Sheep meat; Physico-chemical quality; Microbiological quality; Nutritional quality

## 1. Introduction

Meat is the result of the conversion of muscle following the death of the animal. Four factors are taken into account when assessing its quality: organoleptic, technological, hygienic and nutritional [1]. Because of its high protein content of excellent biological quality, it is considered one of the essential foods in a balanced diet, making it a valuable source of nutrition. Each country has its own pattern of meat consumption, influenced by factors such as history, climate and culture. Consumer preferences when it comes to meat vary from one continent to another [2].

In the north and west of Algeria, mutton and beef are the most prized meats, while camel meat is a major player in meat production in the south. In the current context, consumption practices and, above all, expectations are generally synonymous with quality. This is particularly true of mutton. Farming factors have a significant impact on meat quality, particularly from a nutritional point of view. These include genetics (breed, lineage), physiology (gender, age at slaughter, castration) and rearing methods (feed, management, free-range rearing, …etc.) [3, 4].

Several researches have been carried out around the world to establish the technological and organoleptic characteristics of sheep meat. However, there has been little research into the properties of meat in our country. In this context, this research aims to assess the quality of sheep meat, in particular lamb, sold in three regions of western Algeria.

## 2. Materials

### 2.1. Study areas

The present study involved three samples of meat from a 6-month-old leg of lamb. Random samples were taken in the regions of Djedouia (wilaya of Relizane, in the north-west of Algeria), Tiaret (high plateau area), and Ain Ouassara (wilaya of Djelfa, located between the north and the south).

## 2.2. Methods

### *2.2.1. Sample collection*

Samples were taken in accordance with the decree of December 25/2005 published in JORA[1] n° 27 /2006 [5]. Samples were taken under normal marketing conditions, where the butcher, using a sterile knife, cuts five 200 g samples of leg meat. These samples were individually wrapped in sterile freezer bags, labelled and transported in an isothermal cooler directly to the laboratory.

### *2.2.2. physico-chemical quality*

1) Hydrogen potential (pH)

The pH of raw meat samples was determined according to the method described in the decree of January 15, 2006 JORA n° 27 /2006 [5] where a mass of 5 g of dry matter is placed in 25 mL of distilled water. The suspension was homogenized using a homogenizer. The pH was measured directly on a pH meter.

2) Dry matter content

As indicated in AOAC 2005 [6], dry matter content is determined by dehydrating a 5 g test portion of each sample in an oven (105°C ± 1C°) for 24 hours), after cooling the crucibles in a desiccator. The dry matter is then weighed, and the amount of water evaporated is deducted from the difference with the initial mass. The water or dry matter content of samples is expressed in g/100g of tissue. The percentage of dry matter (DM) in the sample is calculated using the following expression**:**

$$(\%)DM = \frac{Mass(MS)}{Mass(Sample)} \times 100 \quad (1)$$

3) Mineral content

Ash content in meats is determined in accordance with Pirez et *al* [7], which involves incinerating 1 g (±0.1) of meat (previously ground) in a muffle furnace at 550°C for 4 hours. The ashes contained in the crucibles are then transferred to a desiccator and weighed using a precision balance. The operation is repeated three times and the results are expressed as mean ± standard deviation according to the following formula:

$$\text{Ash content } (\%) = \frac{M_2 - M_0}{M_1 - M_0} \times 100 \quad (2)$$

With:
$M_0$ = weight of the empty crucible
$M_1$ = weight of the empty crucible +the sample
$M_2$ = crucible weight + calcined residue

4) Organic matter

Organic matter content is obtained by subtracting ash (or total mineral matter) from dry matter.

### *2.2.3. Nutritional quality of meat samples*

1) Fat content

Soxhlet extraction[2] is a simple and convenient method which allows the extraction cycle to be repeated endlessly with fresh solvent until the solute in the raw material is completely exhausted. The method recommended for its determination is that of [8], whose procedure consists in Drying the extraction apparatus flask for 1 h in an oven set at 105±1°C. After cooling, add 50 mL of hydrochloric acid to the test sample and cover the conical flask with a small watch glass. Heat the conical flask until the contents start to boil, maintain boiling for 1 h, stirring occasionally, add 150 mL hot water. Wet the filter paper in a funnel with water and pour the hot contents of the conical flask onto the filter. Wash the filter paper with hot water until the washing liquids do not alter the color of the blue litmus paper. Then place the filter paper in a glass Petri dish and dry for 1 h in an oven set at 105±1°C. Allow to cool, then roll

[1] Official Journal of the Algerian Republic
[2] https://chemistnotes.com/organic/soxhlet-extraction-principle-extraction-procedure-and-apparatus/

up the filter paper and insert it into the extraction cartridge. At the end of extraction, remove the cartridges and collect the crude solvent, then reweigh the flasks and calculate the percentage of fat extracted.

