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AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
SCHOLARLY, PEER REVIEWED
Volume 24 No. 9
September 2024
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Afr. J. Food Agric. Nutr. Dev. 2024; 24(9): 24409-24431 https://doi.org/10.18697/ajfand.134.25065

Date	Submitted	Accepted	Published
	2nd July 2024	19th September 2024	4th October 2024

ASSESSMENT OF THE PREPARATION AND PRESERVATION PRACTICES OF KADDID, A TUNISIAN DRIED MEAT

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Volume 24 No. 9
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ABSTRACT

The diversity of traditional food products passes down from one generation to another, and contributes to the formation of the cultural identity and gastronomic patrimony. The know-how employed and the variety of preparation techniques reflect the origins, and the references of consumers. This study aims to detail the different steps and practices used by Tunisian women during preparation of the traditional salted and dried meat product known as “kaddid”, and to study its physicochemical and microbial properties. For this purpose, 400 women were interviewed in 8 regions of Tunisia. The results of this survey described the different traditional Tunisian processes, and recipes used for the preparation of kaddid. The outcomes highlighted significant differences in the preparation of kaddid between regions. Kaddid can be made from sheep (89% of respondents), beef (22% of respondents), camel or goat (3% of respondents) and various parts may be used depending on the local food habits. 70% of the interviewed used dry salting combined with seasoning as salting mode. After sun drying, kaddid is frozen until use or traditionally preserved through post-processing steps which consist of frying then storing in sealed jars filled with olive oil (31% according to the respondents) or simply at room temperature in hermetically sealed glass jars. In order to study the physicochemical and microbial characteristics of kaddid, a sample was prepared based on the results of the survey, according to the most commonly used recipe. The pH (5.77±0.03), water activity (0.54±0.001), and moisture (23.67±0.17) values were considered suitable for the safety and stability of the product. The lipid oxidation rate of kaddid expressed in terms of TBARS (0.55±0.02 mg MDA/kg) content was much lower than the upper limit of rancidity (2mg MDA/kg). The results showed a significant effect of the kaddid processing on reducing the initial microbial load of raw meat ($p<0.05$). The microbiological characterization showed that molds, yeasts, and *Staphylococcus* presented the dominant population, while Lactic bacteria was present in low numbers in kaddid samples.

Key words : Authenticity, cultural heritage, dried salted meat, ethnical foods, kaddid, survey

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INTRODUCTION

Heritagisation may be seen as an act of keeping something in order to preserve and transmit it from generation to generation [1]. Food heritagisation in all civilizations is loaded with cultural, religious and social symbols that not only constitute a legacy passed through generations and surrounded by traditional knowledge (TK), but also reflects an integral part of the gastronomic and food heritage [2, 3, 4]. Traditional knowledge links living populations to generations long gone. These relays between generations, most often orally, but also through writing, are essential and allow the preservation of cultural and social identity, and help to maintain a link with a common history and continuity with the past [5]. While preserving their authenticity, the support of traditional food (TF) can be at the origin of a regional or territorial development process, the encouragement of small farmers and artisans, the protection of natural resources, and the environment but also the establishment of new socio-economic, cultural, and tourist dynamics [6].

Traditional food is consumed regionally and can be seen as an expression of local diversity, culture and way of life. The ingredients used are mostly from the region, and the preparation methods used have been transmitted through TK.

Traditional meat products, such as Pastirma (Turkey, Egypt, Russia), Khlii (Morocco, Algeria), Biltong (South Africa), jerky (United States), charqui (South America), pemmican (North America), tasajo (Cuba), nikku (Canadian Arctic), sou nan and rougan (China), carne seca (Mexico) [7, 8, 9], are among the most consumed TF around the world and they are produced using many ancestral techniques such as salting, drying, smoking and fermentation.

The Mediterranean countries, among which those of north Africa, have managed to safeguard, to this present day, a cuisine that is rich in traditional meat products. One of the various traditional products known in the countries of the Maghreb is the Kaddid, also called guedid or achedlouh in Tamazight language depending on the country (Tunisia, Algeria, and Morocco). Kaddid is increasingly less consumed today, which is partly due to the loss of know-how among the new generation. Investigating this product is crucial for the preservation of culinary heritage. In Tunisia, the kaddid meat preparation differs from one region to another, and depends mainly on the used ingredients, the salting and drying techniques as well as the final uses of the product which explains the diversity of the finished products [10]. Kaddid is prepared from sheep, beef, goat or camel meat cut into pieces, and then salted and dried. Two methods of salting are applicable ; dry salting either with or without a mixture of spices and brining [10, 11]. Kaddid is classified by Benkarroum [12], into two types depending on the preparation scheme : the typical salted meat kaddid and the cured kaddid [12]. However, the scientific literature shows a lack of statistical

