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Ethnic meat products of the North-African and Mediterranean countries: an overview

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Running title: Traditional meat products in North Africa

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Abstract

Traditional meat products constitute one of the ancient cultural heritage of the North-African and Mediterranean countries: Egypt, Libya, Tunisia, Algeria and Morocco. Over years, peoples of these countries consumed numerous meat products in such a way that biochemical and microbial action can take place to help increase the shelf life but also to enhance the flavor and nutritional quality of the products. These ethnic meat products are prepared using different animal sources, but all verified to be halal, and consumed during local events, family celebrations or religious feasts. In this systematic review, 32 most known traditional meat products [Melfouf, Merguez, Kofta, Guedid, Cured Guedid, El messli, Kourdass, Tidkit, Soudjouk/Sucuk/Nakanek, Boubnita, Pastirma, Fregate, Merdouma/Mandi/Bourdimm, Tafra-gara, Maynama, Khliiaa Ezir, Laknaf, Osbana, Bnadek, Khlii, Kobiiba, Mcharmla, Boubnita/Member, Mkila, Tehal/Tehane, Ban-Chems, Bouzelouf/Zelif, Klaya, Douara/Bekbouka/T’qalia, Tangia, Mrousia and Cachir] from the 5 countries were documented. The main objectives of this overview were to report the traditional knowledge that covers the origin, preparation, characteristics, and consumption habits of the 32 North-African traditional meat products. Moreover, the listed meat products were grouped into 5 categories using both traditional and scientific knowledge related to their preparation. The identified categories are i) salted and/or marinated meat products but not dried (category I); ii) dried not fermented meat products (category II); iii) fermented semi-dry/dried meat products (category III); iv) smoked meat products (category IV) and v) cooked and/or candied meat products (category V). The common eating practices of these products and the related historical and socio-cultural aspects were discussed.

Keywords: Traditional meat products; North Africa; Ethnic preparation diagrams; Maghreb; Cultural practices; Algeria
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Abstract

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Keywords: Traditional meat products; North Africa; Ethnic preparation diagrams; Maghreb; Cultural practices; Algeria.
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1. Introduction

Ethnic meat products are traditionally, culturally and commercially most the valuable food products in different countries throughout the world [1-5]. They constitute important elements of gastronomic and nutritional heritage of many countries, which are consumed for centuries [6]. In Africa, namely in the North and Mediterranean countries, dozens traditional meat products exist. However, only few of them were scientifically reported [7-11]) and characterized [8-10, 12-18]. On another hand, the regional cultural differences vary greatly within the Mediterranean and African peoples, giving rise to different styles of food across Morocco, Algeria, Tunisia, Libya and Egypt countries that are collectively known as Maghrib (“the West” in Arabic) compared to the Middle Eastern part of the Arab world, called Mashriq (“the East”). The meat products prepared by the North-African peoples are usually dried or cooked, due to the climate, and are rarely smoked. They have a variety of diameters, shapes, sizes, spices, seasonings, and sensory characteristics. Their names differ also according to the geographic origin, sometimes even between very close areas of the same country. Consequently, the information in the scientific literature related to the meat products of these countries is very scarce and refers only to recipes described in few brief culinary books.

In recent years, traditional food products including meat-based ones have been increasingly regaining consumer interest worldwide [15, 16, 19-23]. This would be due to their particular sensory properties, high quality and natural composition [21, 24, 25]. The consumers trust also that they have potential health characteristics [26, 27]. Furthermore, the particularity of ethnic meat products is their close connection to the culture, heritage and the local identity of the concerned countries. Consequently, they would have a strong symbolic value by contributing to the sustainability and development of rural areas. From these viewpoints, this systematic review grouped the main and popular traditional meat products of the North-African countries and overviewed the preparation diagrams of 32 ethnic meat products as well as their related cultural eating aspects. Thus, the intention of this overview is to describe for the first time the most popular traditionally prepared meat products of the North-African countries, their distribution and consumption during local events, family celebrations or religious feasts.

2. Culinary traditions of the North-African and Mediterranean countries: a brief history

The dietary culture and culinary style of the north westernmost part of Africa along the Mediterranean Sea, known as the North-African countries, consisting of Egypt, Libya, Tunisia Algeria and Morocco, is the result of a set of historical, cultural and geographical factors. All these countries are by origin Berber. However, the old trade routes, links with Europe and
Asia, and the Mediterranean climate have all influenced the improvement of preparation and consumption of muscle-based foods in Morocco, Algeria and Tunisia in the west (the Maghreb or Maghrib) to Libya and Egypt in the east (the Mashrek or Mashrik) [28, 29]. Egypt occupies an ambiguous position: while it has cultural, ethnic and linguistic ties to both the Mashriq and the Maghreb, it is different from both and is usually seen as being part of neither; however, when it is grouped with one or the other, it is generally considered part of the Mashriq due to its closer ties to the Levant. Similarly, Libya may itself be seen as bifurcated between Mashriq and Maghrib influences, with its eastern part seen as linked more to Egypt and the Mashriq.

The historical and archaeological Romans showed that the earliest humans at the beginning of their existence in North Africa survived by hunting and mountain foraging. Therefore, meat animals, intestine and blood were probably the primary source of food for these people [29]. For many years, several ethnic practices were used in North-African countries mainly to preserve the excess of meat into more stable products that could be consumed when food or meat sources are scarce; using primitive processes such as curing, smoking, sun-drying or fermentation. Because the North-African countries are predominantly Muslim, “halal” meats are usually eaten and that is what is reported in the actual recipes. In all North-African and Mediterranean countries, halal meat is available for purchase everywhere. Halal is an Arabic word that means “permissible” [30, 31]. As reported by these last authors, permissible meat in the Islamic tradition comes from animals that have been treated kindly, and killed in a way that minimizes the animal’s suffering. The words of the Basmala “In the name of God, most beneficent, most merciful” must be uttered at the time of animal slaughtering. All blood must be drained from the animal, and it must be cleansed before being eaten. Thus, pork and any food products derived from pork are forbidden from the diet and traditional meat products in accordance with the Islamic dietary laws.

Various civilizations invaded North-African countries namely Phoenicians (332 B.C), Romans (30 B.C), Arabs (642 A.D), Spanish, Turks (16\(^{\text{th}}\) century), Italians, and finally the French and British (18\(^{\text{th}}\) and 19\(^{\text{th}}\) century), which all influenced the eating practices of these countries and contributed to the diversify meat-based foods [32]. However, The North-African areas were under ottoman control for a long time (14\(^{\text{th}}\) - 18\(^{\text{th}}\) century). Therefore, there were more significant influences of Turkish culture than others [33].

3. Socio-cultural, religious and hygienic aspects of preparation and consumption of meat products in North-Africa countries
Initially, farming was the main activity of the North-African people where meat was the main food product in the region, consumed in an indigenous way together with wheat. The domestic livestock in this area is mostly beef, sheep, goats, camel, and poultry [33]. The lamb and mutton consumption is particularly privileged in the North-African countries, namely during the religious feasts. However, as stated above and owing to religious considerations, pork consumption is prohibited [34]. For milk, cattle is the most and principal source but goat milk is also highly consumed. Usually, beef is eaten only when the animal becomes older and of no economic use. Whereas, lamb is slaughtered on special occasions. For example, during the religious feast of the sacrifice "Aid Al Adha", weddings, birth of a child, and circumcisions [33]. The feast of "Aid Al Adha", also known as the great (el-Kebir), takes place on the 10\textsuperscript{th} day of the month of Dhu 'l-Hijja, the day that the pilgrims to Mecca sacrifice a sheep. Muslims around the world are expected to do the same if they can afford to and to distribute part of the meat to those who cannot do it. As a result, the foods of "Aid Al Adha" tend to involve meat. Thus, all parts of the animal are valorized (meat, offal, fat, head, and legs) to prepare meat products or dishes with typical characteristics using ancestral practices that correspond to each ethnic people [35].

The North-African peoples consider meat products as nutrient-rich products that ensure health and wellness. Also, for the people of these countries serving meat to guests is a sign of respect and a way to honor them. The traditional meat preparation involve natural and oldest techniques such as curing, drying, fermentation, cooking, and sometimes smoking, which are all used not only to increase the shelf-life but also to enhance the flavor and nutritional quality of the products [9, 10, 36-38].

Different meat products are prepared using one or mix of techniques, and there exist meat products, which are usually dried (\textit{e.g. Guedid}), smoked (\textit{e.g. Fregate}), fermented (\textit{e.g. Pastirma}), roasted on a charcoal (\textit{e.g. Melfouf}), cooked (\textit{e.g. Tangia}) and some of them are fried (\textit{Mkila}). As well, the intestines are used to prepare sausages (\textit{e.g. Sudjouk}) or sausage-like products (\textit{e.g. Kourdass}) [7, 39]. The preparation of most of North-African meat products had their own typical organoleptic characteristics, which are mainly attributed to the spices and herbs added during seasoning [7]. The use of spices plays an antimicrobial activity and improve the microbiological quality of final meat products [10, 40].

