



# Indigenous practices and quality perception in the production of *kilichi*, a grilled dried meat in Niger

Ramatou Boubacar Seydou, Victor Anihouvi,  
Adam Mamadou, Hamani Marichatou,  
Marie-Louise Scippo, and D. Joseph Hounhouigan

**Abstract:** *Production and processing of meat constitute important activities that procure substantial revenues for breeders, food processors, and sellers, as well as supplying animal proteins to the populations of Niger. Among the meat products, kilichi is one of the most popular, made of a diversity of meats, but also produced in diverse forms. A survey involving 695 stakeholders was carried out to investigate kilichi production, selling, consumption, and quality perception in different regions known to be the highest production zones of kilichi in the country. Data collected were analysed by descriptive statistics and correspondence analyses. Production and commercialization of kilichi involved men exclusively, all from the Hausa ethnic group, with more than 80 per cent between 21 and 50 years old, all of Islamic religion and low educational level. Two categories of kilichi were produced from bovine, camel, ovine, and goat meat, comprising coated kilichi enrobed with sauce made from blends of ingredients and uncoated kilichi slightly seasoned. Within each category, types of kilichi were differentiated by the process, mainly involving enrobing, drying, and grilling, and the types of seasonings used, which probably affect the organoleptic, nutritional, and sanitary quality of kilichi. The quality attributes of kilichi are flavour, tenderness, friability, and shelf life. The survey also showed that the production of kilichi was artisanal, and unsanitary conditions prevailing in the workshops can result in unsafe food.*

**Keywords:** meat, *kilichi*, stakeholders, processing, quality attributes, Niger

PRESERVING MEAT IN TROPICAL COUNTRIES is important, due to the perishable nature of the product, the lack of adequate infrastructure for its preservation in the fresh state, and the climatic and environmental conditions that favour its rapid degradation. Low-cost, traditional preservation techniques are used in these countries either

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Ramatou Boubacar Seydou ([boubarahma@yahoo.fr](mailto:boubarahma@yahoo.fr)) and Adam Mamadou ([mamadou.adam@yahoo.fr](mailto:mamadou.adam@yahoo.fr)) researchers, National Institute of Agronomic Research of Niger (INRAN), Niger; Victor Anihouvi ([victor.anihouvi@gmail.com](mailto:victor.anihouvi@gmail.com)) Professor, University of Abomey-Calavi, Benin; D. Joseph Hounhouigan ([joseph.hounhouigan@gmail.com](mailto:joseph.hounhouigan@gmail.com)) Professor, Sch University of Abomey-Calavi, Benin; Hamani Marichatou ([maricha@refer.ne](mailto:maricha@refer.ne)) Professor, Abdou Moumouni University, Niger; Marie-Louise Scippo ([mlscippo@uliege.be](mailto:mlscippo@uliege.be)) Professor, University of Liège, Belgium.

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alone or in combination, such as solar drying, salting, smoking, frying, and fermentation (Kalilou et al., 1998; Jones et al., 2001; Ogunsola and Omojola, 2008; Fonkem et al., 2010). In Niger, an agro-pastoral country in the Sahel, the production of processed meat constitutes an important activity that provides substantial revenues to food processors and sellers, as well as supplying animal proteins to the populations of rural and urban zones. *Kilichi* is one such processed meat product, which is made from thin flakes of meat, enrobed or not with sauce, dried, then grilled. The *kilichi* comes from the Tuareg word *kiliss*, which means meat flakes, and was previously reserved for the traditional chieftaincy. The technique of production is the Tuareg technique of red meat dehydration learned by the Hausa during societal exchange (Beidari and Mahamadou, 2014). Previously located in the regions of Maradi, Tahoua, and Zinder, the production of *kilichi* became an artisanal activity practised by many butchers all over the country as a result of promotional actions by some intervention programmes in favour of the sector and income generated by this activity. This product has socio-economic importance for the country but there are a lack of statistics on production and the actors in the industry.

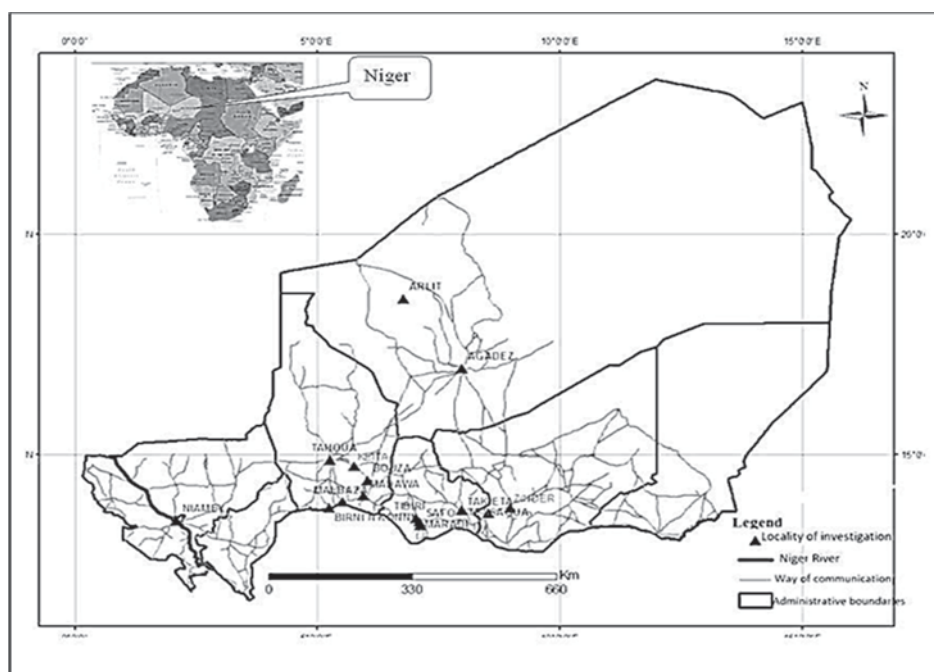
Previous studies carried out on *kilichi* have focused on the physico-chemical, organoleptic, and sanitary characterization of the product of a given locality and the optimization of drying and enrobing operations (Kalilou et al., 1998; Yacouba, 2009; Fonkem et al., 2010; Mbawala et al., 2010; Olusola et al., 2012). These works noted that the production of *kilichi* is artisanal, with low yields leading to a product of low sanitary quality or inconformity to standards. No studies upstream of these works on the characterization of the whole traditional systems of production, preservation, commercialization, and consumption of the product in different zones of the country have been carried out to identify the major problems and bottlenecks related to the product and the process, as well as the risk to the consumer.