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data on the production of this local product whose preparation remains directly related to women traditional culinary knowledge and limited to the household level, and by the frequency of its consumption [13]. Addressing the need to maintain the taste and nutritional quality characteristics of this traditional product, it is imperative to preserve the manufacturers' indigenous knowledge, ancient nutritional habits, and the unique terroir characteristics that contribute to their distinctiveness.

The aims of this study were to investigate the traditional knowledge related to the preparation of kaddid through a survey carried out in various Tunisian regions, and to describe the know-how through the diversity of methods of preparation of traditional Tunisian kaddid. This study represents an important step towards ensuring the perpetuation of traditional gastronomic culture and the protection and sustainability of this product. The second part studied the physicochemical and microbiological parameters of Tunisian kaddid prepared according to a recipe established from the results of the survey.

METHODS AND MATERIAL

Survey Data collection

A survey was conducted over six months (from January 2020 to June 2020) by interviewing a sample of respondents (400 women) from across the country. The country map was divided into eight regions as shown in Figure 1. Simple random sampling was used allowing the survey results to be more representative of the larger population. The choice of the sample size and the gender of respondents were predefined based on the number of the total population and the product under survey. In this survey, the target audience was therefore, exclusively women. This choice was based on two factors, firstly on the culture of the country, where food preparation is mainly the responsibility of women, and secondly on the expertise they have acquired and passed down through the generations for the preparation of this product. The interviewees were informed about the purpose of the study and the use of the data, emphasizing that the information requested would be exclusively used for research, guaranteeing confidentiality. Their contribution in the survey was voluntary. Two survey data collection methods were used : face-to-face survey and online survey hosted on social networks which facilitate data collection, and avoid errors in the transcription of the answers to the statistical software.

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Figure 1: **Regional categorization of the Tunisian map used for the study**

Data Collection Tool and Procedures

Data was collected using a structured questionnaire which was composed of different parts and each section had a specific goal : respondent demographic information, preparation steps and ingredients of kaddid. Participant profile questions included age, professional activity, education and regional origin [14]. Technical terms in the questionnaire were described in Tunisian-Arabic and interviews were conducted using the same language. The questionnaire was pre-tested on a convenience sample to ensure clarity of interpretation and ease of completion improving the validity of responses.

Sample preparation

Based on the results of the survey, a sample of kaddid was prepared in order to determine the physicochemical and microbiological parameters of this Tunisian product. The choice of meat parts, spices and salting method was based on the frequency of use in Tunisia (results of the survey). Five kg of lamb meat were

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purchased from a local butcher in Tunisia, obtained from the lamb leg at 48 hours post-mortem. The pieces of meat were carefully sliced and then seasoned with a mixture of spices (salt, paprika, coriander powder, turmeric and dried mint). The meat sample was then sun dried for 4 days at an average temperature of 32±4˚C until reaching a water activity of 0.54 (Figure 2).

Figure 2: **Photos of the preparation steps of kaddid: (1) Meat cut into strips, (2) Seasoning, (3) Sun drying**

Physicochemical analysis

In order to characterize the physicochemical quality of Kaddid samples, the following parameters were determined, namely moisture, ash and sodium chloride content, pH, a_w, TVB-N and TBARS on the raw meat and on kaddid samples. Moisture was determined by drying 5 g of kaddid sample in an oven for 24 hours at 105˚C until a constant weight was obtained [15]. Water activity measurements were carried out with a 5 g sample of kaddid using a pre-calibrated rotronic water activity meter (Hygro-Lab C1, Decagon Devices, Inc.) at 23˚C ± 0.5. To determine pH values, 10 g of the sample was homogenized with 90 ml of distilled water using a digital pH meter (Hanna Instruments, Romania) as described by Lorenzo *et al.* [16]. Sodium chloride content was measured as described in AOAC (2000) using the ammonium thiocyanate and silver nitrate method with ferrous sulphate as indicator [15].