4. Popular traditional meat products of North-African and Mediterranean countries: classification according to the indigenous knowledge of preparation
This systematic review was conducted in two phases. Initially, a field survey was conducted in different areas of the North-African countries. The information were sought directly from local household on traditional knowledge of preparation of ethnic meat products. The questionnaires were sometimes conducted to collect maximum of the traditional meat products and the corresponding preparation diagrams. The survey has targeted mostly the aged persons and in some cases, only women’s are considered. This was however judged reasonable since the native skills of food preparation is mainly passed in the North-African countries from mothers to daughters. However, the respondents were, when possible and namely for Algerian peoples, face-to-face interviewed using a written semi-structured questionnaire consisting of simple open-ended questions. The survey questions focused mainly on traditional knowledge of preparation, mode of consumption, meat source, sociocultural practice, and the ethnic value. We tried to select the informants based on their knowledge in the indigenous North-African culture and heritage. The second phase of the preparation of this overview was based on scientific and literature knowledge. Thus, all the previously published studies in the field were used including the North-African and Maghreb culinary books. Thus, 32 most common ethnic meat products of the North-African and Mediterranean countries were identified and listed in the Table 1. The 32 meat products were then grouped into different sub-families before projection in a geographical map (Fig. 1) by their corresponding number as in Table 1.

For several reasons, it is extremely difficult to classify ethnic meat products due to the use of several preparation steps including more than one transformation technique. The available literature indicated that there is no common classification system to categorize meat products into distinct sub-families [41]. Therefore, we tried to list all the information available for the 32 meat products concerning the animal species, preparation steps, method of preservation, use of spices and ingredients and even the final product characteristics and uses. Thus, the 32 listed ethnic meat products considered the above characteristics and were grouped into 5 categories based on the preparation and preservation techniques steps (Table 1). The distinguished 5 categories were i) salted and/or marinated meat products but not dried (Category I); ii) dried not fermented meat products (Category II); iii) fermented semi-dry/dried meat products (Category III); iv) smoked meat products (Category IV) and v) cooked and/or candied meat products (Category V). Before the presentation of the ethnic meat products of each category, a brief overview is given based on the literature. After what, the corresponding meat products were then presented and once possible photograph of their final aspects (ready-to-eat) are depicted.

4.1. Salted and/or marinated meat products but not dried (Category I)
Since ancient times, meat and salt have been the only two strictly necessary ingredients in the preparation of several meat products. Typically, salt, namely NaCl is historically the first ingredient used for the preservation of fresh meat into cured meats [42-45]. For example, it was used by the Egyptians c. 2000 BC as a rock salt, sea salt or mined salt [46]. Salt plays a number of effects on meat products, most of them desirable, as it provides a salty taste and flavor perception, it allows the control of microbial growth, it modifies the water activity and hence controlling microbial spoilage and it enhances the occurrence of oxidative processes of the muscle food [47]. NaCl is generally added during the mixing phase, while for the whole meat pieces, it can be added by means of dry or wet salting. On another hand, the cured meats are the meat products that have been treated with NaCl and nitrate or nitrite. Broad ranges of other ingredients, most of them from plants, are also used.

The addition of spices and herbs to traditional cured meat products, as for salt, improve the sensory and textural properties and contribute to the enhancement of the microbiological safety of the final products [8, 48-50]. Among these we can found for the North-African countries: coriander, curcuma, garlic, cardamom, celery seeds, cinnamon, cumin, ginger, saffron, paprika, and pepper (black, white or red), that have been the most frequently employed as Sharmula (spicy preparation) for marinated meat products [7, 9]. Sharmula is added to the meat as a dry powder or dissolved in water to form a curing marinade. The use of spices is very frequent in the case of traditional meat products. The addition of spices not only contributes to color and flavor development, but also provides a source of external contamination, an antioxidant effect, and in some cases an inhibition of microbial growth [51, 52].

Salted and/or marinated meat products can be prepared from whole tissue of meat or from a piece of meat cut into small cubes such as Melfouf or ground coarsely as Merguez and Kufta. Further preparation steps such as cooking or smoking [41] can also be salted or marinated. The final products are generally ready-to-eat meats, which are consumed within 2 days after preparation [41, 53]. In this first category, three products were listed and are 1) Melfouf known also as Boulfaf or Zenan, 2) Merguez and 3) Kufta named also as Kufta or Kabab.

4.1.1. Melfouf /Boulfaf / Zenan [Product 1]

Melfouf is prepared from liver lamb that is slowly roasted under an open hearth (Table 1). It is a very popular meat product prepared in the North West of Algeria and Morocco, namely during the religious feast of “Aid Al Adha”. The traditional preparation diagram and final aspect of Melfouf are given in Fig. S1A and Fig. 2, respectively. For its preparation and after removing blood vessels and small skin, the whole liver is grilled for an approximate of two
minutes on each side to just cook the surface of the liver and the inside should remain raw. Then, it is trimmed into small cubic pieces of 2 to 3 cm³ before salting and seasoning with spices (salt, pepper and hot red pepper). Subsequently, a lamb caul previously cleaned and salted wraps each cut liver piece. This allows preserving pieces of liver against drying and burning. Finally, the chunks skewered onto wooden or iron skewers and roasted with occasional turning until well done. Some consumers prefer Melfouf that is less spiced as they judge that spices mask the liver taste characteristic. Melfouf can be served on bread/wraps with vegetables and sauces with for example h’rissa (a hot sauce originally from Tunisia).

4.1.2. Merguez [Product 2]

The origin of Merguez is usually attributed to the Maghreb native people (North-Africa) but the hometown of this worldwide consumed product remains unknown [54]. Merguez, for which there are several spellings, and all have the same meaning designate a "Sausage". It is known in Maghrebian Arabic as "Mergâz" or "Merkâza" and in Spanish Arabic as "Mirkâs" or "Merkaš". The etymology of the word comes from Berber language (Tamazigh) designing "Amergaz". The first written recipe for Merguez (Mirqâz) is in an anonymous thirteenth-century Hispano-Muslim cookery book. The process of manufacturing Merguez is highly variable from one country to another and even among regions of the same country, depending on the seasoning, the specific casing used, as well as the way of consumption [55, 56]. It is generally made of lean and fat lamb, beef and buffalo mixed with condiments (Table 1 and Fig. S1B). Poultry meat can also be used as recently reported [34]. This sausage normally contains relatively high amounts of fats (over 20%), with a sodium content around 800 mg/100 g [15]. Briefly, ground meat is mixed with spices and then stuffed into natural casing namely from lamb intestine (Fig. S1B and Fig. 2). In morocco, it is heavily spiced with chilli pepper or h’rissa, conferring its hot and red color characteristic [15]. Further spices such as fennel and mint would be also included in its preparation. Merguez is a fresh raw sausage that has a short shelf life even when stored at refrigeration temperature, it should therefore, be consumed within 2 to 3 days after preparation [7, 57]. For its consumption, it is usually grilled or barbecued, locally known as “Chwa” which derives from the word “Mechoui” [Mechoui is the traditional North-African roast where a whole lamb is roasted on a spit or in a pit dug into the ground] to prepare sandwiches. In some countries, likely in Tunisia and Algeria, Merguez is commonly eaten as an ingredient with couscous. Merguez is now part of the menu in many restaurants around the world and is widely consumed in different European and Asiatic countries.
4.1.3. Kofta / Kefta / Kabab [Product 3]

Kofta or Kefta or Kabab is a meat product of oriental origin that has become a fast-food staple across the world, namely in the North-African countries. It is believed that Kofta has been brought to North-African and Mediterranean countries from Middle East. In fact, the term “Kofta” means “to grind” in Persian. Whereas, it has been suggested that Kabab is originally a Turkish meat product that is brought by Ottoman soldiers who grilled the meat on their sword. Kofta is a ready-to-eat meat product that is prepared from ground meat by charbroiling [34, 56]. The traditional method for Kofta preparation is summarized in Fig. S1C. Briefly, the boneless lean meat is minced and mixed with spices, herbs and smashed onions (for the complete list of condiments see Table 1). The blend is usually formed into cigar-shape and left at least 2 hours before cooking (Fig. 2). The pieces of Kofta can be roasted directly on glowing charcoal or molded on a wooden skewer then grilled. In this case, it is called Sikh Kabab by Egyptians [58]. In Algeria, another very similar traditional meat product prepared from beef, lamb or poultry, namely in Algiers (the capital of Algeria) is used to produce a similar Kefta product that is named Mthewem, because it contains high amounts of garlic. However, this is eaten in a sauce with some boiled Chickpea. Inversely to Mthewem, the Kofta or Kebab is served immediately with pita bread, Tahini sauce or with boiled rice. We can further found another similar snack or appetizer in Morocco known as Qotban (literally, “sticks”) which is typically made by marinating the meat with vinegar, onions, and pepper.

4.2. Dried not fermented meat products (Category II)

Drying is considered as the oldest method for meat preservation. Originally, it is done for the single purpose of dehydrating fresh meat for extension of storage, or to preserve meat when available at quantities exceeding immediate needs [44, 59, 60]. Drying may also be one of various processing steps during the preparation of specific meat products. Dried meats refer to a wide variety of products that have been subjected to dehydration, so that moisture content could be reduced to levels at which the microbial growth is limited [50, 59]. Overall, the unique sensory quality and microbiological stability of dried meats products are directly related to several factors including i) the extent of the drying; ii) the achieved moisture and iii) the method of drying. Dried meats products can be prepared from whole-tissue to fine emulsion of meat [41]. The popularity of dried meat products in the North-African countries may have begun as long ago as roman times and it was practiced in the Nile valley for thousands of years [53]. In this second category, 5 products were listed and are 1) Typical Guedid known also as
Kadid in Maghreb Arabic or Achedlouh in Berber (by Kabylian peoples in Algeria), 2) Cured Guedid, 3) El M’selli, 4) Kourdass and 5) Tidkit.