The present study was carried out to describe the traditional technical systems of *kilichi* production and preservation, the commercialization system, the consumption patterns, and to identify the quality attributes of the *kilichi* as perceived by stakeholders so as to suggest opportunities for improving the *kilichi* value chain in Niger.

## Methodology

### *Survey areas and sampling of stakeholders*

Field investigations were conducted in the regions of Niamey, Tahoua (Bouza, Keita, Konni, Malbaza, Madaoua, and Tahoua District), Maradi (Maradi District, Safo Tchicagi, Tessaoua, and Tibiri Maradi), Zinder (Takeita and Zinder District), and Agadez (Agadez District and Arlit) (Figure 1). These regions were previously identified as high production zones by the geographic indication of *kilichi* study (Beidari and Mahamadou, 2014). A total of 695 stakeholders (234 processors, 220 sellers, and 241 consumers) were randomly selected for survey in the different regions (Table 1) according to Dagnelie (1998) as described by Chadare et al. (2008).



**Figure 1** Survey locations of *kilichi* processors, sellers, and consumers in Niger

**Table 1** Number and categories of *kilichi* stakeholders surveyed per locality in the survey zones

Area surveyed		Number of stakeholders surveyed			Total number of actors surveyed
Region	Locality	Producers	Sellers	Consumers	
<b>Niamey</b>	Niamey	38	38	21	<b>97</b>
<b>Maradi</b>	Maradi District	14	5	29	<b>48</b>
	Safo Tchicadji	48	42	8	<b>98</b>
	Tessaoua	2	2	19	<b>23</b>
	Tibiri Maradi	24	18	14	<b>56</b>
<b>Tahoua</b>	Bouza	6	10	9	<b>25</b>
	Keita (Tamaské)	15	14	10	<b>39</b>
	Konni	15	14	13	<b>42</b>
	Madaoua	22	15	13	<b>50</b>
	Malbaza (Salewa)	15	20	10	<b>45</b>
	Tahoua District	13	21	13	<b>47</b>
<b>Zinder</b>	Takeita	2	1	31	<b>34</b>
	Zinder District	5	5	41	<b>51</b>
<b>Agadez</b>	Agadez District	11	11	6	<b>28</b>
	Arlit	4	4	4	<b>12</b>
<b>Total</b>		<b>234</b>	<b>220</b>	<b>241</b>	<b>695</b>

### **Data collection**

The surveys were carried out in two phases: a qualitative survey to test a draft of the questionnaire, followed by a quantitative survey. The latter was carried out using the previous questionnaire improved on the basis of the qualitative survey, focusing on the sociocultural status of different stakeholders, the methods of production and preservation of different types of *kilichi*, and the types of intermediate and finished products. Other information was collected on the types of raw materials and ingredients used, the fuels and equipment for grilling, the quality attributes of raw materials and *kilichi* as perceived by different stakeholders, the consumption patterns of the finished products, and the different problems linked to production, preservation, and commercialization. The surveys were carried out by individual interview of different stakeholders and by observation of processors at work.

### **Data analyses**

The collected data were recorded and means of descriptive statistics were performed using Sphinx Survey Plus2 software (version 5). Factorial Analysis of Correspondences (FAC) to describe the links between the types of *kilichi* produced and the type of meat used, the ingredients used and the types of *kilichi* produced, as well as the quality attributes of the products were performed with Minitab software (version 16).

## **Results and discussion**

### ***Sociocultural profile of processors, sellers, and consumers of kilichi***

The sociocultural and professional characteristics of the stakeholders are presented in Table 2. Production and commercialization of *kilichi* are exclusively undertaken by men, all of Islamic religion and the Hausa ethnic group. No Fulani were found in this activity in Niger, as reported by Jones et al. (2001). All three generations (18 to more than 50 years old) are involved in the production and commercialization of *kilichi* with the majority between 31 and 50 years old. The processors and sellers of *kilichi* have a low education level; 35 per cent have a primary education, less than 3 per cent have secondary education, and not more than 6 per cent are literate in French. The majority of the processors are also sellers. They are married, household heads, and have taken part in the activity for more than 10 years. The majority of sellers are retailers. However, 17.3 per cent are wholesalers and 10.9 per cent export the *kilichi* informally. Five ethnic groups are represented among the consumers, with the Hausa group as the most important (90.5 per cent). More than 65 per cent of the consumers are married and household heads. All education levels are represented, the majority consuming *kilichi* for more than 10 years.

### ***Kilichi production***

*Types of kilichi known and types produced for sale.* There are two main categories of *kilichi* according to the production process: coated *kilichi* and uncoated *kilichi*. Different types of *kilichi* are distinguished within each category. The types of coated *kilichi*

**Table 2** Sociocultural and professional characteristics of *kilichi* processors, sellers, and consumers

<i>Characteristics</i>	<i>Processors<sup>1</sup> (%)</i>	<i>Sellers<sup>2</sup> (%)</i>	<i>Consumers (%)</i>
<b>Age (years)</b>			
≤20	0.9	3.6	4.1
21–30	12.8	16.8	23.2
31–40	35.5	38.6	44.4
41–50	35.9	29.5	22.4
>50	15	11.4	5.8
<b>Ethnic groups</b>			
Djerma	0	0	5
Hausa	100	100	90.5
Tuareg	0	0	1.7
Kanuri	0	0	2.5
Gourmantché	0	0	0.4
<b>Academic qualification</b>			
Primary school	35	35	41.5
Secondary school	2.6	2.3	18.7
University	0	0	6.6
Literate	6	4.5	12.9
Illiterate (no school)	1.3	1.8	12
Koranic school	55.1	56.4	8.3
<b>Marital status</b>			
Unmarried	6.4	11.8	29.5
Married	92.7	87.3	66.4
Divorced	0.9	0.9	4.1
<b>Religion</b>			
Islam	100	100	99.2
Christian	0	0	0.8
<b>Household position</b>			
Household head	90.2	84.5	65.6
Dependant	9.8	15.5	34.4
<b>Act./Cons. time (years)</b>			
<10	2.6	6.8	3.7
10–19	26.9	32.7	36.9
20–29	37.2	35.5	36.5
30–39	25.2	18.2	18.3
40–49	6.8	5	3.3
≥50	1.3	1.8	1.2