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Total volatile basic nitrogen (TVB-N) of the kaddid sample was determined by the microdiffusion method of Conway [17]. The analyses of kaddid's lipid oxidation were carried out following the method of thiobarbituric acid reactive substance (TBARS) as described by Botsoglou [18]. A calibration curve was used to calculate the sample concentration. The thiobarbituric acid reactive substance (TBARS) values were expressed as mg malondialdehyde (MDA)/kg of muscle.

Microbiological analysis

Total viable counts were determined on Plate Count Agar (PCA) incubated at 30˚C for 72 hours. Total coliforms were determined on Violet Red Bile Glucose (VRBG), incubated at 37˚C for 24 hours. Yeasts and molds were enumerated on Sabouraud agar after 5 days of incubation at 25˚C. Staphylococci were determined on Chapman Agar, incubated at 37˚C for 48 hours. Lactic Acid Bacteria (LAB) were determined on Man Rogosa Sharp Agar (MRS) incubated at 30˚C for 72 hours [11].

Statistical Analysis

The IBM SPSS statistics program version 23 was used to carry out the descriptive analysis of the data obtained from the survey. Data normality and homogeneity were verified using Levene's test [19]. Physicochemical and microbial analyses were carried out in triplicate. Mean values and standard deviation of the repeated measures were calculated. One-factor ANOVA test was used to identify the presence of a significant difference between the different samples using Duncan's test for comparison [19]. The significance of statistical analyses was set at 0.05.

RESULTS AND DISCUSSION

Respondents profile

Respondent's profiles are presented in Table 1. This survey was carried out with 400 women from all regions of Tunisia. The profile of the respondents shows participation from all age groups. Of these women, 28% are between 40 and 50 years of age, 25% are between 30 and 40 years of age, 19% are in the age range of 20-30 years while the remaining 18% are over 50 years. Most of them (78%) have a university-level education, 12% have a high-school level education and only 10% have a primary-level education.

Preparation steps

Animal source and cuts

Results presented in Table 2 clearly showed that animal sources and cuts used for kaddid preparation differ significantly between regions ($P<0.05$). Indeed, the results of the survey revealed a variety in the animal source and cuts used for Kaddid processing which can be an important factor in the diversity of the final product as mentioned by Gagaoua and Boudechicha [10, 20].

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The findings showed that the majority of Tunisian women (89%) use sheep meat for the preparation of kaddid, while 22% of respondents use beef and only 3% use goat meat, which is mainly the case in the south-west part of the country (20% of respondents of this region). The South-eastern region (SE) is the area where beef meat is mostly used to prepare Kaddid (50% of the region's respondents) even if sheep meat is preferred more than beef for the preparation of kaddid in this region (70% of respondents). The higher percentage of sheep meat used in kaddid preparation is related to the fact that this product is often prepared during the Aid El Adha celebration during which sheep are slaughtered. Indeed, traditionally, during this religious holiday period, women use all the parts of the sheep in order to preserve them for the longer possible period. The choice of meat to be used is mainly related to the nature of the livestock in the geographical region [11]. Abolghait *et al*. [21] reported that in the sub-arid areas of Libya the preparation of kaddid is based on camel and goat meat. The diversity of animal sources used is supported by the research of Bader *et al.* [21] on traditional Algerian kaddid made from four meat sources (lamb, beef, goat, and camel) from different regions. With the exception of the collar meat ($P = 0.24$), the used parts differed significantly between the studied areas ($P<0.05$). Similarly to traditional jerky, different parts of meat can be used, but generally lean cuts such of beef or pork, heart and liver are used [8].

Salting and seasoning

According to this survey, the salting methods differ significantly from regions ($p<0.05$). Around 70% of the interviewed women use a dry salting method either through a mixture of salt and spices to ensure simultaneous salting and seasoning of their kaddid or using salt only. Seasoning mode appears to be largely used in the majority of the regions while dry salting is mainly practiced in CB, SA and NW regions, with 58%, 30% and 20%, respectively (Figure 3). Brining appears to be rarely used (26% in NE region). The salting techniques used for the preparation of Tunisian kaddid are the same as those applied for traditional Algerian kaddid preparation, however, in the southern regions of Algeria (Tamanrasset), vinegar is added to the brine solution for better preservation [11]. Salting time averages between 12 and 24 hours, but this duration increases to more than 24 hours for 54% of women interviewed in the Southwest region (Figure 4). This step plays an important role in the preparation process of cured products, with an impact on their safety and sensory profile. Chabbouh *et al.* [22] highlighted the effects of the salting method and duration as well as the brine salt concentration on the salt uptake of meat. This may explain the longer salting period experienced in the SW region where a higher salt uptake may improve preservation during drying under higher weather temperature.