4.2.1. Guedid/Kadid/Achedlouh and cured Guedid [Products 4, 5]

Guedid is a well-known salted and sun-dried traditional meat product prepared in the Maghreb countries (Morocco, Algeria, and Tunisia) most often after “Aid Al Adha”. It can be prepared from many types of red meats including camel meat and any part of the carcass is used [11, 12, 17]. The preparation of Guedid differs from one region to another and depends mainly on the ingredients used, the salting and drying techniques (Fig. S2A,B) as well as the final uses of the product. Thus, the final aspect and color is not always the same (Fig. 3).

Traditionally, the raw meat is cut into thin strips mixed with salt and eventually spices. Salted strips are then suspended in an open air for sun drying [18, 41]. Salting can be carried out either dry or in brine, the amount of salt of which is visually appreciated depending to the quantity of meat used [11]. However, the addition of spices (fresh garlic or powder, hot red pepper, coriander and mint) is mostly related to the customary use of the area in question [7].

The most reported traditional preparation diagrams are given for typical Guedid (Fig. S2A) and cured Guedid (Fig. S2B). Furthermore, the climatic conditions of the preparation area determine the chemical, microbiological and final sensory aspects and quality of Guedid.

The water activity of Guedid can ranges from 0.50 to 0.7 [17]. The dominant microflora that ensures the safety of Tunisian Guedid was found to be Staphylococci [12]. Accordingly, the isolated strains of S. xylosus from Tunisian Guedid had good antimicrobial and lipolytic activities as well as acidifying activities. In addition, the earlier studies reported that Guedid owes its characteristic flavor to lipolysis [17]. Guedid is generally stored in plastic bags or glass jars at room temperature in a dry place to prevent rehydration for several months [61]. For its consumption, it is added to flavor or prepare some traditional dishes such as couscous, legume stews, Aiche, and “Couscous Avissar”, a wheat Semolina based dish prepared in Kabylia region (Algeria) during winter and for the Berber new year which is now at 2968 corresponding to 2018.

4.2.2. El M’selli [Product 6]

El M’selli is a traditional low moisture meat product found to be prepared in the North West regions of Algeria. Its traditional preparation process has been reported [11] and summarized in Fig. S2C. Briefly, boneless lean meat is trimmed into thin pieces or long strips. A mixture of salt and spices including black pepper, coriander and garlic hot paprika are sprinkled into the
cuts and left overnight. The seasoned pieces are then exposed to the sun by hanging on a wire.

After drying, the meat is then incorporated in melted fat and preserved in plastic or glass containers for several days. *El M’selli* is mainly consumed with stew or sauce.

### 4.2.3. Kourdass [Product 7]

*Kourdass* is a sausage-like product prepared from offal lamb using stomach, intestines, liver, lung, spleen and fat (*Fig. S2D*). All the constituents are chopped into small pieces before salting and seasoning with salt, cumin, hot red pepper, garlic and black pepper (*Table 1*). The mixture is stuffed into previously washed and cleaned stomach pieces of about 15×10 cm to form small balls, the rough side of the stomach toward the exterior [*7, 39, 56*]. After that, each ball is diametrically rolled up with the intestine to be sealed and sun-dried (*Fig. 3*). The drying time depends on the size of ball, weather conditions and season. *Kourdass* is eaten after 10 to 15 min boiling. It is either sliced and served with *Couscous*, other traditional dishes or consumed as a grilled/fried sausage. *Kourdass* is usually prepared for home consumption during weddings and festivals or during *Moussems*, an annual religious celebration.

### 4.2.4. Tidkit [Product 8]

*Tidkit* is a sun-dried meat product that is consumed in the southern regions of Morocco. According to the surveyed persons, it is a mixture of dried meats and chopped fat. Traditionally, strips or thin pieces of meat are mixed with salt and sun-dried for at least 7 days depending on the meat thickness and weather conditions. The dried strips called “*Tichtar*” by Moroccan Berber peoples, are ground to obtain a powder of meat and then mixed with animal fat and water (*Fig. S2E*). The blend is usually shaped into small balls before cooking for 5 min. *Tidkit* is a shelf-stable meat product that can be conserved at room temperature. However, the earlier studies reported that due to the high fat content of *Tidkit*, its stability is affected and lead to the development of oxidative rancidity [*62*]. *Tidkit* is similar to *Sharmoot*, a traditional Sudan meat product [*63*] and to *Pemmican*, a North-American meat product [*64*]. However, *Pemmican* is sold in market as “energy bars” popular around the world [*64*] while *Tidkit* still a locally consumed and served at very special events. *Tidkit* is also used to prepare some soups and sauces.

### 4.3. Fermented semi-dry/dried meat products (Category III)

Fermented meats are meat products that owe, at least partially, their characteristic properties to the activity of microorganisms [*65, 66*]. They are subdivided into fermented sausages (made from comminuted meat) and meat products prepared by salting/curing and dry of the entire
muscles or cuts, followed by an ageing period, known as ripening, to achieve the desirable sensory qualities of the product. Fermented meat products are traditionally and commercially most the valuable meat products [24, 25, 67, 68]. They can be categorized into several groups based on various criteria such as the preservation practices of fermentation, the country of origin or according to the moisture/protein ratio. Furthermore, the classification can be based on the degree of drying to undried, semi-dry and dry fermented sausages that differ in their water-activity and final pH [65, 67, 69]. Accordingly, fermented meat products are considered as “shelf-stable meat” products. The microbiological stability results from a series of specific factors mainly: i) lowering of pH; ii) high lactic acid bacteria growth rates; iii) decreasing of water activity; iv) extent of the drying and v) addition of salt and spices [2]. Historically, the preparation of fermented meat products is often linked to the climatic conditions of production area [65]. Many types of fermented sausages are produced in the North-African countries that are usually dried. In this third category, 3 products were listed: 1) Soudjouk, known also as Sucuk, or Nakanek, 2) Boubnita and 3) Pastirma.

4.3.1. Soudjouk, Sucuk, Nakanek [Product 9]

Soudjouk or Sucuk (Turkey) and related products in the Middle East and Maghreb (Nakanek) is a cured, dry fermented and uncooked sausage of Turkish origin [70, 71]. It is made entirely from beef or water buffalo, camel and lamb meat (Table 1). It has been produced and consumed around the Balkans and the Middle East for many years [72]. Traditionally, Sucuk is prepared by mixing ground meat and sheep tail fat (90% lean meat and 10% fat), sugar, salt, garlic and spices including black or red pepper, paprika and cumin (Fig. S3A). The Sucuk mix is then stuffed into natural casings, often using the small intestine of sheep. After that, the sausage is hung to ripen and to dry for several weeks at ambient temperature (20 – 25°C) and humidity. Subsequently it is dried to water activity values usually below 0.90 hence conferring to Sucuk its solid aspect (Fig. 4). The fermentation of Sucuk can be either made by microorganisms naturally present or by added starters mostly composed by Staphylococcus carnosus and Lactobacillus plantarum in order to speed up the process and standardize the quality of the finished product [73]. In Sucuk, and irrespective of the preparation process, fat plays important technological roles during processing. It helps loosen the mixture, which facilitates continuous moisture release from inner parts of the product. Regular moisture release from the product is essential for proper fermentation and aromatization of the fermented product [73, 74]. The final pH and moisture of Sucuk are in the ranges of 4.8 – 5.5 and 4.2 – 6.3%, respectively. Sucuk is eaten as sliced breakfast ingredient (with eggs or cheese).
or included in a sandwich filling. It is further served as an appetizer or used as a topping on savory pastries and sandwiches [75].

4.3.2. Boubnita [Product 10]

*Boubnita* is a typical Moroccan dry fermented sausage (*Table 1*), prepared and consumed mostly after the religious feast “Aid Al Adha”. The origin of the word is thought to derive from Maghreb dialect, "Boubnit" referring to “large intestine of beef/lamb”; where the meat is stuffed. To prepare *Boubnita*, lamb meat is cut into small cubic pieces, seasoned with spices (salt coriander, cumin, ginger, red hot pepper, paprika, and olive oil) and stuffed into previously cleaned lamb intestine (*Fig. S3B*). The sausage is then tied with a rope and suspended in the open air where it is left to dry and ferment slowly in the shade (Daoudi et al., 2006; Benkerroum, 2013). The final product (*Fig. 4*) is consumed in a sauce with vegetables or pasta.