Notes: Act. = activity; Cons. = consumption

<sup>1</sup> 79.1% of processors are sellers

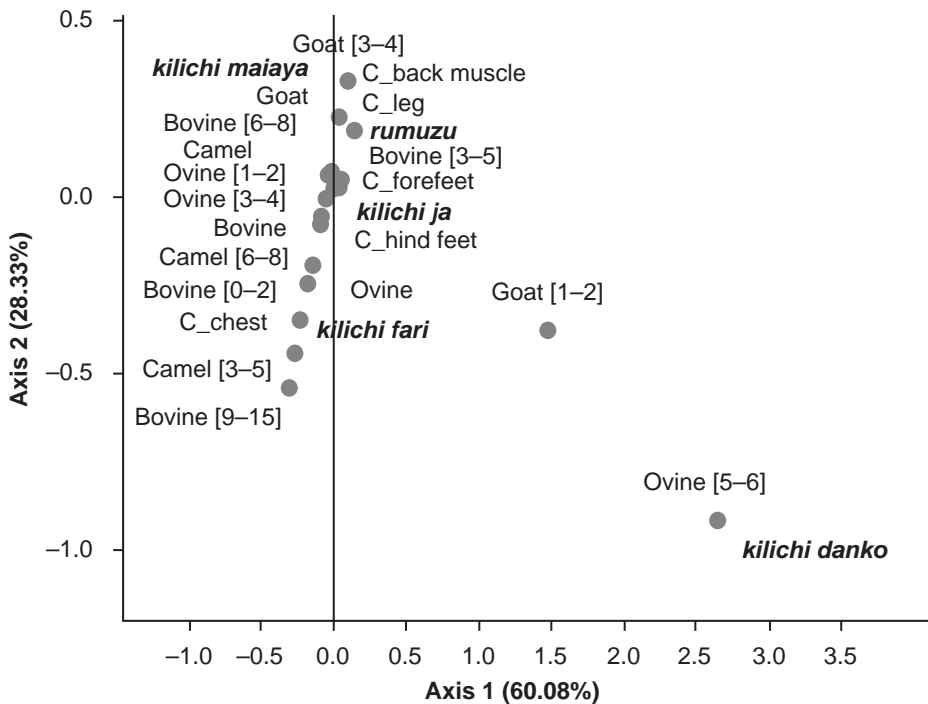
<sup>2</sup> 17.3% wholesalers, 98.2% retailers, 10.9% exporters

**Table 3** Production, commercialization, and preference for *kilichi* types

Kilichi type	Production %	Commercialization %	Consumer preferences %
<i>Rumuzu</i>	79.1	75.5	54.4
<i>Ja</i>	87.2	89.1	43.6
<i>Fari</i>	22.2	20.9	2.1
<i>Maiaya</i>	0.4	0.5	0
<i>Danko</i>	0.4	0	0

are: (1) *kilichi* enrobed with a sauce composed of defatted groundnut paste combined with a cocktail of ingredients with colourant (*ja*, 99.6 per cent of processors) or without colourant (*fari*, 91 per cent of processors); (2) *kilichi* enrobed with a sauce of tiger nut (*Cyperus esculentus*) combined with a cocktail of ingredients (*maiaya*, 30.8 per cent); (3) *kilichi* enrobed with a sauce of sesame combined with a cocktail of ingredients (*mayriddy*, 6.4 per cent). Other minor types of coated *kilichi* are *danko* (0.4 per cent), *maidabino* (0.9 per cent), *maizoumoua* (3.4 per cent), and *mainginger* (1.7 per cent). The second category, uncoated *kilichi*, also known as *rumuzu* or *dankalambé*, is made by 98.3 per cent of the processors. It comprises: (1) *kilichi* seasoned with salt and oil; or (2) *kilichi* slightly seasoned with salt, oil, spices, and pepper (*mardji*). According to the processors, among all these *kilichi* types, five types are mostly produced for sale (Table 3): *ja* (87.2 per cent), *rumuzu* (79.1 per cent), *fari* (22.2 per cent), *maiaya* (0.4 per cent), and *danko* (0.4 per cent). The reasons for engagement of processors in the activity are in decreasing order: profitability (85.5 per cent); inheritance of the activity from parents (25.2 per cent); and preservation of meat (9 per cent). The knowledge of *kilichi* production is acquired by heritage (69.2 per cent), learning from a head of production (28.6 per cent), or from friends (1.3 per cent). Table 3 shows also that *rumuzu*, *ja*, and *fari* are by far the most commercialized and consumed *kilichi* compared with *danko* and *maiaya* that are produced most often on request.

*Raw materials and other ingredients.* The main raw material used for the production of *kilichi* is red meat of good quality with no tendons (Jones et al., 2001; Beidari and Mahamadou, 2014). *Kilichi* from guinea fowl and fish constitutes the innovations introduced recently. The following quality criteria are used for the choice of meat destined for the production of *kilichi*: fresh, safe, fatty, and tender meat (81.2 per cent); without ligaments (59.4 per cent); without adipose tissues (38.9 per cent). Meat is supplied from slaughterhouse (71.8 per cent), markets (19.2 per cent), or through slaughtering at home (8.5 per cent). The meat is transported to the workshop by motorcycle (52.1 per cent), in other vehicles (18.4 per cent), on carts (14.1 per cent), on heads (9.8 per cent), in taxis (9 per cent), or on bicycles (2.1 per cent). Bovine meat (2–15 years old), camel meat (3–8 years old), ovine meat (1–4 years old), or goat meat (1–2 years old) are the most used for *kilichi* production. For bovine species, Bororo races (39.1 per cent), Goudali (35.4 per cent), Azawak (35.1 per cent), and Djelli (27.8 per cent) are the most appreciated for *kilichi* production. For the other animal species, the race does not have importance. All parts of the carcass can be used for the production of *kilichi* but the best choice is for the back muscles



**Figure 2** Factorial Analysis of Correspondences showing the relationships between the type of meat used and the type of *kilichi*  
 Note: C = carcass

(fillet, false fillet, rump steak), the leg, the chest, the forefeet without the topside, and hind feet without the topside.