The total fat content of the sample, in percentage by mass, is equal to:

$$\text{Total fat (\%)} = \frac{(M_2 - M_1)}{M_0} \times 100 \quad (3)$$

2) Protein content

Protein content in meats was determined using Official Methods of Analysis of AOAC[3] INTERNATIONAL [9], divided into three stages: mineralization, distillation and titration.

$$\text{Protein percentage} = (\%)N \times f \quad (4)$$

where %N is the nitrogen content and f the conversion factor.

3) Water holding capacity (WHC)

In 45 mL fluted centrifuge tube, 7.5 mL of water are added to 5 g of meat, ground with a mortar, and the samples are centrifuged for 20 min at 6.500 rpm in a water-cooled centrifuge. After centrifugation, the supernatant liquid is removed. The tubes containing the centrifuged pellet are left to drain for 10 minutes, after which the weight loss or gain corresponding to water loss or retention is determined [10,11].

4) Microbiological quality

The method for preparing samples, stock suspension and decimal dilutions for the microbiological examination of fresh meat and meat products was carried out according to the decree of December 31, 2017, published in JORA n°11/2018 [12]. Table 1 summarizes the germs sought in meat samples.

Table 1

The germs sought in meat samples.

| Germ | Growth conditions | reference |
|---|---|---|
| Total aerobic mesophilic flora | Agar PCA inoculation . incubation at 30°C/ 72 h | ISO 15214:1998 [13] |
| Total coliforms | Enumeration on VRBL medium. 37°C/24h | NF V 08-053 [14] |
| faecal coliforms | Enumeration on VRBL medium. 44°C /24 hours to 48h.In case of positive test, *Escherichia coli* identification is done by the following tests: TSI, Simmons Citrate, Urea-Indole and Mannitol-mobility. | NF V08-017 [15] |
| *Staphylococci positive coagulase* | Incubation of 24h at 37°C after inoculation on Baird Parker medium | [16] |
| *Listeria monocytogenes* | Pre-chill : modified LEB<br>Inoculation : MMA+ transillumination oblique + *Henry illumination*+ identification | [17,18] |
| *Salmonella* | Pre-enrichment: 9 mL sterile buffered peptone water + 1 mL bacterial suspension. 24 h at 37°C<br>Inoculation: 2 tubes of 10 mL Rapp port Vassili adis Soja broth inoculated with 0.1 mL suspension.41°C/24h<br>Isolation: surface inoculation with Hecktoen agar. 37°C/48h | [19,20] |

## 3. Results

### 3.1. Physical and chemical quality of meats

The results of the physico-chemical characterization of the meats are summarized in figure 1.

[3] Association of Official Agricultural Chemists. Later, the Association of Official Analytical Chemists: https://www.aoac.org

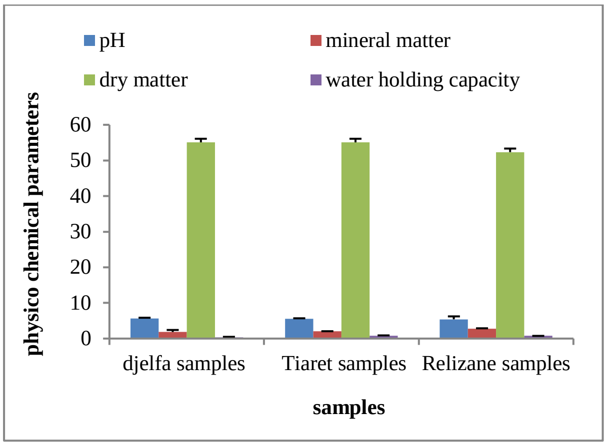


Figure 1: Physico chemical quality of meats

The pH of the three meats ranged from 5.41±0.82 to 5.64±0.2. On the other hand, the samples analyzed lost a significant amount of water, resulting in very high dry matter values (around 55.08±0.36) exceeding Algerian standards. As for mineral matter, the lowest content was recorded in meat from Djelfa (1.86±0.56) and the highest in meat from Relizane (2.77±0.12). Water retention capacity, an important technological feature in meat quality assessment, was variable in all three samples, and below that prescribed by the JORA standard [12].

3.2. Meat nutritional quality

As shown in Figure 2, meat from lamb legs from Djelfa contains less lipid and more protein (11.40±1.53%; 17.68±1.04%) than meat from the Tiaret and Relizane regions.