4.3.3. Pastirma [Product 11]

*Pastirma* (Basterma, Basturma or Pastrami) is a ready-to-eat meat product commonly prepared and consumed in Egypt. In fact, *Pastirma* is derived from Turkish “Basturma” that means pressing, as it is the crucial step of its preparation process [72]. The traditional preparation process of *Pastirma* takes several weeks and includes three well-defined steps (*Fig. S3C*): salting, pressing and finally drying and ripening [76-78]. The product is mostly prepared using whole beef or water buffalo muscles, lamb and camel meat (*Table 1*) and different parts of the carcass are used. However, it seems that the quality of the finished product depend on the muscle cuts used. The traditional diagram and a photograph of *Pastirma* are given in *Fig. S3C* and *Fig. 4*, respectively. Briefly, the meat is trimmed into strips of 60 cm long and 5 cm in diameter. After that, the meat strips are rubbed and covered with salt, piled up and cured for 2 to 5 days. During this period, the salted meat is sometimes turned or salted again. After what, the salted meat strips are rinsed with water to remove the excess of salt and air dried for 2 to 3 days during summer and up to 15 days in winter. The dried meat blocks are generally piled up and pressed with heavy weights then dried. After pressing and drying, the entire surface of the blocks are covered with a paste consisting of hot pepper, garlic and fenugreek called "çemen" and kept for 1 day. Finally, 5 to 12 days of sun-drying are needed to obtain a ready-to-eat *Pastirma*. The final pH of *Pastirma* ranges from 5.7 to 6.1 [79]. The microbiological counts indicated that lactic acid bacteria, *Micrococcus* and *Staphylococcus* were the most abundant microorganisms in *Pastirma* [80]. The sliced cuts of *Pastirma* are usually consumed with
scrambled eggs that are fried, grilled lightly over a charcoal fire [58]. More recently, it is used as a topping for pizza.

4.4. Smoked meat products (Category IV)

Smoking has been applied for centuries in preservation of meat, by exposing it to smoke, which is produced by pyrolysis of wood [44]. Smoking is almost an elemental part of curing, as it is a thermal processing [81, 82]. Smoke curing is a combined treatment, based on the concerted action of enzymes and heat, which promotes protein and lipid changes in the previously treated raw material. The treatment has also nutritional implications and affects the sensory quality, safety, and shelf life of the product due to the bacteriostatic effect of the compounds present in the smoke. However, the extension of these changes will depend on many factors, including the type of smoking, the relative humidity, velocity, temperature, density, and composition of the smoke and the duration of smoking [83, 84].

Meat products can be smoked at any point in the preparation process and consequently, many smoking procedures are used. However, the applied temperatures affect both the typical sensory properties and the shelf life of the final products [85]. Hot smoking or warm smoking are carried out at high temperatures and the meat in this case is usually cooked. Contrary to cold smoking, the meat remains relatively moist with light brown to dark brown color with a typical smoked flavor [86]. Usually, some of the cold smoked meat products undergo further treatments before consumption [37]. In this fourth category and among the North-African traditional meat products, we have listed 4 meat products that are 1) Fregate, 2) Merdouma known also as Bourdim or Mandi, 3) Tarfa-Gara and 4) Maynama.

4.4.1. Fregate [Product 12]

Fregate is a ready-to-eat meat traditional product prepared and highly appreciated by the indigenous population of southern regions of Algeria called “Tuareg” (Table 1). The Tuareg people also spelled Twareg or Touareg are a large Berber ethnic confederation. They principally inhabit the Sahara desert, in a vast area stretching from far southwestern Libya to southern Algeria, Niger, Mali and Burkina Faso. Fregate prepared by Tuareg consists of cured, smoked and eventually dried meat pieces mostly prepared from camel meat [11]. The preparation diagram of Fregate has been identified and is given in Fig. S4A. For its preparation, boneless camel meat is cut into whole pieces of 5 to 6 cm length and 5 cm thick, carefully incised, then dry seasoned with salt and a set of spices including onion, garlic, coriander and hot red pepper. The pieces are partially sun-dried and smoked for two to three days. The meat is then buried in
a Matmora, a hole in the sand that contains ashes for 7 days. Fregate can be consumed directly after smoking or dried again before storage at ambient temperature. In its final aspect, Fregate is eaten with traditional prepared dishes or served with other traditional Saharan foods such as “Mella” bread.

4.4.2. Merdouma / Bourdim / Mandi [Product 13]

Merdouma is one of the most popular ready-to-eat meat products made from a whole carcass (usually a young and small sized lamb/goat) or whole pieces of beef meat that is incised, mixed with salt and a set of spices (Table 1). It is important to note that the use of spices is optional. The cuts are cooked in a Tandoor (known also as a Taboon), which is a special kind of oven presented as a hole dug in the ground and covered inside by clay. The dry wood is placed in the Tandoor and burned to generate a charcoal. Before closing the hole, the meat cuts are suspended inside the Tandoor without touching the charcoal (Fig. S4B and Fig. 5). The cooking duration depends on the type of meat and the size of the cuts [87]. Mandi (in Egypt) or Bourdim (in Libya) is considered as the main dish served during special events, such as weddings and feasts. It is formerly served with cooked rice or wheat. In Algeria, Merdouma still basically a Bedouin practice used after hunting. The term Bedouin means a grouping of nomadic Arab peoples who have historically inhabited the desert regions in North Africa, and the word comes from the Arabic badawī, which means "desert dweller”.

4.4.3. Tarfa-Gara [Product 14]

Tarfa-Gara is another meat product prepared by the Algerian Saharan peoples. Thus, the origin of the word is thought to derive from “Tuareg” which refers to the stomach of animal. Indeed, Tarfa-Gara is prepared from stomach and offal of lamb or camel (Table 1). The previously cleaned stomach is stuffed by small cubic pieces of offal (intestines, liver, lung, spleen, and kidney), salted and seasoned (Fig. S4C). After that, big stones of approximately 8 cm and preheated in the charcoal are placed inside the stomach. The smoking/cooking is ensured by the heat of the stone, stirred occasionally to turn the offal inside stomach and ensure an homogeneous cooking. Tarfa-Gara preparation is a common Bedouin practice after hunting.

4.4.4. Maynama [Product 15]

Maynama is a traditional Algerian meat product that has become highly popular in the Southern region of the country. It is a ready-to-eat roasted spicy whole-tissue beef, lamb, goat or camel meat [88]. The traditional preparation process of Maynama (Fig. S4D) is similar to that of Merdouma, which consists on trimming, seasoning and smoking. However, the quality
of the finished product depends on the meat cuts (amount of lipid content), spices (quantity and type) and on the type of wood (curing smoke). Maynama is now part of the menu in many restaurants in Southern regions of Algeria. It stills also a common Bedouin practice after hunting (Fig. 5).

4.5. Cooked and/or candied meat products (Category V)

Cooking or thermal treatment is an essential step in cooked and/or candied meat products preparation. Generally, meat is subjected to cooking to enhance its palatability by intensifying the flavor and to extend its storage life by reducing the incidence of spoilage [89, 90]. The origin of cooking meat is unclear although it has been existed for millennia when early humans may first have savored roast meat accidentally, when the flesh of an animal killed in a forest fire was considered more agreeable and easier to chew and digest than usual raw meat. Dry and wet (moist) cooking or frying are the most popular thermal processing methods that have substantial effects on the sensory quality and authenticity of the final products [38]. The dry procedures refer to a direct exposure of meat to heat including roasting, broiling and grilling. However, the wet cooking that encompass boiling, stewing and steaming, is a thermal process that uses a liquid transfer medium [44]. All these cooking techniques contribute to modify the final texture and aspects of meat and meat products. Cooking contributes further to their stability by destruction of spoilage and pathogenic organisms [50]. The specific cooking techniques applied to raw meat are linked to the ethnic background, cultural habits and tradition of each population and region. Usually, cooked meats are considered as ready-to-eat meat products [10, 91, 92]. Traditionally, fats and oils are the medium that are often used to extend the shelf life of cooked meat. They contribute also for certain products to create vacuum conditions. In this fifth category of North-African traditional meat products, we have listed 17 ethnic meat products that are 1) Khliaa Ezir, 2) Laknaf, 3) Osbana, spelled also Osbane, 4) Bnadek, 5) Khlii, 6) Kobiba, 7) Mcharmla, known also as Kemounia, 8) Boubnit, known also as Membar, 9) Mkila, 10) Tehal or Tehane, 11) Ban-chems, 12) Kawareh or H’Rgma, 13) Klaya, 14) Bekbouka known also as T’qalia or Douara, 15) Tangia, 16) Mrouzia and finally 17) Cachir.

4.5.1. Khliaa Ezir [Product 16]

Khliaa Ezir is a typical traditional meat product prepared and consumed exclusively in the North East of Algeria (Table 1). It seems that this meat product originate from Turkey, probably brought to Algeria between the 15th and 16th centuries during Ottoman rule in North Africa. The origin of the word is thought to derive from old Arabic, “Khliaa” referring to the
storage step in olive oil and fat mixture and “Ezir” referring to the earthenware jar, the utensil where it is preserved [10]. *Khliaa Ezir* is a cured and cooked meat produced using fresh boneless (beef, lamb, goat or camel) meat. In the past, *Khliaa Ezir* was prepared to conserve meat, when it is available at excessive quantities especially in the religious feast “Aid Al Adha”, but nowadays it is preferred as a processed meat [11]. Its preparation still a family art involving different well-defined steps (Fig. S5A): trimming, marinating, cooking, ripening and ageing in an earthenware jar or Ezir (Fig. 6). The particularity of its traditional diagram process is the ripening step in Ezir for more than 1 year and at room temperature [9, 10]. Thus, *Khliaa Ezir* is prepared according to the traditional diagram given in Fig. S5A based on empirical observations and traditional recipes. Briefly, lean boneless meat (5 – 8 cm length, 4 – 6 cm thick) is cured by applying a dry mixture of spices including coriander, caraway and fresh smashed garlic. The amount of salt is ~9% of the total weight. The cured meat is marinated for 7 days, kept at cool place with occasional stirring before cooking at an average temperature of 80°C on water. After cooking, the meat blocks are immersed in a mixture of melted bovine fat and olive oil. The mixt is then preserved in Ezir for numerous months at ambient temperature [8-10]. The average pH of final product is around 6.04 (±0.12). Regarding sensorial characteristics, *Khliaa Ezir* is judged very tender with high intensity of flavor that is especially attributable to the presence of garlic flavor. The processing conditions of *Khliaa Ezir* indicated that there is efficient preservation against microorganisms causing microbial spoilage. Several factors ensure microbial stability of *Khliaa Ezir* namely i) dual action of salt and spices, ii) temperature and time of cooking and iii) the storage in olive oil and fat that create sous-vide conditions [10]. *Khliaa Ezir* is a ready-to-eat meat product, since it is generally consumed without further processing. It is eaten as an appetizer with bread or added to traditional dishes such as Chakhchoukha and Aiche.