The relationships between the type of meat used and the type of *kilichi* produced were analysed by factorial analysis of correspondences (Figure 2). The two axes together account for 88.41 per cent of information, of which 60.08 per cent is explained by axis 1 and 28.33 per cent by axis 2. Considering the axis 1, the processors prefer ovine meat aged 5–6 years or goat aged 1–2 years to produce the *kilichi danko*. On the same axis, for the *kilichi fari*, the choice is led by goat meat aged 1–2 years. Considering axis 2, to produce the *kilichi fari*, the processors can choose meat from the chest of bovine (0–2 years or 9–15 years). On the same axis, the processors prefer the muscles of the back and the leg from bovines aged 3–5 years to produce the *rumuzu*. Previous studies have shown that to produce *kilichi*, the meat must be of good quality from large ruminants (bovine or camel aged 3–6 years) and small ruminants (ovine or goat 1–3 years) (Beidari and Mahamadou, 2014). An animal's weight is also considered in the choice of the meat used for *kilichi* production.

The sauce ingredients for enrobing come from local markets (69.7 per cent), or through a supplier (32.5 per cent), or retailers (12 per cent). Apart from the ingredients listed above, the main spices are onion (*Allium cepa*), cloves (*Eugenia caryophyllata*), Maggi cube taste enhancer, ginger (*Zingiber officinale*), pepper (*Capsicum frutescens*),

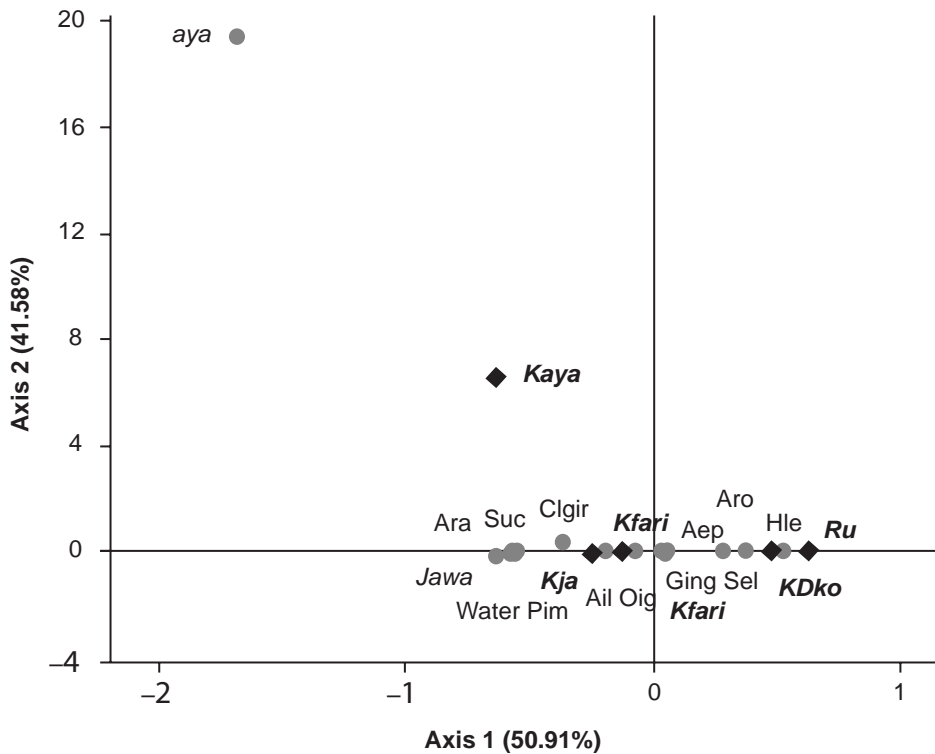


and garlic (*Allium sativum*). To these major spices, other spices are used such as white pepper (*Pimpinella anisum*), black pepper (*Piper guineense*), *soumbala* (fermented African locust beans), and calabash nutmeg (*Monodora myristica*). Plant extract (from *Bixa orellana*) can be added for its red colour (87.6 per cent of processors). Salt, Maggi cubes, and pepper are added for a salty taste or piquancy of the product (99.5–100 per cent). Oil is added to confer brilliance to the product (59 per cent), for better grilling (38 per cent), and for retaining the flexibility of the meat (28.2 per cent). The different spices are added in general to improve the organoleptic quality of the finished product: the taste (30.3–88.6 per cent) and the flavour (20.1–69.7 per cent). Specifically, barley and ginger are also added for good preservation of the *kilichi* (respectively, 12.4 per cent and 0.7 per cent of respondents). Shamsuddeen (2009) also showed that the spices are added to season the *kilichi* in order to enhance the flavour.

Our survey reveals that the groundnut paste that constitutes the matrix of the cocktail of ingredients plays an important role. So, according to the respondents, the groundnut paste gives a consistency to *kilichi* (61.5 per cent), enhances the taste (47 per cent), plays a role in thickening (5.1 per cent), and optimizes the profitability of the product (6.4 per cent). Olusola et al. (2012) also mentioned that groundnut is the key ingredient in the preparation of enrobed *kilichi*. The *aya*, or tiger nut, is used for its sugary taste and replaces the groundnut paste in the preparation of *kilichi maiaya*. Of 234 processors surveyed, 20 add sugar to the enrobing paste to balance the ingredients and for good preservation. According to Shamsuddeen et al. (2009), the step of application of spices is the most important and constitutes a critical control point. This author also reported that these spices are a source of microbial contamination of the product instead of a preservative. A factorial analysis of correspondences to determine the links between the types of ingredients and the types of product (Figure 3) showed that the two axes account for 92.49 per cent of the total variation, of which 50.91 per cent is explained by axis 1 and 41.58 per cent by axis 2. Figure 3 shows the correlations between the ingredients and the type of *kilichi* produced. Considering axis 1, to produce *rumuzu*, the key ingredients that the processors utilize are salt, aroma, and oil; for the *kilichi ja*, the ingredients used are water, groundnut paste, and colourant (*Bixa orellana*). Considering axis 2, the key ingredients used for the *kilichi maiaya* is *aya*, or tiger nut. Figure 3 also shows that for the production of *rumuzu*, onion, ginger, and other spices can be added. But, for this type of *kilichi*, pepper, garlic, and clove can only be used moderately.