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The meat parts, well mixed with the spices, are left to rest for a period of time which, as described above, varied from 12 to over 24 hours according to regions and then proceed to drying. This seasoning period does not exceed 24 hours for the majority of the regions studied. According to the results of this study, 82.8% of the interviewees added spices in the preparation of their kaddid. The most widely used spices in NE, NW, GT, SA, ME and SE are paprika (50% - 86%), coriander (42% - 74%) and garlic (46% - 82%) as shown in Table 2. In Tunisia, the cultivation of pepper and its drying process (sun drying) play an important economic role, as paprika and red hot pepper paste (harissa) are considered among the most used traditional ingredients in Tunisian culinary habits. Paprika is known for its aromatic and colorful characteristics as well as its antioxidant power, and antimicrobial effects against pathogenic bacteria such as *Clostridium botulinum* and *Listeria monocytogenes* [23, 24]. Several research reports have proved that from a technological and scientific point of view, garlic and coriander can serve as a natural meat preservative by reducing antioxidant activity, and help preventing spoilage of meat due to bacterial growth during storage [25]. In the South-West region (SW), kaddid is seasoned mainly with *Curcuma* (82% of respondents) and Carvi (40% of respondents). However, women in CB region appear to spice their kaddid less compared to the other regions (10% - 30%). The choice of spices can be explained by consumer preferences and culinary culture of the region, however, the addition of these ingredients as a step in the processing of kaddid meat may also be seen to potentially improve the flavor of the final product and change the physicochemical and microbial characteristics of the dried meat, and speed up the drying rate [26]. Indeed, regional variation seems to have a significant effect on the frequency of use of each ingredient (harissa, garlic, cilantro, coriander, caraway, paprika and mint). Table 2 shows that there is a high use of curcuma in the southwest region (82%). Likewise, although the presence of dried mint is not predominant, it is strongly applied in the region of Tunis (80%) but rarely used and even absent in Cape Bon and in the South-West. According to the literature, spices such as black pepper, garlic and coriander are commonly used in other dried products such as jerky and biltong [8, 27].

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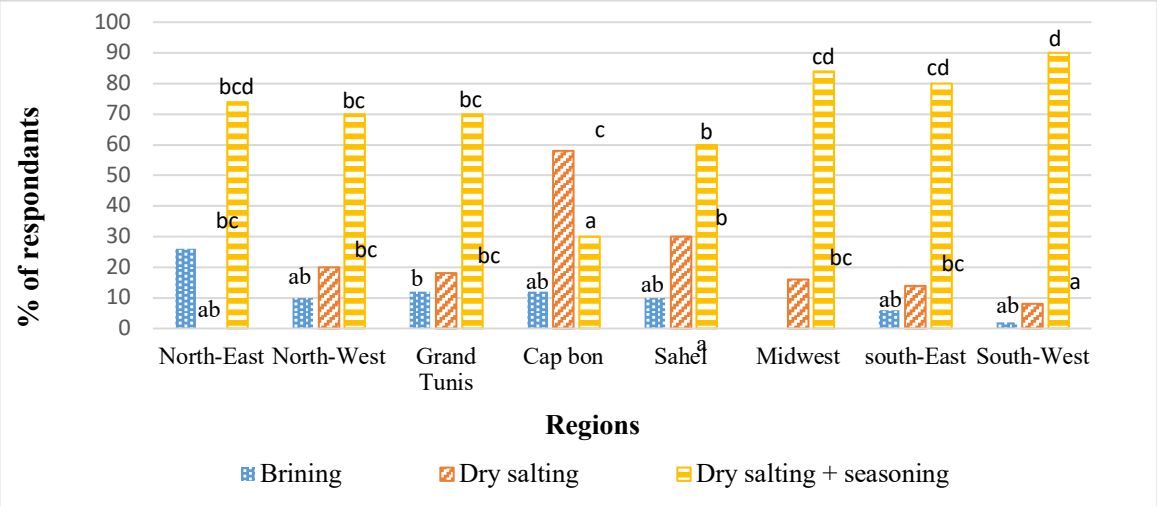

Figure 3 : **Variation of salting methods depending on the region**

[a–c]Means within **histogram** with different superscripts significantly differ among regions ($P < 0.05$) for each type of salting