### 4.5.2. Laknaf [Product 17]

*Laknaf* is a typical North Eastern Algerian meat product (Table 1), which is prepared using whole tissue of beef or lamb meat (Fig. S5B). Lean boneless meat cuts of 5 – 8 cm length and 4 – 6 cm thick are salted, marinated in a mixture of spices for 2 days before cooking in water until fibers are easy to separate. The seasoning/marinating spices mixture includes fresh garlic, coriander and cumin. *Laknaf* is a ready-to-eat meat product that is mainly consumed with *Sfenj* (a fried donut), or added as an ingredient to various culinary preparations such as lentils and chickpeas [11].

### 4.5.3. Oshana/Osbane [Product 18]
Osbana spelled also Osbane or Usban is one of the most popular ready-to-eat meat products mostly prepared and consumed in weddings and feasts in the North-African countries (Table 1). It is usually served with couscous or in sauce [93]. Osbana is a sausage-like product prepared from offal lamb (heart, liver, spleen, kidneys) firstly cut into small cubic pieces, seasoned with red hot pepper, garlic, coriander, mint and ginger (Fig. S5C). Sometimes, rice and chickpeas are also included in its preparation. The mixture is then stuffed into previously cleaned lamb stomach. The final aspect of Osbana (Fig. 6) is similar to that of Kishka, which refers to various types of sausage or stuffed intestine with a filling made from a combination of meat and meal, often a grain [94]. Kishka sausage is popular across Eastern Europe as well as with immigrant communities from those areas. During different events, namely “Aid Al Adha”, Osbana is served with couscous or in a sauce [35].

4.5.4. Bnadek [Product 19]

Bnadek is a typical Tunisian specialty that is exclusively prepared from grounded meat firstly mixed with salt and dry-spices containing dry-mint, coriander, h’rissa, curcuma and black pepper (Table 1). The blend is subsequently shaped by hand into balls of desirable size that are fried in hot olive-oil for a short time (2 min) with frequent stirring (Fig. S5D). Then, the balls are covered with water and boiled for less than one hour until complete evaporation of the entire water [87]. The meatballs dipped in oil are conditioned in glass containers hermetically closed and stored at ambient temperature (Fig. 6). Bnadek owes its characteristic flavor to h’rissa, a Tunisian hot and spice mixture. Bnadek are usually served as appetizers even in a sandwich or added to a stew/sauce or soups. It is usually eaten by Tunisian peoples with Kafteji (fried vegetables) also known as köfteci in Turkey or with Ojja (scrambled eggs) [95].

4.5.5. Khlii [Product 20]

Khlii is a typical and very popular Moroccan candied meat product prepared from boneless whole-tissue of beef, lamb, goat and camel meat (Table 1). According to [7], Khlii is probably brought to Morocco at the beginning of the 8th century by Arab warriors during Islamic expansions to Andalusia.

The preparation process of Khlii has been described in earlier studies [7, 56, 57]. The ethnic preparation diagram and final aspect of Khlii are given in Fig. S5E and Fig. 6, respectively. Briefly, boneless meat trimmed into strips of 5 – 10 cm are marinated in Sharmula that include salt, vinegar, cumin, seed oil, coriander and smashed garlic. After that, the mixture is kept in a
cool place with occasional stirring for one or two days. After this step, the cured meat strips are hung on a laundry rope or wire and sun-dried for at least one week. The dried meat strips are then boiled in a pot that contain water, animal fat and eventually olive oil with frequent stirring until complete evaporation of water. Following this preparation steps, three variants of Khlii are distinguishable. First, the “Typical Khlii”, which consists of whole strips of meat immersed in liquid animal fat, stored in containers of glass or plastic and preserved at ambient temperature. The small pieces of meat and Sharmula obtained after Khlii cooking are called “Agrish” which is the main ingredient of salty traditional pancakes. The third one is “Diet Khlii” which is the cooked meat strips dipped in olive oil as an alternative to animal fat.

It is judged healthier and may be it decreases the risks for cardiovascular diseases. Irrespective of its variants, Khlii is consumed as a ready-to-eat meat product, fried with eggs for breakfast. It is also used as an ingredient in different traditional dishes such as soups, and more recently, as a topping for pizza [39]. Khlii is now part of the menu in many Moroccan restaurants served with various Tajine. Khlii is considered as shelf stable meat product that can be preserved for more than 2 years at room temperature. However, lipid oxidation (rancidity flavor) and color stability (unattractive color) are major problems during storage of Khlii because the high content of animal or vegetal fat.

4.5.6. Kobiba [Product 21]

Kobiba is a typical Egyptian popular meat product (Table 1) that is a deep fried meatball mostly served grilled or cooked with a sauce based on milk and flour [58]. Kobiba is usually prepared from ground beef or lamb meat kneaded with soft rice or Burghul (wheat semolina), onion and garlic and the whole is seasoned with pinches of cumin and several other spices (Fig. S5F). The meatballs are deep-fried at a medium heat turning until golden brown over (Fig. 6). Kobiba is similar to Çiğ köfte, a traditional Turkish meatballs prepared following the same way but consumed without cooking [72]. Several meatballs variants similar to Kobiba are described in many parts of the world such as Kebba, a traditional meat product prepared in Lebanon and Syria [58]. Finally, Kobiba is eaten as an appetizer with prepared salad or cooked rice.

4.5.7. Mcharmla/ Kemounia [Product 22]

Mcharmla, also known as Kemounia is one of the most popular meat product prepared in the religious feast “Aid Al Adha” in Algeria and Morocco (Table 1). Mcharmla is a ready-to-eat meat product made exclusively from liver (Fig. S5G). After removing the blood vessels
and small skin, the liver is cut into small cubic pieces and mixed with a mixture of spices including red hot pepper, black pepper, cumin and coriander. Minced tomato and olive oil are further added to the mixture (Fig. 6). The whole is then covered and cooked for 20 to 30 min.

*Mcharrma* is mainly prepared from lamb and beef liver, poultry offal can be also used. It is usually consumed with bread and at any time of the year.

### 4.5.8. Boubnit / Membar [Product 23]

*Boubnit* also known as *Membar* depending on the country of origin, is a sausage-like product prepared using beef or lamb intestine that are previously cleaned and soaked in boiling water to be used as a natural casing (Table 1). Its preparation varies between countries and communities depending on the ingredients used and seasoning. Even the name differ, it is called “*Boubnit*” in Algeria and “*Membar*” in Egypt. In Algeria, *Boubnit* is a stuffed lamb or beef intestine with a mixture of semolina, chopped animal fat, dried grapes, smashed fresh garlic, salt, ginger, coriander, pepper, hot red pepper, olive oil and water (Fig. S5H). The stuffed intestine can be twisted at intervals to divide it into several separate sausages. It is then boiled in water with onion and spices that are generally the same used for seasoning. The final product is sliced and served alone or with sauce (Fig. 6). In Egypt, *Membar* is stuffed with ground beef, salt, chopped onion, fresh mint, fresh parsley, chopped fresh tomato, rice and some spices like coriander, pepper and dry paprika (Fig. S5H and Fig. 6). It is then covered with water and boiled in water for of one hour. After cooking, *Membar* is drained and fried in little butter [58]. In both countries, *Boubnit* or *Membar* is served immediately (as it crisps) and is mostly consumed as appetizer or in sauce.

### 4.5.9. Mkila [Product 24]

*Mkila* is one of the most well-known Moroccan specialties (Table 1). It consists of cured and fried meat strips from all types of red meats [39]. Originally, the word *Mkila* derives from the term “*Makla*” in Arabic, which means “frying pan”, the utensil used to cook meat [7]. For its preparation, strips or pieces of meat are mixed with salt, spices and chopped animal fat (Fig. S5I). Then, the mixture is marinated all the day in cold place before being cooked in water until the meat is very tender. After that, the tender meat strips are fried in vegetable oil (preferentially olive oil) and animal fat until complete evaporation of water. The final product (Fig. 6) is conditioned with oil (where it has been cooked) in glass containers hermetically close and stored at ambient temperature for more than one year. Basically, *Mkila* is similar to a traditional Turkish meat product called “*Kavurma*” [72, 96]. These products are all considered as ready-to-eat meat products that can be consumed without further processing or cooking. In
Morocco, *Mkila* is usually served with various types of *Tajine* (a Maghrebian dish named after the earthenware pot where it is cooked). It is further called a *Marag/Marqa* in North Africa and the Middle East. *Tajine* would also designate a braised stew of lamb or chicken or beef with vegetables eaten as well or served with couscous.