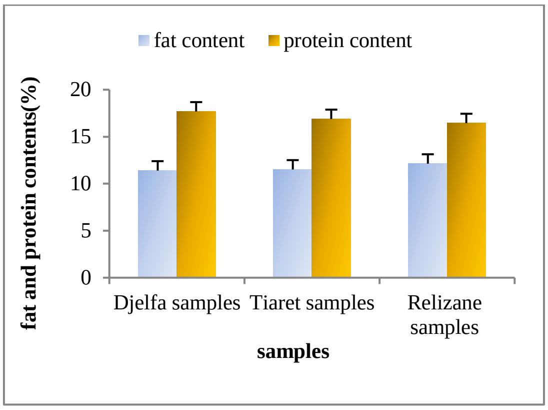


Figure 2: Nutritional quality of meats

*3.2.1. Microbiological quality of meats*

Microbiological quality results for the three meat samples are summarized in table 2.

Table 2
Microbiological quality of meat samples

| | Djelfa | | | Tiaret | | | Relizane | | | Standard ( JORA, 2017) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **n** | **c** | **V.A** | **n** | **c** | **V.A** | **n** | **c** | **V.A** | **N** | **C** | **m** | **M** |
| Total aerobic mesophilic flora (UFC/g) | 5 | 2 | $1.10^3$±1 | 5 | 1 | $1.56.10^3$±0.23 | 5 | 2 | $8.5.10^2$±1.56 | 5 | 2 | $5.10^5$ | $5.10^6$ |
| Total coliforms (UFC/g) | 5 | 1 | $1.04.10^2$ ±0.35 | 5 | 1 | 99±1.2 | 5 | 1 | 69±3.22 | 5 | 2 | $10^3$ | $10^4$ |
| faecal coliforms (UFC/g) | 5 | 2 | 12±1.81 | 5 | 1 | 17±0.1 | 5 | 1 | < 15 | 5 | 2 | 50 | $5.10^2$ |
| *Staphylococci positive coagulase* (UFC/g) | 5 | 0 | < 15 | 5 | 0 | 18±0.19 | 5 | 1 | 31±2.5 | 5 | 2 | $5.10^2$ | $5.10^3$ |
| *Listeria monocytogenes* (UFC/g) | 5 | 0 | 0 | 5 | 0 | 0 | 5 | 0 | 0 | 5 | Absent in 25 g | | |
| *Salmonella* | 5 | 0 | 0/10 g | 5 | 0 | 0/10 g | 5 | 0 | 0/25 g | 5 | 0 | Absent in 25g | |

n: number of sample units, c: , m et M: microbiological limits, VA: analytic values
N.B: results are the average of five repetitions

Applying a three-class sampling plan (c different to 0), we found that the load of TAMF, total coliforms and faecal coliforms in meat samples from the three regions studied (Relizane, Tiaret and Djelfa) was between the microbiological limits (m and M) indicated by the JORA standard [12]. Similarly, the Staphylococcus aureus load was below the recommended detection limit (more than 15 colonies for reliable counting) in the Djelfa sample and less than 30 CFU/mL in the other samples. Based on a two-class sampling plan (c=0 with a single microbiological limit m=M=0), there was a total absence of *Listeria monocytogenes* and *Salmonella* in 25 g of meat respectively. This is perfectly in line with the current standard. In the light of these results, we conclude that the microbiological quality of meats from the Tiaret, Relizane and Djelfa regions is satisfactory.

**Discussion**

The meats studied had varied physico-chemical characteristics. Their dry matter content was higher than that reported by Berrighi [21], with values of 25.11±0.53% for a leg from the Djelfa region and 17.45 ±0.26% for a leg from Tiaret. Furthermore, Belabbes and Bouderoua [22] noted that the dry matter content of a leg of lamb from Mostaganem did not exceed 25.36±1.55%, nor that of a sample from Laghouat, which was 25.95±1.39%. The mineral content recorded by Belabbes and Bouderoua [22] ranges from 4.29±0.02% in a leg of lamb from the Djelfa area to 4.59±0.05% for a sample from Tiaret. Water retention capacity, defined as the meat's ability to retain its own liquid or absorb more, according to Leonid [23], was within the range observed by Budimir *et al*. [24], from 1.055 to 1.152 g/g. pH is the result of post-mortem glycolysis until rigor mortis is reached. Low CRE and pale meat color are often caused by a rapid drop in final meat pH, which in turn is caused by a combination of factors, such as genetics, pre-slaughter stress and post-slaughter handling [23]. The mineral content of lamb legs can be influenced by a number of parameters, including environmental and soil/climate conditions, rearing practices and feed quality. The use of mineral-rich feed supplements and other rearing practices or methods (e.g. watering frequency) can vary from region to region and account for good mineral content. Meat with a high pH is more tender, as the reduction in glycolysis leads to more rapid ATP depletion, early rigor and prolonged protease activity, whereas acid pH leads to inhibition of enzymes involved in tenderization and loss of water retention capacity; Jaborek *et al.* [25] have shown that the pH of ovine meat is not influenced by the type of farming (artificial or traditional), the type of fodder, or the age and weight of the animal at slaughter.