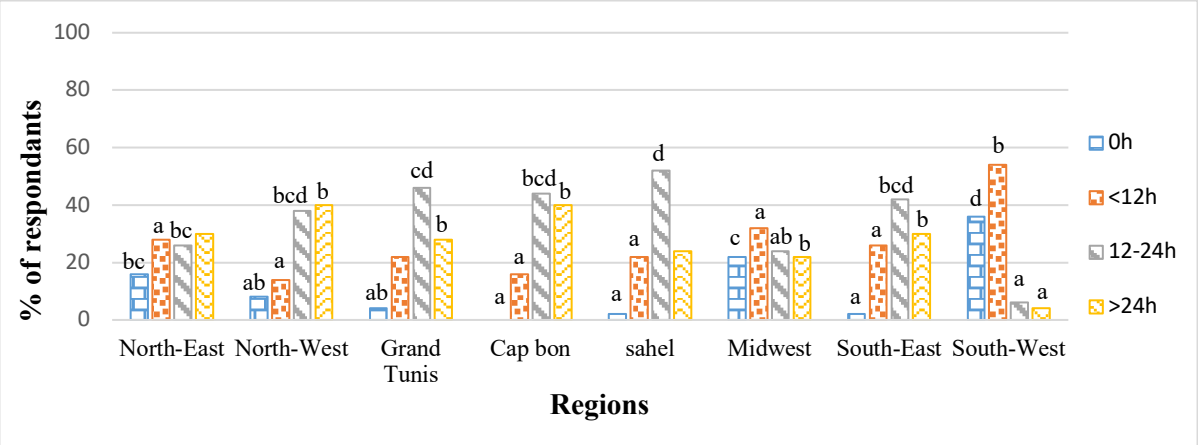

Figure 4 : **Variation of salting times depending on the region**

[a–c]Means within **histogram** with different superscripts significantly differ among regions ($P < 0.05$) for each salting time

Drying

In all regions of the Maghreb, which is the region of North Africa bordering the Mediterranean Sea, kaddid is dried naturally by exposing to the sun light by hanging it on a string during the day, collecting each day before sunset and stored overnight in a cool, airy place until it is completely dried [12, 28]. Differently in South Africa, Bitlong a local salted dried meat product, is traditionally wind-dried in the shade during the winter, or produced in a drying box with a fan at an ambient temperature not exceeding 22˚C [24]. This survey shows that drying durations differed significantly from one region to another ($p<0.05$) depending on variations in climatic conditions (Figure 5). Results showed that drying period is longer than 5 days for the

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most regions studied. The higher drying time is noted for the region of South West. South regions are considered the hottest in Tunisia, where the average annual temperature exceeds 20°C. Longer drying periods may be necessary under these higher temperature conditions since crust formation on the surface of the drying product have been observed and related to drying rate decrease [28]. Meanwhile longer time of exposure to air and heat, acts on the color, texture and hardness of the kaddid thus contributing to the specific character of the kaddid in the Southern region. Tan *et al*. reported a drying period of 6 days for the preparation of biltong [27].

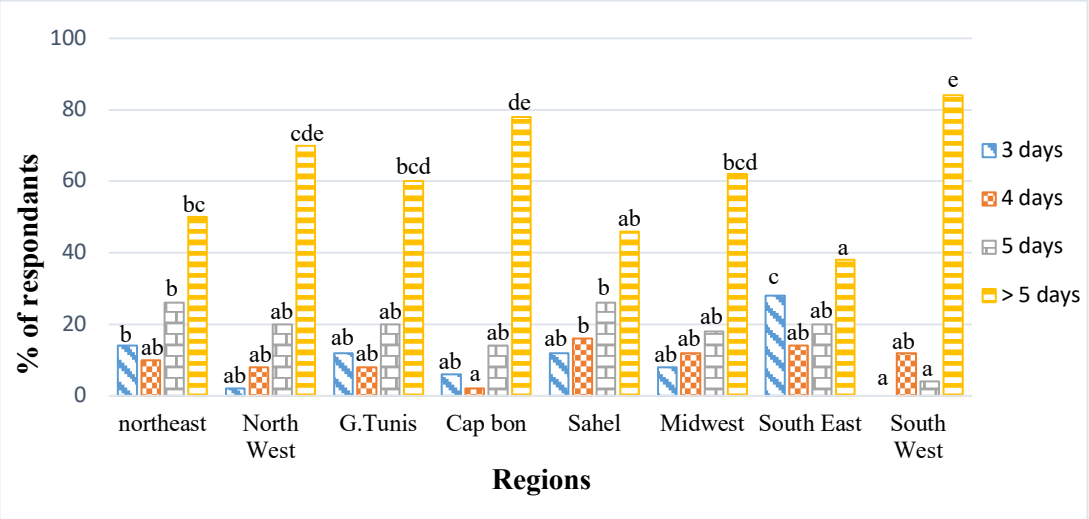

Figure 5 : K**addid drying duration depending on the region**

a, b,c,d,eMeans within **histogram** with different superscripts significantly differ among regions ($P < 0.05$) for each drying time