### 4.5.10. Tehal/Tehane [Product 25]

*Tehal*, spelled also *Tehane* is another Moroccan traditional meat product specialty (Table 1). *Tehal* is an Arabic word which means spleen, the primary ingredient of the product [7, 39]. Thus, *Tehal* is a stuffed bovine/ovine spleen with ground beef, lamb or camel meat, olives, chopped fat and spices including coriander, ginger, fresh smashed garlic and hot red pepper ([Fig. S5J](#)). The stuffed spleen is mostly baked in a bread oven and this confers a soft and creamy texture to the final product ([Fig. 6](#)). For its consumption, sliced *Tehal* are griddled and served in a sandwich or with boiled rice.

### 4.5.11. Ban-chems [Product 26]

*Ban-chems* is a typical Libyan meat product (Table 1). It is prepared from bovine offal (intestines, liver, lung, spleen, and kidney) that are cut into small pieces before mixing with chopped fat and spices ([Fig. S5K](#)). The mixture and the previously cleaned stomach are sun-dried separately. After drying, the stomach is stuffed with pieces of offal and subjected to a period of cooking before conditioning in animal fat. *Ban-chems* is commonly added as an ingredient in cooked couscous or served with pasta [7, 56].

### 4.5.12. Bouzelouf/Zelif/Kawareh/H’Rgma [Product 27]

*Bouzelouf* is mainly prepared in religious feasts such as “Aid Al Adha” (Table 1). *Bouzelouf* is known by other names, such as *Zelif* (in Morocco), *H’Rgma* or *Bouzelouf* (in Algeria), *Bouzelouf* (in Tunisia) and *Kawareh* (in Egypt) [97, 98]. After slaughter, lamb or beef head and lower part of legs are cleaned, flamed and scraped to remove the hair, then boiled before cutting ([Fig. S5L](#)). The pieces of head and legs are mixed with onion, garlic, coriander, caraway, red hot pepper and fresh parsley [93]. The whole is then covered with water and boiled until bones are easily separable ([Fig. 6](#)). *Bouzelouf* can be roasted with vegetables or served with a sauce. In Egypt, it is eaten as *Fettah Kawareh* (boneless head and legs) with cooked rice and the sauce where it was cooked can also be served as a soup known as “*Chorbat Kawareh*” that is mostly consumed in winter [58]. Currently, *Bouzelouf* is part of the menu in many popular restaurants in Algeria, namely in the localities near Constantine region.

### 4.5.13. Klaya [Product 28]
Klaya is a Tunisian ready-to-eat meat product that is prepared from meat and offal of beef and lamb (Table 1). For its preparation, the meat, liver, kidney and fat are all cut into small cubic pieces and then boiled in a salted water for a moment (Fig. S5M). After boiling, the pieces are mixed with salt and a mixture of spices before frying in olive oil with frequent stirring until complete evaporation of water [98]. Klaya can be consumed immediately or conserved in glass containers that contain olive oil firstly served for its cooking (Fig. 6). Klaya is mainly prepared for family, during Moussems (an annual religious celebration) or weddings.


Bekbouka is one of the famous dishes of the Maghreb countries (Morocco, Algeria and Tunisia), prepared from beef or lamb stomach (Table 1). Traditionally, after cleaning, the stomach is cut into small pieces and mixed with salt, fresh tomato, onions and spices including hot paprika, ginger, coriander, cumin, pepper and fresh garlic (Fig. S5N and Fig. 6). The mixture is cooked in water and olive oil until complete evaporation of the added water [39, 93, 98]. This ready-to-eat meat product is consumed at any time of the year namely soon after “Aid Al Adha”. It is also prepared on the eve of weddings by the groom’s family.

4.5.15. Tangia [Product 30]

Tangia, is a typical Moroccan specialty, namely from the locality of Marrakech (Table 1). It is a slow-cooked meat prepared in an urn-shaped terra cotta cooking vessel (earthenware jar) called a “Tangia”. Thus, it is also the name of the stew cooked in the pot, and hence of the ethnic meat product, Tangia. Traditionally, Tangia is cooked in an oven adjacent to a Hammam (a communal bathhouse), where it would slow-cooked in the ashes from the fire used to heat the bathhouse [35]. To prepare Tangia, whole pieces of meat are mixed with onion, garlic, parsley or cilantro, spices and chopped preserved lemon rind (Fig. S5O). The cured meat is then transferred to the earthenware jar and covered with a circle of parchment paper (Fig. 6). The cooking is very long, approximately 6 to 7 hours. This popular ethnic meat product is usually served as a family dish on Friday with a selection steamed seasonal vegetables as well with bread [39, 99].

4.5.16. Mrouzia [Product 31]

Mrouzia is a sweet and spicy Moroccan and Tunisian traditional meat product (Table 1). It is traditionally prepared in the days following the Islamic feast “Aid Al Adha” or during the fasting month of “Ramadan” due to its high calorie value [39]. This product originated from Spain and it was simmered for the first time in Andalusia, a few centuries ago [35]. For its preparation, the pieces of meat are mixed with salt and spices (Ras El Hanout and Saffron),

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garlic and onion, then marinated overnight before cooking over medium heat, stirred occasionally to turn the meat as it browns (Fig. S5P and Fig. 6). After that, water is added and covered before it is simmered. After an approximate of two hours, drained raisins, honey, sugar and cinnamon are added. The pot is once again covered and let to simmer for 20 to 30 minutes, until the raisins are plump and the sauce is reduced to a thick syrup-like consistency [100]. In Tunisia, *Mrouzia* is prepared in the same way as in Morocco except that the Tunisian *Mrouzia* contains chickpeas. The characteristic taste of *Mrouzia* is due to saffron and “Ras El Hanout”, a spice blend of cardamom, coriander seeds, nutmeg, cinnamon, pepper, clove, turmeric, ginger, and cumin. Caraway seeds, ground fennel and green anise can be also used. *Mrouzia* may be made a day or two in advance, as the flavors will continue to improve with time. Honey and sugar play pivotal roles as preservatives, therefore, *Mrouzia* can be preserved more than 10 days. Thus, this ready-to-eat meat product is consumed with bread.

**4.5.17. Cachir [Product 32]**

The sausage “*Cachir*” is the most prepared (both traditional and industrial scale) and consumed ready-to-eat meat product in Algeria (Table 1). The etymology of the word derived from Hebrew word “*Kasher*” that means “fit to be eaten”, according to Jewish dietary laws. Historically, from the 18th and 19th century and during the presence of the French colonists in Algeria, the Algerian *Jews* use the word “*Casher*” to distinguish their meat products from those of other European charcuteries, which are pork-based. This appreciated meat product is a cured and cooked sausage. Traditionally, it is prepared by mixing ground meat from beef, chicken, lamb or camel with eggs, salt, dry spices (paprika, cumin, caraway and black pepper), and fresh smashed garlic and pitted green olives (Fig. S5Q). The blend is stuffed into natural or synthetic casings that is then steamed. After complete cooking, casing is removed and to be eaten, the sausage is cut into slices (Fig. 6) after a chilling period. It is often used to garnish sandwiches. *Cachir* is to some extent similar in its aspect and taste to *Mortadella* and *Luncheon* sausages.

**5. Conclusion and future prospects**

This review listed the most popular traditional meat products of the North-African and Mediterranean countries. For the first time, 32 ethnic meat products were presented and their ethnic preparation diagrams were identified. The meat products were then grouped into 5 groups according to the preparation techniques used and their final aspects. In the North-African regions, meat products are not well-valorized and very little knowledge is available about them. Furthermore, the lack of commercial availability for most of the North-African meat products
and gradual decadence of the traditional practices due to globalization has led to the extinction of numerous ethnic meat products. Thus, it is imminent to consider the age-old knowledge regarding the culinary heritage, the ancestral food preparation practices and the nutritional value for their beneficial aspects attributable to belong to the Mediterranean diet. However, the traditional food products would play important role in tourism and other social and economic aspects of the North-African countries. For these, their characterization for both physic-chemical, technological and microbiological aspects are needed for most of the listed meat products in this review since only some of them were slightly characterized. Thus, it is of great importance to revive and save the preparation steps or diagrams of the 32 traditional meat products for the future generations. It would be also useful to conduct further studies to identify those, which are not identified in this work due to the complexity of the North-African and Mediterranean countries for their high number of ethnic groups and the vast area they occupy. On another hand, as a response to the emerging negative perceptions of consumers related to ethnic meat products, sensory studies would be conducted for better promotion of the products. All these guidelines would be beneficial in order to increase the cultural treasures of North-African and Mediterranean countries.

Acknowledgments

The authors would like to greatly acknowledge all the persons and informants who participated, answered or helped to report the traditional preparation diagrams of the listed meat products described in this overview. Special thanks to Miss Meriem SELLAMA for her help in the identification of some traditional meat products of the Northeast of Algeria. The authors further thank their friends and colleagues in the North-African countries for contributing significant information on meat products associated with their native countries.

Conflict of interest

The authors declare that no competing interests exist.

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References


Figure captions

Fig. 1. Map of the geographical distribution of the most common and 32 listed ethnic meat products of the North-African and Mediterranean countries prepared in special or different countries. They are grouped and identified by colors according to the proposed classification that is based on the traditional preparation types. Each circle number refers to the name of the traditional meat product given in the legend of the map.