*Steps of processing meat into kilichi.* The survey showed that the technologies of *kilichi* production are artisanal and utilize rudimentary materials. The materials currently used by processors are a knife (100 per cent), table (99.6 per cent), basins (99.6 per cent), sorghum or millet stem mats (88 per cent), drying bed (88.9 per cent), cord (7.7 per cent), hanger (9.8 per cent), and a mud brick kiln (66.7 per cent) or half-barrel kiln (30.8 per cent). These materials may be sources of contamination of the product. Production workshops are often located in unsanitary places; by the roadside, in the market, or in open air under trees. The lack of good hygiene practices observed in the workshops can result in unsafe products. Unit operations (Figure 4) are not standardized; the variation includes the cocktail of ingredients, drying, enrobing, and grilling and depends on the desired flavour and the environmental conditions.





**Figure 3** Factorial Analysis of Correspondences to enhance the correlations between the types of ingredients used and the types of *kilichi* produced

Note: Ru = *rumuzu*; Kdko = *kilichi danko*; Kja = *kilichi ja*; Kfari = *kilichi fari*; Kaya = *kilichi maiaya*; Ara = groundnut; Suc = sugar; Clgir = clove; Pim = pepper; Aep = other spices; Ging = ginger; Oig = onion; Aro = aroma; Hle = oil; Aya = tiger nut; Sel = salt; Ail = garlic; Jawa = *Bixa Orelana*

For example, in the category of coated *kilichi* two variants of *ja* can be obtained if grilling is done without a second drying (*kilichi* of Bouza) or if second drying is done without grilling (*kilichi* of Tessaoua called *dankatcharé*) (Figure 4). In the category of uncoated *kilichi*, *rumuzu* is generally obtained without a second drying, except *rumuzu* of Tessaoua which undergoes a second drying without a grilling step (Figure 4). After receiving the meat in the workshop, the first operation is deboning, which consists of separating all the flesh from the bones. An improper boning affects *kilichi* yield. Trimming occurs just after boning and consists of carefully removing the nerves and clusters of fat from the flesh. The muscle then takes shape and is ready to be cut. This operation must be done with skill and flexibility. The boned and trimmed meat is cut into pieces of parallelepiped shape with a thickness of about 5 cm.

The production of thin straps, a key operation of the production of *kilichi*, consists of a parallel unwinding of the fibres that allows the parallelepiped piece of about 5 cm to be processed to flakes of about 2–4 mm thickness. The operator must be skilled, cautious, and careful in the handling in order to carry out his work with precision (32.9 per cent of respondents). The operation requires a fine