Storage

Traditionally, kaddid is prepared during the Aid-Al-Adha feast during which sheep, beef or other cattle are widely slaughtered and consumed in Tunisia. Kaddid is prepared in order to preserve the unused meat parts and even though it is a dried product, the water activity, often reached, does not allow its long term preservation. Hence, Tunisian women proceed to several methods before storing their products. The most common post-production treatments used are preservation in olive oil (48%) or in hermetic glass jars without any treatment (35%). Thirty-one percent of Tunisian women preserve kaddid by frying. Lately, as freezers have become a common part of domestic home appliances, kaddid has been frozen until further use (national average 25%). This study represents an innovation in traditional food research, which makes it difficult to compare the results with the existing literature on Kaddid. However, it highlights the need for an innovative approach to food research, and for exploring new dimensions to better understand these culturally significant products and their importance in the society.

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In general, kaddid from all regions of Tunisia is prepared with sheep meat, with the exceptions of the southwest and southeast parts of the country, where goat and beef, respectively, are the most commonly used meats. In most regions, salting and seasoning are combined in a single step, using a mixture of spices. However, the kaddid from the CB region is the least spicy, with no dry mint used. Data reliability is crucial to ensure the validity of survey results. The challenges associated with self-reported data and regional bias underline the need to ensure data reliability to avoid distorted conclusions. Self-reported data may lack precision due to participants' poor memory or social desirability biases. For future research, it would be beneficial to use triangulation methods to verify self-reports with objective sources, and to incorporate longitudinal assessments to reduce recall errors. With regard to regional bias, participants were selected from various regions to ensure better representativeness of the study sample. The use of mixed methodologies and innovative technologies also improved data collection and analysis, thereby enhancing the reliability of the research results.

Physicochemical characterization of kaddid

Physico-chemical parameters of the retained recipe are presented in Table 3. The initial pH value of the sheep meat used to prepare Kaddid was 5.52±0.01. A significant drop was observed throughout the process to reach a final value of 5.33±0.01. This increase may be related to the accumulation of organic acid produced by microorganisms during the preparation [21]. As discussed in the literature, the pH of meat products depends on the initial pH of the raw meat used, the level and nature of added ingredients, the initial microbial load, water activity and all the physicochemical parameters. Similar pH values were reported for Tunisian and Southeastern Algerian Kaddid [29, 30]. Results of the present study are also in accordance with the finding of Teixeira *et al.* [31] for sheep and goat cured legs. Petit *et al*. reported pH values for different biltong samples ranged from 5.00 to 6.26. [9].

Water activity level decreased from 0.895±0.001 for raw meat to a final value of 0.54±0.001. Higher values were reported by Boubakri *et al.* [32] for southeastern Algeria Kaddid [29] and Bader *et al.* [21]. Chabbouh *et al.* [26] reported that the addition of spices contributes to the reduction in water activity. The moisture content of kaddid, ranging around 23.67±0.17%, was higher than the level of Moroccan Kaddid (10.38%) [33]. However, higher percentages were found for South African Biltong [9, 27] goat and sheep cured legs [31] and smoked goat ham [34]. The ash content increased significantly after drying ($p<0.05$) from 1.7±0.38 for raw meat to 56.62±1.8 g/100g for dried kaddid. This content represents the total quantity of mineral salts present in the sample. The obtained value is higher than the one recorded in Algerian meat product Khliaa Ezir (3.46%) [35]. Chloride content increased significantly ($p<0.05$) following drying compared to raw meat samples from

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1.02±0.53 to 4.71±0.2 g/100 g of fresh matter. As a comparison, Tan *et al*. [27] reported a lower chloride content in the Biltong and attributed this change in salt content to the reduction in the amount of water in the finished product.