- **I. Salted and/or marinated meat products but not dried**: grouped (1) Melfouf (Boulfaf / Zenan), (2) Merguez and (3) Kofta (Kufta/Kabab/Kefta).


- **III. Fermented semi-dry/dried meat products**: grouped (9) Soudjouk (Suçuk/Nakanek), (10) Boubnita and (11) Pastirma (Basturma).

- **IV. Smoked meat products**: grouped (12) Fregate, (13) Bourdim (Merdouma/Mandi), (14) Tarfa-Gara and (15) Maynama.


Fig. 2. Photographs of Melfouf/Boulfaf, Merguez and Kofta ethnic meat products. These ethnic North-African meat products are classified in the category I. Salted and/or marinated meat products but not dried. Melfouf is prepared from liver lamb that is slowly roasted under an open hearth. Merguez is generally made of lean and fat lamb, beef and buffalo mixed with condiments. For its preparation ground meat is mixed with spices and then stuffed into natural casing namely from lamb intestine. Kofta is a ready-to-eat meat product that is prepared from ground meat by charbroiling: the boneless lean meat is minced and mixed with spices, herbs and smashed onions and the blend is usually formed into cigar-shape and left at least 2 hours before cooking. The indigenous methods of preparation of these meat products are given in Fig. S1.

Fig. 3. Photographs of Guedid in Arabic or Achedlouh in Tamazight language (the language of the Berbers) and Kourdass ethnic meat products. These North-African ethnic meat products are grouped in the category II. Dried not fermented meat products. Guedid is a well-known salted and sun-dried traditional meat product prepared in the Maghreb countries most often after “Aid Al Adha”. Guedid or Achedlouh and its variants are prepared from many types of red meats including camel meat and any part of the carcass is used. Kourdass is a sausage-like product prepared from offal lamb using stomach, intestines, liver, lung, spleen and fat. The indigenous methods of preparation of these meat products are given in Fig. S2.

Fig. 4. Photographs of Soudjouk/Sucuk/Nakanek, Boubnita and Pastirma ethnic meat products. These North-African ethnic meat products are grouped in the category III.
Fermented semi-dry/dried meat products. Soudjouk or Sucuk is a cured, dry fermented and uncooked sausage of Turkish origin that is made entirely from beef or water buffalo, camel and lamb meat. Boubnita is a typical Moroccan dry fermented sausage prepared and consumed mostly after the religious feast “Aid Al Adha”. Pastirma is a ready-to-eat meat product commonly prepared and consumed in Egypt and its traditional preparation process takes several weeks and includes three well-defined steps: salting, pressing and finally drying and ripening. The indigenous methods of preparation of these meat products are given in Fig. S3.

Fig. 5. Photographs of Merdouma/Mandi/Bourdim and Maynama ethnic meat products. These North-African ethnic meat products are grouped in the category IV. Smoked meat products. Merdouma is one of the most popular ready-to-eat meat products made from a whole carcass of young and small sized lamb/goat or whole pieces of beef meat that is incised and mixed with salt and a set of spices. To make Merdouma, the cuts are cooked in a Tandoor (known also as a Taboon), which is a special kind of oven presented as a hole dug in the ground and covered inside by clay. Maynama, a traditional Algerian meat product, that is a ready-to-eat roasted spicy whole-tissue beef, lamb, goat or camel meat. Its preparation is similar to that of Merdouma, which consists on trimming, seasoning and smoking. The indigenous methods of preparation of these meat products are given in Fig. S4.

Fig. 6. Photographs of Khliaa Ezir [the earthenware jar (Ezir) on the top and the final ready-to-eat meat product (Khliaa) in the bottom], Osbana, Bnadek, Khlii, Kobiba, Mcharmla, Boubnita, Member, Mkila, Tehal/Tehane, Boucelouf (Zelif), Klaya, Douara/Bekbouka/T’qalia (showing two different final aspects), Tangia, Mrouzia and Cachir ethnic meat products. These North-African ethnic meat products are grouped in the category V. Cooked and/or candied meat products. The preparation, consumption and socio-cultural aspects of all these meat products are detailed in the text one by one and all summarized in Table 1. Furthermore, the indigenous methods of preparation of these meat products are given in Fig. S5.
Table 1. List of the 32 most common ethnic meat products of the North-African and Mediterranean countries prepared in special or different countries (distribution), which are grouped according to their classification, based on the traditional preparation type.

<table>
<thead>
<tr>
<th>Number</th>
<th>Meat product</th>
<th>Country</th>
<th>Livestock source</th>
<th>Main ingredients</th>
<th>Steps of preparation</th>
<th>Traditional product uses</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Melfoul (Boulfat / Zenan)</td>
<td>Algeria, Morocco</td>
<td>Lamb</td>
<td>Salt, Pepper, Hot red pepper</td>
<td>Trimming, Cutting, Seasoning, Roasting</td>
<td>Ready-to-eat meat product prepared during the religious feast “Aid Al Adha,” after the sacrifice of the sheep. It is mainly consumed with bread.</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Merguez</td>
<td>Algeria, Tunisia, Morocco</td>
<td>Lamb, Beef, Buffalo</td>
<td>Salt, Spices</td>
<td>Grinding, Mixing, Stuffing</td>
<td>Usually fried or barbecued to prepare sandwiches. It can be also used as an ingredient in traditional dishes such as “couscous.” [34, 54, 55, 57]</td>
<td>[34, 54, 55, 57]</td>
</tr>
<tr>
<td>3</td>
<td>Kofta, Kufta (Kabab), Kefta</td>
<td>Egypt, Libya, Tunisia, Algeria, Morocco</td>
<td>Lamb, Beef, Poultry</td>
<td>Salt, Spices (coriander, caraway, cummin, black pepper), Smashed onion, Fresh minced garlic, Minced parsley, Olive oil</td>
<td>Mincing, Mixing, Grilling, Roasting</td>
<td>The product is generally served immediately with pita bread, tahini (a sauce) or with cooked rice. [34, 58]</td>
<td>[34, 58]</td>
</tr>
<tr>
<td>4</td>
<td>Typical Guedid, (Kadid / Achedlouh)</td>
<td>Algeria, Morocco, Tunisia</td>
<td>Beef, Lamb, Goat, Camel</td>
<td>Salt</td>
<td>Trimming, Salting, Sun-drying</td>
<td>Initially these variant of Guedid products are prepared to preserve meat. They are used as ingredients in various dishes (couscous, legume stews, aiche and avissar in Kabylia) prepared when meat is not available, likely during winter. [7, 17, 18]</td>
<td>[7, 17, 18]</td>
</tr>
<tr>
<td>5</td>
<td>Cured Guedid</td>
<td>Algeria, Morocco, Tunisia</td>
<td>Beef, Lamb, Goat, Camel</td>
<td>Salt, Spices (fresh garlic, hot red pepper, mint, coriander)</td>
<td>Trimming, Cutting, Salting, Curing, Sun-drying</td>
<td></td>
<td>[12, 101]</td>
</tr>
<tr>
<td>7</td>
<td>Kourdass</td>
<td>Algeria</td>
<td>Lamb</td>
<td>Salt, Cumin, Hot red pepper, Garlic, Black pepper</td>
<td>Cutting, Seasoning, Stuffing, Sun-drying</td>
<td>Prepared during Moussems (an annual religious celebration) with other traditional dishes. [7, 56]</td>
<td>[7, 56]</td>
</tr>
<tr>
<td>8</td>
<td>Tidkit</td>
<td>Morocco</td>
<td>Lamb, Beef, Camel</td>
<td>Salt, Spices</td>
<td>Seasoning, Sun-drying, Chopping</td>
<td>Tidkit is mainly used to prepare soups and sauces.</td>
<td></td>
</tr>
</tbody>
</table>
### III. Fermented semi-dry/dried meat products

<table>
<thead>
<tr>
<th>Table 1. Continued</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>9 Soudjouk, Suçuk, Nakanek</td>
<td>Egypt</td>
<td>Lamb, Beef, Buffalo, Camel</td>
<td>Salt Spices</td>
</tr>
<tr>
<td>10 Boubnita</td>
<td>Morocco</td>
<td>Lamb</td>
<td>Salt Spices</td>
</tr>
<tr>
<td>11 Pastirma (Basturma)</td>
<td>Egypt</td>
<td>Beef, Lamb, Goat, Camel</td>
<td>Salt, Cemen, Freshly ground garlic, Fenugreek, Paprika, Mustard, Water, Cumin, Coriander</td>
</tr>
</tbody>
</table>

### IV. Smoked meat products

| 12 Fregate | Algeria | Camel | Salt, Spices and condiments (onion, garlic, coriander, hot red pepper) | Cutting, Salting, Sun-drying, Smoking | Consumed in the Sahara region with a traditional bread known as Mella. [11] |
| 13 Merdouma (Bourdim/Mandi) | Egypt Libya Algeria | Beef, Lamb, Camel, Goat, Poultry | Salt Spices | Seasoning, Smoking | The product is considered as the main dish served during special events, such as weddings and feasts. It is formerly served with cooked rice or wheat. [87] |
| 14 Tarfa-Gara | Algeria | Lamb Camel | Salt Spices | Cutting, Seasoning, Smoking | Consumed after hunting [88] |
| 15 Maynama | Algeria | Lamb, Beef, Goat, Camel | Salt Spices | Seasoning, Smoking |  |