In a similar vein, Rebai *et al* [26], have highlighted the crucial role of feed in meat pH, concluding that the use of soybean meal as the main source of protein in concentrated feed tends to induce ultimate pH values close to or above 5.8. As for the dry matter of meats, Ertbjerg et *al*.[27] elucidated that the rupture of muscle cells during preservation, followed by a drop in water retention capacity, results in a loss of liquid as soon as the temperature rises. The water retention capacity of muscles is directly or indirectly linked to the organoleptic and nutritional properties of meat (textural properties, juiciness, tenderness, color, taste and nutrient retention. It should be pointed out that water retention capacity is the product of various factors.

From a nutritional point of view, Berrighi [21] found mean values of (3.80) and (3.86) for leg of lamb meats from Tiaret and Djelfa respectively. Belabbes and Boudeoua [22] recorded an average fat value of 3.15±1.10% in leg of lamb meats from the steppes where their diet is based on pastures in Laghouat, and an average fat value of 4.89%±0.93 in lamb legs from the Mostaganem plains fed on concentrate, while the average MG values obtained on the cuts of these lambs are higher (17.13%±1.85) and (14.05%±1.25) respectively. However, they conclude that the fat content of their samples was influenced by muscle type and not by feed type.

Lipid content is the most variable parameter in meat composition. It depends essentially on intrinsic animal factors (breed, sex, age) and extrinsic factors (diet, rearing and slaughtering factors). In addition to the effect of breed, where certain breeds are genetically predisposed to produce more intramuscular fat, the age and fat cover of the animals are essential factors for the fat content of the meat. As for protein, the average content in the meat of lamb legs was 17%. This is close to that reported by Berrighi [21] (16.66%). Lamb leg meats tested by Belabbes and Bouderoua [22] were richer in protein, with contents ranging from 18.75%±3.03%, 23.28±1.38 and 22.23±1.03 in lamb legs from the plains of Mostaganem and the steppes of Laghouat respectively. Geay *et al.* [28] reported values ranging from 19 to 25%.

The CIV meat information Center [29] has shown that the protein content of lamb meat ranges from 17 to 23 g of protein per 100 g of meat. Protein-rich meat tends to be more tender and juicier, as these proteins improve its overall texture (water-lipid bonds and myofibrillar proteins). Genetics may also play a role in the ability of animals to absorb and store minerals in their muscles.

In line with current standards, the microbiological quality of the three meat samples (lamb legs) analyzed was found to be satisfactory, attesting to compliance with hygiene conditions. In fact, total aerobic mesophilic flora

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(TAMF) is an important indicator of good hygiene practices, and is the predominant flora in the overall contamination of sheep carcasses. Guiraud [12] have demonstrated the close correlation between slaughter conditions and initial meat contamination. However, the presence of aerobic mesophilic germs in our sheep meat samples can be attributed to contamination originating from this flora, influenced by transport conditions, handling, breaking of the cold chain and thawing.

Faecal and total coliforms, which contaminate surfaces, can originate from the digestive tract during evisceration, particularly from the floor and the hands of employees in direct contact with the viscera. The load of total aerobic flora observed in slaughterhouses indicates insufficient general hygiene and ineffective hygiene measures, which seem inappropriate in these infrastructures [30].

In addition, the hides of slaughtered animals are a vector of (endogenous) contamination for the carcass, whether through direct contact or via the working equipment used for other carcasses and ambient air, making them equally contaminating. Skins can harbor numerous germs, such as *Escherichia coli* and various coliforms (*Aerobacter*, *Enterobacter*, *Serratia*, *Klebsiella*) [31]. It should be noted that sheep meat from the Djelfa region was less contaminated than that from Tiaret and Relizane. This difference in contamination can be explained by the presence of pastures containing components with antimicrobial properties, such as flavonoids, polyphenols and vitamins A and E.

## 4. Conclusion

Sheep meat, especially lamb, remains a highly attractive food product, due to its sensory qualities and its nutritional and dietary benefits. These factors are influenced by the meat production and preservation system. Quality assessment of three samples of sheep meat marketed in Algeria revealed significant differences ($p<0.05$) in physico-chemical and nutritional aspects, while the meat samples were of satisfactory microbiological quality, reflecting good hygienic quality, strongly influenced by slaughtering and preservation conditions. In the future, it would be interesting to increase the number of samples analyzed, to assess the organoleptic quality of the meats and to detect the correlation between the animal's physiological parameters, soil and climate, feed and meat quality.

## Conflicts of interest

The authors declare no conflict of interest.

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