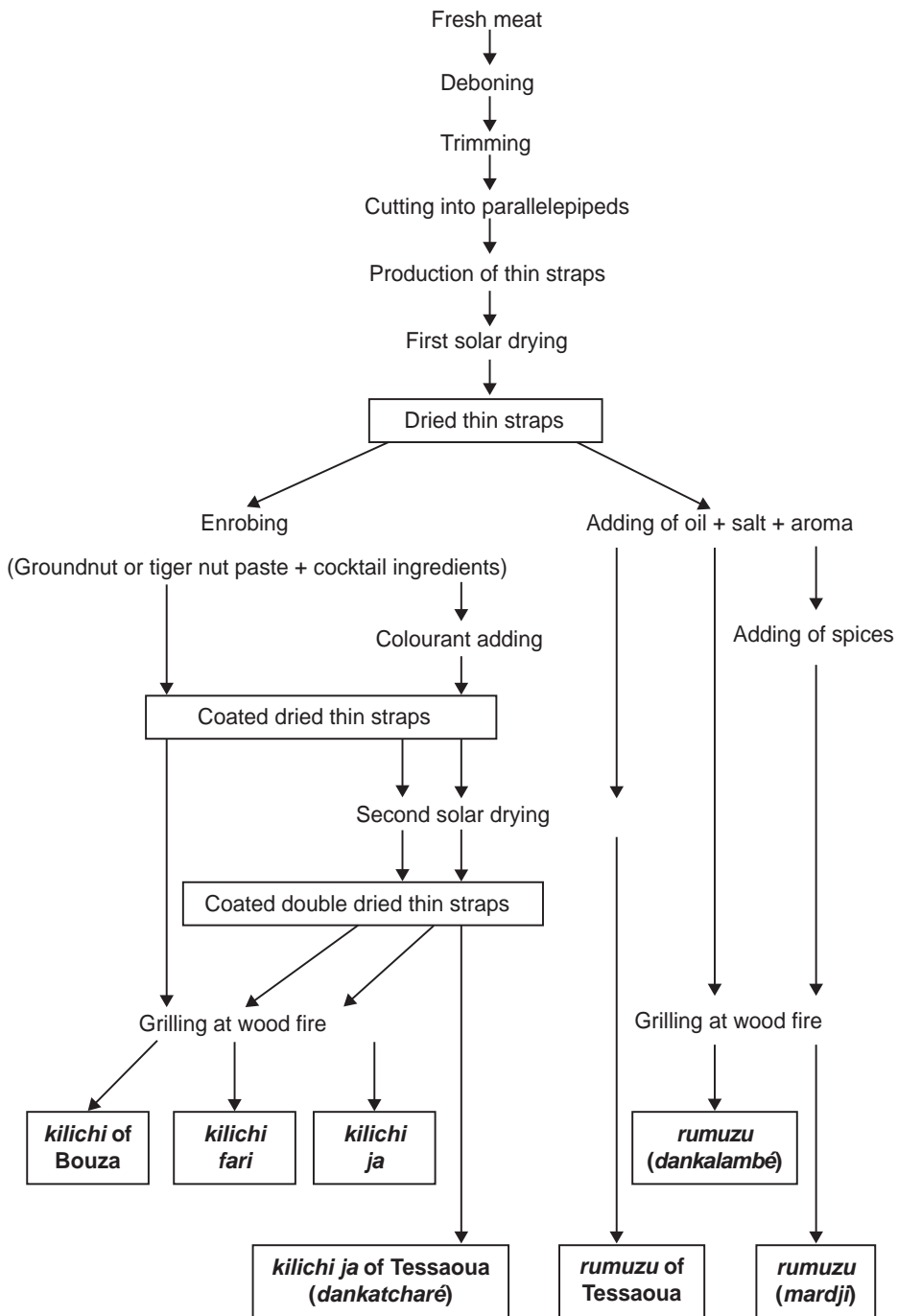


Figure 4 Flow diagram of meat processing into different *kilichi* types

and sharp curved knife which predetermines the yield of production in terms of number of *kilichi* straps. It is the most time consuming (65 per cent of respondents) and tedious (20.1 per cent) operation of the process. A bad execution of the operation is characterized by an irregularity of the thickness of straps and the intermittent appearance of holes (20.5 per cent). For 92.5 per cent of respondents, the poorly made thin straps do not dry well, and affect the odour (32.5 per cent) and the taste (33.8 per cent) of *kilichi*. According to 96.2 per cent of processors, the production of thin straps is the most difficult operation of the process. One of the constraints of this operation is the manual practice, with a high risk of wounds to the fingers that can affect the sanitary quality of the product. The thin straps of meat are generally laid on millet or sorghum mats that are placed on supports such as tables or hangers, placed against a door, or well suspended on nets and cords, for sun drying. During the drying, the straps are turned regularly to allow uniform drying. This operation is carried out simultaneously with the production of thin straps. Its shelf life varies according to the type of meat, the type of *kilichi* produced, and the time of year. For 35.47 per cent of processors, camel meat dries fastest, followed by bovine meat, then that of the ovine; goat meat is the most difficult to dry. The first drying of thin straps destined for the production of *rumuzu* lasts longer than that for the other types of *kilichi* (87.1 per cent of the respondents). All the processors fear the rainy season for production. The processors from the region of Agadez complain of the dry cold season period that is also a period of sandstorms and dust. For 42.3 per cent of processors interviewed, bad drying affects the odour of *kilichi* (37.6 per cent), its crunchiness or friability (21.8 per cent), and taste (26.3 per cent). The exposure of the operator to the sun (28.4 per cent of respondents) and the need for constant monitoring of the product (45.7 per cent of the respondents) constitute the major constraints of drying. The easy separation of the straps from the mats (82.1 per cent), the change in colour of thin straps (19.7 per cent), and the toughness of thin straps to touch (13.7 per cent) are the main indicators of the end of the first drying.

The enrobing is carried out in two steps: the preparation of the enrobing sauce and the immersion of the dried meat straps in the sauce. The composition of the cocktail varies from one processor to another and allows some differentiation among them with regard to the flavour of their *kilichi*. In fact, a bad mixing of ingredients leads to a *kilichi* of poor taste (17.9 per cent). The enrobed thin straps undergo a second sun drying. As in the case of the first drying, the dry cold seasons and the rainy seasons are the feared periods. This second drying can also vary according to the type of meat and the type of *kilichi*. The composition of the enrobing paste affects the duration of drying of *kilichi* according to 30 per cent of respondents. The main indicators of the end of the second drying are that: the enrobing sauce does not stick to fingers (61.5 per cent); the thin straps are hard (23.1 per cent); and the thin straps are easy to separate from the mats (20.5 per cent).

The dried, enrobed thin straps are heated on a grill placed on a kiln made of a half barrel or mud bricks. The source of heat is charcoal (5.6 per cent) or firewood (98.7 per cent). The charcoal is used to avoid carbonization and for slow cooking. Many types of wood are used (Table 4). Bad grilling can lead to non-uniform cooking, carbonization

**Table 4** Types of wood commonly used for *kilichi* grilling in Niger

Local name	Scientific name	Family	Number of citations	%
Kalgo	<i>Piliostigma reticulatum</i> (DC.) Hochst.	Caesalpinaceae	77	32.9
Bagaruwa	<i>Acacia nilotica</i> (L.) Willd. & ex Del.	Mimosaceae	63	26.9
Sabara	<i>Guiera senegalensis</i> J.F.Gmel.	Combretaceae	64	27.4
Taramnya	<i>Combretum glutinosum</i> Perr. ex DC.	Combretaceae	45	19.2
Marjee	<i>Acacia nilotica</i> (L.) Willd. ex Del.	Mimosaceae	4	1.7
Geza	<i>Combretum micranthum</i> G.Don	Combretaceae	34	14.5
Gao	<i>Faidher bialbida</i> (Del.) Chev.	Mimosaceae	36	15.4
Kanyia	<i>Diospyros mespiliformis</i> Hochst. ex A. Rich.	Ebenaceae	1	0.4
Adoua	<i>Balanites aegyptiaca</i> (L.) Del.	Balanitaceae	15	6.4
Tchiriri	<i>Combretum nigricans</i> Lepr. ex Guill. & Perr.	Combretaceae	11	4.7
Mareke	<i>Anogeissus leiocarpus</i> (DC.) Guill. & Perr.	Combretaceae	16	6.8
Kiria	<i>Prosopis africana</i> (Guill. & Perr.) Taub.	Mimosaceae	15	6.4
Erehi	<i>Acacia senegal</i> (L.) Willd.	Mimosaceae	8	3.4
Kanatchi	<i>Cleome gynandra</i> L.	Capparaceae	29	12.4
Malga	<i>Lannea microcarpa</i> Engl. & K. Krauce.	Anacardiaceae	1	0.4
Anza	<i>Boscia senegalensis</i> (Pers.) Lam. ex Poir.	Capparaceae	1	0.4
Jiga	<i>Maerua crassifolia</i> Forsk.	Capparaceae	2	0.9
Akkora	<i>Acacia laeta</i> R. Br. ex Benth.	Mimosaceae	3	1.3
Kandili	<i>Acacia tortilis</i> subsp. <i>raddiana</i> (Savi) Brenan	Mimosaceae	13	5.6
Tazara	<i>Cornulaca monacantha</i> Del.	Chenopodiaceae	13	5.6