### V. Cooked and/or candied meat products

<p>| 16 Khliaa Ezir | Algeria | Beef, Lamb, Goat, Camel | Salt, Coriander, Caraway, Fresh garlic, Olive oil, Animal fat | Trimming, Curing, Cooking, Ripening in earthenware jar | The product is eaten as an appetizer in Constantine region or added to traditional dishes such as Chakhchoukha and aiche served during feasts. [8-11] |
| 17 Laknaf | Algeria | Beef Lamb | Salt, Fresh garlic, Cumin, Coriander | Trimming, Cutting, Salting, Curing, Cooking | Consumed with Sfenj (a fried donut), or added as an ingredient to various culinary preparations such as lentils and chickpeas. [11] |
| 18 Osbana (Osbane) | Tunisia Libya Morocco | Lamb | Salt, Spices (red hot pepper, garlic, coriander, mint, ginger), Rice, Chickpea | Cutting, Seasoning, Stuffing, Cooking | The product is served with couscous or in a sauce. / |</p>
<table>
<thead>
<tr>
<th>No.</th>
<th>Product</th>
<th>Origin Country</th>
<th>Main Ingredients</th>
<th>Preparation</th>
<th>Typical Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>Bnadek</td>
<td>Tunisia</td>
<td>Lamb, Beef</td>
<td>Grinding, Mixing, Cooking</td>
<td>Used as an appetizer or added to a stew/sauce or soups. [87]</td>
</tr>
<tr>
<td>20</td>
<td>Khlii</td>
<td>Morocco</td>
<td>Beef, Lamb, Goat, Camel</td>
<td>Trimming, Cutting, Curing, drying, Cooking, Conditioning</td>
<td>Consumed such a ready-to-eat meat product or fried with eggs for breakfast. It is used in different traditional dishes such as soups, Tajine and couscous or, more recently, as a topping for pizza. [7, 39, 57]</td>
</tr>
<tr>
<td>21</td>
<td>Kobiba</td>
<td>Egypt</td>
<td>Lamb, Beef</td>
<td>Grinding, Mixing, Frying</td>
<td>Is eaten as an appetizer with prepared salad or cooked rice. [58]</td>
</tr>
<tr>
<td>22</td>
<td>Mcharmla</td>
<td>Algeria, Morocco</td>
<td>Lamb, Beef, Poultry</td>
<td>Cutting, Seasoning, Cooking</td>
<td>Served during “Aid Al Adha” (religious feast). It is very popular in Algeria where it is consumed at any time of year.</td>
</tr>
<tr>
<td>23</td>
<td>Boubnit / Membar</td>
<td>Algeria, Egypt</td>
<td>Lamb</td>
<td>Cutting, Seasoning, Cooking</td>
<td>Consumed as appetizer or in sauce. [58]</td>
</tr>
<tr>
<td>24</td>
<td>Mkila</td>
<td>Morocco</td>
<td>Beef, Lamb, Goat, Camel</td>
<td>Cutting, Seasoning, Cooking, Frying</td>
<td>Served with Tajine. [7, 39]</td>
</tr>
<tr>
<td>25</td>
<td>Tehal/Tehane</td>
<td>Morocco</td>
<td>Beef, Lamb, Goat, Camel</td>
<td>Seasoning, Stuffing, Cooking</td>
<td>Sliced Tehal can be grilled and served in a sandwich or with cooked rice. [7, 56]</td>
</tr>
<tr>
<td>26</td>
<td>Ban-chems</td>
<td>Libya</td>
<td>Beef, Lamb</td>
<td>Cutting, Stewing, Drying, Cooking</td>
<td>Commonly added as an ingredient in prepared “couscous” or served with pasta. [7, 56]</td>
</tr>
<tr>
<td>27</td>
<td>Bouzelouf (Zelif / Kawareh / H’Rgma)</td>
<td>Algeria, Morocco, Tunisia, Egypt</td>
<td>Lamb</td>
<td>Cutting, Cooking</td>
<td>Usually consumed during a religious feast “Aid Al Adha” and weddings as a sauce. Sometimes and during winter, as a soup known as Chorbet Kawareh. [58, 93, 97]</td>
</tr>
<tr>
<td>28</td>
<td>Klaya</td>
<td>Tunisia</td>
<td>Beef, Lamb</td>
<td>Cutting, Boiling, Frying</td>
<td>Prepared during Moussem (annual religious celebration) or weddings.</td>
</tr>
<tr>
<td>29</td>
<td>Bekbouta/T’galia / Douara</td>
<td>Algeria, Tunisia, Morocco</td>
<td>Beef, Lamb</td>
<td>Cutting, Cooking</td>
<td>Consumed at any time of year namely soon after “Aid Al Adha”. It is also prepared on the eve of weddings by the groom’s family. [39]</td>
</tr>
<tr>
<td>30</td>
<td>Tangia</td>
<td>Morocco</td>
<td>Beef, Lamb</td>
<td>Cutting, Seasoning, Cooking</td>
<td>Prepared for Hammam (steam bath) on Friday and served with a selection of steamed and seasonal vegetables as well as bread. [39, 99]</td>
</tr>
<tr>
<td>31</td>
<td>Mrouzia</td>
<td>Morocco, Tunisia</td>
<td>Lamb, Beef, Goat</td>
<td>Cutting, Seasoning, Cooking</td>
<td>Is mainly prepared after “Aid Al adha” and is consumed with bread. [39]</td>
</tr>
<tr>
<td>32</td>
<td>Cachir</td>
<td>Algeria</td>
<td>Beef, Lamb, Goat, Camel</td>
<td>Grinding, Mixing, Steaming, Cooking</td>
<td>Eaten as an appetizer with salad and used to garnish sandwiches.</td>
</tr>
</tbody>
</table>
Fig. 1.
Fig. 2.
Fig. 3.
Fig. 4.
Fig. 5.
Fig. 6.
Supplementary data

Ethnic meat products of the North-African and Mediterranean countries: an overview

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Running title: Traditional meat products in North Africa

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Supporting Information

Supplementary Fig. S1. Flowchart of the indigenous A) Melfouf, B) Merguez and C) Kofta making. These ethnic North-African meat products are classified in the category I. Salted and/or marinated meat products but not dried.

Supplementary Fig. S2. Flowchart of the indigenous A) Guedid, B) Cured Guedid, C) El messli, D) Kourdass and E) Tidkit making. These North-African ethnic meat products are grouped in the category II. Dried not fermented meat products.

Supplementary Fig. S3. Flowchart of the indigenous A) Soudjouk/Sucuk/Nakanek, B) Boubnita and C) Pastirma making. These North-African ethnic meat products are grouped in the category III. Fermented semi-dry/dried meat products.

Supplementary Fig. S4. Flowchart of the indigenous A) Fregate, B) Merdouma/Mandi/Bourdim, C) Tafra-gara and D) Maynama making. These North-African ethnic meat products are grouped in the category IV. Smoked meat products.

Supplementary Fig. S1
Supplementary Fig. S2

A) Beef, lamb, goat or camel meat
   - Trimming
   - Strips or thin pieces of meat
   - Salting
   - Salted meat strips
   - Sun-drying
   - Cured Guedid / Achedlouh

B) Beef, lamb, goat or camel meat
   - Trimming
   - Strips or thin pieces of meat
   - Salting / seasoning
   - Cured meat strips
   - Sun-drying
   - Cured Guedid

C) Beef, lamb, goat or camel meat
   - Trimming
   - Strips or thin pieces of meat
   - Salting / seasoning
   - Cured meat strips
   - Sun-drying
   - Dried meat strips
   - Immersion in melted fat
   - El messli

D) Offal lamb (heart, liver, spleen, kidneys)
   - Cutting
   - Small cubic pieces
   - Seasoning
   - Cured pieces
   - Sun-drying
   - Dried pieces
   - Stuffing
   - Pieces stuffed into lamb stomach rolled up in the intestine
   - Sun-drying
   - Kourdass

E) Camel meat
   - Cutting
   - Strips or thin pieces of meat
   - Salting and seasoning
   - Cured strips
   - Sun-drying
   - Dried strips (Tichtar)
   - Grinding
   - Ground meat and chopped animal fat shaped into small balls
   - Cooking
   - Tidkit
Supplementary Fig. S3
A) Camel meat
   - Trimming
   - Lean boneless meat
     (5 - 6 cm length, 5 cm thick)
     - Salting / seasoning
     - Cured meat pieces
     - Sun-drying
     - Dried meat cuts
     - Smoking
   - Smoked meat cuts
     - Burying
     - Fregate

B) Beef, lamb, camel goat or poultry meat
   - Trimming
   - Whole carcass or pieces of meat
     - Salting / seasoning
     - Cured meat pieces
   - Burying / smoking
   - Merdouma / Mandi / Bourdim

C) Stomach and offal
   - Cutting
   - Whole stomach and small cubic of offal
     - Salting / seasoning
     - Cured offal
     - Stuffing
     - Stuffed stomach
     - Smoking by hot stone
   - Smoking
   - Maynama

D) Beef, lamb, camel goat or poultry meat
   - Trimming
   - Whole carcass or pieces of meat
     - Salting / seasoning
     - Cured meat pieces

Supplementary Fig. S4
Supplementary Fig. S5. Continued.