Measurements of protein oxidation by quantifying total volatile basic nitrogen (TVB-N) showed a significant reduction in the values obtained for kaddid compared to raw meat (from 12.36±0.04 to 10.08±2.7 mg N_2/100g). These values are below the threshold determined by Hu *et al*. [36] who demonstrated via a sensory evaluation that mutton meat with TVB-N levels > 15 mg/100 g was still of acceptable quality. However, a specific threshold for lamb and mutton remains to be developed. Several authors pointed out the relationship between TVB-N and microbial loads [37]. Lyu *et al*. [38] reported a decrease in proteolysis and amine generation following a reduction in microbial flora. This relation is consistent with the obtained results revealing a reduction in microbial flora following the kaddid preparation process. The lipid oxidation values measured for lamb kaddid are in the order of 0.55±0.02mg MDA/kg. The obtained result is lower than what was reported by Zioud *et al.* [39] for sun-dried lamb kaddid and between the oxidation rates obtained with convective drying and ISAD drying methods [0.38 - 0.6 mg MDA/kg].

Microbiological analyses

To assess the hygienic quality of the finished product, the total aerobic mesophilic flora (TAMF), staphylococci, lactic acid bacteria, yeasts and molds, total coliforms, *Listeria monocytogenes* and *Salmonella* were analyzed. The results obtained showed a comparison between the average load of raw meat and the final product. The microbiological count of the germs studied is presented in Table 4. The results obtained showed a significant effect of processing on the reduction of the initial microbial load of raw meat ($p<0.05$). The initial total viable count content of raw meat was 2.85 log CFU/g. After drying, it decreased by 0.03 log CFU/g to reach a final value of 2.6 log CFU/g. This result is higher than the level obtained by Benlacheheb *et al*. [11] in the Algerian kaddid. This significant decrease ($p<0.05$) can be explained by the environmental conditions and confirms the impact of the reduction in water activity coupled with salting on microbial proliferation [40].

The yeasts and molds level in kaddid differed significantly compared to raw meat (from 3.36±0.7 to 3.08±0.11 log_{10} CFU/g). In the present study, results showed a low level of total coliforms in both raw meat and kaddid. Following drying, there was a significant reduction ($p<0.05$) in these germs to 1.87±0.36 log10 CFU/g. In light of this finding, it can be concluded that drying conditions applied to Kaddid are sufficient to slow the development of total coliforms, yeasts and molds.

Lactic acid bacteria are a highly sought-after bacterial group in the production of charcuterie and fermented meat products. Contrary to the results revealed by

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ISSN 1684 5374

Benlacheheb *et al.* [11], the LAB in the study were among the least abundant micro-organisms in raw meat and the final product ranging between 1.73 and 1.79 log CFU/g. Microbiological analysis of raw meat showed an initial load of *Staphylococci* of 3.29 log_{10}CFU/g. Staphylococci are halophilic microorganisms that may survive in high salt concentrations. However, drying reduced the proliferation of these germs, reaching a value of 2.28 log_{10}CFU/g. This result is close to the results of Zaier *et al*. [30] but not consistent with those of petit *et al*. [9] and Benlacheheb *et al*. [11]. In the conducted study, the staphylococcus count obtained is below the limit of 10^6 CFU/g, which is the threshold for considering a food to be potentially dangerous [11]. The finished product does not contain the following germs : fecal coliforms, sulphite-reducing anaerobes, *listeria monocytogenes* and *Salmonella*. These results therefore, confirm the microbial safety and stability of the sample analyzed. In addition, and in an interesting way it clearly appears that the traditional process used to prepare Kaddid allows its physicochemical and microbial safety and allows assuming its reproducibility and its scaling up by SMEs.

CONCLUSION AND RECOMMENDATIONS FOR DEVELOPMENT

The results of this survey revealed the diversity of practices and methods employed by Tunisian women in the preparation of the traditional kaddid. The survey showed that the preparation of kaddid varies according to the region ; the product can be made from several animal parts and sources using different processing methods depending on the dietary habits. The salted and dried kaddid can then be directly preserved at room temperature or after frying for an average period of one year for daily use or during the religious festivities in typical Tunisian dishes.

A sample of kaddid was prepared according to the most used recipe, in order to study the physicochemical and microbial properties of kaddid. The pH, water activity, and moisture values were considered suitable for the safety and stability of the product which confirms and validates the ancestral practices used. The lipid oxidation values are much lower than the upper limit of rancidity. The microbiological characterization showed that molds, yeasts and *Staphylococcus* presented the dominant population, while LAB was present in low numbers in kaddid samples.