of the product, and can affect the taste, the odour, the tenderness, and the friability of the *kilichi*. The exposure to heat and the need for permanent monitoring of the product are some of the difficulties that the operators encounter. The addition of oil to the product during grilling (45.7 per cent of respondents) can lead to contamination by polycyclic aromatic hydrocarbons (PAHs), presenting a risk of chronic poisoning that may result in cancer (Ledesma et al., 2014; Martin et al., 2015). Table 4 shows that among the 20 types of woods used by *kilichi* processors, seven are cited by at least 10 per cent of respondents: *Piliostigma reticulatum*, *Guiera senegalensis*, *Acacia nilotica* var. *adansonii*, *Combretum glutinosum*, *Acacia albida*, *Combretum micranthum*, and *Gynandropsis gynandra*. It is reported that incomplete combustion of wood during the smoking/grilling process where there is direct contact of the flame with the product can produce considerable amounts of PAHs depending on the type of wood (José et al., 2010; Giuseppe et al., 2014). The production of *ja* and *fari* types of *kilichi* where the processor applies groundnut sauce with high fat content prior to grilling suggests a possible contamination by PAHs in these products as shown by Afsaneh Farhadian et al. (2010) and Manda et al. (2012). Further studies are needed to test these hypotheses on *kilichi* produced in Niger.

### ***Packaging and storage of kilichi and intermediate products***

*Kilichi* and intermediate products are conditioned in old cardboard boxes (46.2 per cent), in iron basins (32.5 per cent), or in aluminium basins (17.5 per cent). In these cases, the processors use a plastic bag to cover the product (50.9 per cent). Some processors conserve their product in a metallic box, in a wooden box (4.5 per cent), or in a glass cupboard (11.5 per cent). The sale packaging consists of recycled paper most often made of cement paper (97 per cent) and aluminium foil (1.7 per cent). Inappropriate packaging can reduce the market quality of the product or even its sanitary quality. The shelf life of the product depends on at which stage of production it has been collected. Minimum duration of conservation of dried thin straps and enrobed straps is one month according to 94.9 per cent of processors interviewed, and maximum duration for their conservation is about 3 months (44.4 per cent to 47.4 per cent). For some processors, produced *kilichi* is sold on the day of production and the problem of conservation does not occur. Nevertheless, *kilichi* can be conserved for a minimum of one month (80.8 per cent of the processors against 63.1 per cent of sellers), and for a maximum of one year or more (40.2 per cent of the processors against 31.5 per cent of sellers). The major problems encountered by the processors during the conservation of their products are contamination by dust (29.9 per cent), attack by insects (37.6 per cent), and increase in humidity (23.9 per cent).

### ***Quality attributes of kilichi and intermediate products***

Five products are distinguished during the production of *kilichi* (Table 5): dried thin straps, dried enrobed thin straps, dry enrobed dried thin straps, grilled enrobed dried thin straps, and grilled dry enrobed dried thin straps. A Factorial analysis of correspondences (FAC) was realized to determine the links between the products obtained and the quality attributes (Figure 5). The two axes obtained account for 97.88 per cent of the total variation, of which 61.58 per cent are explained by axis 1 and 36.30 per cent by axis 2. Figure 5 shows the correlation between the products and the quality attributes. Considering axis 2, the form, the highly dried state, and the lightness of the straps are the criteria used by the processors to appreciate the quality of the thin straps after the first drying. According to axis 1, the tenderness, the crunchiness, and the quality of seasoning are the quality attributes used for the grilled enrobed dried straps (*kilichi*). With regard to axis 2, the form of the thin straps is the main quality attribute of dried straps, and the quality of the seasoning determines the quality of dried enrobed thin straps. According to the sellers and consumers, the quality criteria sought for *rumuzu* are crunchiness (27–28.8 per cent), tenderness (27–28.7 per cent), and taste (24.2–24.6 per cent). But, for *ja* and *fari*, the quality criteria used by the sellers and consumers are: tenderness (22.9–25 per cent), flavour (21.2–23.4 per cent), consistency (15–15.6 per cent), taste (9–13.5 per cent), and adhesion of the enrobing sauce (11.5–17.2 per cent). To these criteria are added good presentation of the product (26.2 per cent of sellers against 14.4 per cent of processors), striking aspect of the product (16 per cent of sellers against 10.2 per cent of processors), hygiene (13.4 per cent of sellers against 21.14 per cent of processors),

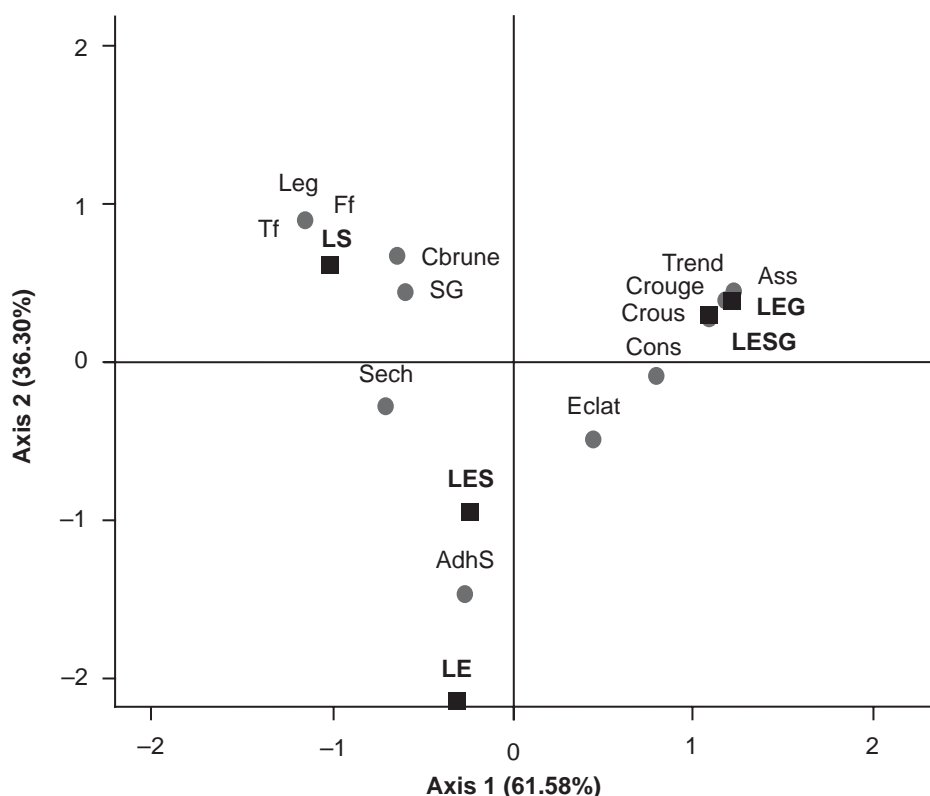
**Table 5** Intermediary and final products