The evolution of the classic family model over the last decades is leading to the abandonment of traditional food products. Consequently, the industrialization of traditional food products is taking over to ensure the survival of these cultural products. However, this transition requires the study and control of each traditional step of the manufacturing diagram to be able to innovate while keeping the traditional value expected by the consumer. This study presents the first steps towards the creation of a database to ensure the sustainability of such traditional products, the continuity of traditional practices and the know-how of the Tunisian kaddid.

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AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
SCHOLARLY, PEER REVIEWED
Volume 24 No. 9
September 2024
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

ACKNOWLEDGEMENTS

This research was carried out as part of the PRIMA project "Innovative Bio-interventions and Risk Modelling Approaches for Ensuring Microbial Safety and Quality of Mediterranean Artisanal Fermented Foods" (PRIMA-S2-2018-PCI2019-10345).

Conflict of interest

The authors declare that they have no conflicts of interest to disclose.

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ISSN 1684 5374

Table 1 : **Socio-demographic characteristics of the respondents**

Variables (N=400 respondents)		Frequency	Percentage
Gender	Women Men	400 0	100%
Age	20-30 30-40 40-50 50-60 >60	78 99 113 72 38	19% 25% 28% 18% 10%
Region	Northeast (NE) North West (NW) Tunis (GT) Cap bon (CB) Midwest (MW) Sahel (SA) South East (SE) South West (SW)	50 50 50 50 50 50 50 50	12.5% 12.5% 12.5% 12.5% 12.5% 12.5% 12.5% 12.5%
Education level	Elementary school High school University	38 47 315	10% 12% 78%

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Table 2 : Type of meat, parts and spices used in different regions (%) for preparation of Kaddid

	Regions								
Items	**NE**	**NW**	**GT**	**CB**	**SA**	**MW**	**SE**	**SW**	**National**
Animal source									
Lamb	92	92	90	88	94	84	70	98	89
Beef	16	8	28	28	24	20	50	2	22
Goat	0	0	0	0	0	0	0	20	3
Cuts									
Cote	66	84	56	80	90	52	70	92	73
Chest	32	24	26	28	30	14	46	90	36
Gigot	24	28	50	26	22	56	34	46	36
Shoulder	24	30	52	26	22	56	34	48	37
Meat collar	4	6	2	10	12	10	2	4	6
Spices									
Curcuma	52	36	32	18	19	52	28	82	40
Harissa	64	22	34	16	10	20	12	0	28
Paprika	50	76	66	34	62	86	68	18	58
Coriandre	74	60	72	30	42	62	51	31	54
Carvi	40	42	30	22	32	50	48	40	38
Garlic	48	50	80	28	46	58	82	0	49
Dry mint	46	46	80	10	28	28	34	0	34

Regions : NE : Northeast ; NW : Northwest ; GT : Grand Tunis ; CB : Cap bon ; SA : Sahel ; MW : Midwest ; SE : South-East ; SW : Southwest

Table 3 : Physicochemical parameters of Kaddid samples

Parameters	Raw meat	Kaddid
pH	5.52±0.01^{a}	5.77±0.03^{b}
A_w	0.895±0.001^{a}	0.54±0.001^{b}
Moisture content %	74.36±0.33^{a}	23.67±0.17^{b}
Ash %	1.7±0.38^{a}	56.62±1.8^{b}
Chloride	1.02±0.53^{a}	4.71±0.2^{b}
Fat content	7.3±0.5^{a}	1.60±0.14^{b}
TVB-N (mg N2/100g)	12.36±0.04^{a}	10.08±2.7^{b}
TBARS (mg MDA/kg)	-	0.55±0.02

**mean ± standard deviation ; (-) : no value ; a, b : different letters within the same row differ significantly ($p < 0.05$)*

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Volume 24 No. 9
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ISSN 1684 5374

Table 4 : **Bacterial count of Kaddid (log CFU/g)**

Microbial groups	Raw meat	Kaddid
TAMF	2.85±0.3[a]	2.6 ±0.2[b]
Yeasts and Molds	3.36±0.7[a]	3.08±0.11[b]
Total Coliforms	2.29±0.5[a]	1.87±0.36[b]
Lactic Bacteria	1.73±0.19[a]	1.79±0.29[a]
Staphylococcus aureus	3.29±0.004[a]	2.82±0.08[b]
Listeria. Mono	-	-
Salmonella spp.	-	-

**mean ± standard deviation ; (-) : no detection ; a, b : different letters within the same row differ significantly ($p < 0.05$)*

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