Products	Number	Frequency	Number	Frequency	Number	Frequency	Number	Frequency
	of citations (row 1)	(%)	of citations (row 2)	(%)	of citations (row 3)	(%)	of citations (sum)	(%)
Dried thin straps	234	100	0	0	0	0	234 (3)	100
Dried enrobed thin straps	0	0	6	2.6	0	0	6 (0.05)	2.6
Dry enrobed dried thin straps	0	0	227	97	1	0.4	228 (1.94)	97.4
Grilled enrobed dried thin straps	0	0	0	0	6	2.6	6 (0.03)	2.6
Grilled dry enrobed dried thin straps	0	0	1	0.4	227	97	228 (0.98)	97.4
<b>Total observations</b>	<b>234</b>		<b>234</b>		<b>234</b>		<b>234</b>	

and the place of sale (14.2 per cent), which give added value to the product. For the consumers, *rumuzu* must be easy to chew (46 per cent), hygienic (21.5 per cent), attractive (11.3 per cent), and natural (20 per cent). *Ja* and *fari* are preferred also for the quality of seasoning (63.4–87.5 per cent), for their affordable price (23.7 per cent), their colour (11.1–15.2 per cent), and because they constitute a main meal (16.8 per cent). The quality attributes of *kilichi* which encourage the consumer to buy more are the presentation (30.2 per cent), the hygiene (15 per cent), and the product's shining aspect (13.3 per cent).

### Commercialization

Among the different types of *kilichi*, *rumuzu*, *ja*, and *fari* are the most often sold in urban as well as rural areas (Table 3). The sellers prefer to produce these types of *kilichi* because they are highly appreciated by the consumers (44.6 per cent) and their market value and profitability are high (73.6 per cent). For processors, the demand for *rumuzu* and *ja* is high (respectively, 60.8 per cent and 70.8 per cent of respondents), but less important for *fari* (21.2 per cent). In most cases, sellers display their product in the market (48.2 per cent), at the roadside (34.1 per cent), at a managed site (9.5 per cent), or along the road (5 per cent). Among them, 5 per cent are strolling sellers. According to 92.3 per cent of processors surveyed, the sale price of *kilichi* varies with the price of the animal. Only 18.8 per cent have mentioned a variation in relation to the total cost of production. The low prices are observed between November and February (56–73 per cent).



**Figure 5** Factorial analysis of correspondences to reveal the correlations between the products (intermediary and finished) and their quality attributes

Note: LE = enrobed thin straps; LEG = grilled enrobed thin straps; LES = dried enrobed thin straps; LESG = grilled dried enrobed thin straps; LS = dried thin straps; AdhS = adhesion sauce; Ass = seasoning; Cbrune = colour brown; Cons = consistency; Crouge = red colour; Crous = crunchiness; Eclat = striking; Ff = sheet form; Leg = lightness; Sech = dried; SG = without fat; Tf = sheet size; Trend = tenderness

The prices increase between June and October (43.2–79.9 per cent) with a peak in August, the period that coincides with the rainy season when the animals are on pasture. The prices are constant between March and May (32.9–47.7 per cent). About 49.2 per cent of sellers declare that they don't have problems with selling. Meanwhile, 18.4 per cent have mentioned a problem with a slump in sales, and 26.5 per cent declared that the sites of sale are inappropriate. These problems are linked to the season (16 per cent) or to the spoilage of the product (21.8 per cent). The survey reveals a problem with packaging. In fact, the availability of safe packaging (31.4 per cent) and the constraints linked to access to plastic packaging (9.5 per cent) and aluminium (1.4 per cent) are the difficulties encountered by the sellers. All the categories of the population buy *kilichi*. According to the respondents, *rumuzu* is bought much more by traders and civil servants (74.5–75 per cent), whereas *fari* (18.2–20.5 per cent) and *ja* (85.5–89.1 per cent) are bought by all categories of the population including farmers, artisans, traders, and civil servants.



### Consumption

The most consumed *kilichi* types are *rumuzu* (54.4 per cent), *ja* (43.6 per cent), and *fari* (2.1 per cent) (Table 3). Generally consumed alone as a snack (95.4 per cent), or associated with bread (3.7 per cent) or accompanied with fruit juice (0.8 per cent), *kilichi* is consumed in the afternoon (65.1 per cent), between meals (29.5 per cent), or at special occasions (12.4 per cent). Regarding the frequency of consumption, most of the respondents eat *kilichi* once per week (39 per cent), two to three times per week (19.1 per cent), and once per month (20.7 per cent). *Kilichi* is often consumed at home (67.2 per cent), at the market or roadside (20.7 per cent), or at the *Fada* (youth meeting point) (10.4 per cent). The different types of *kilichi* are consumed by children (83–89.2 per cent), adults (90.9–93.4 per cent), and old people (72.6–89.2 per cent). According to the consumers interviewed, *kilichi* does not have therapeutic virtue; only 6 per cent declare that it is a nutritive product.

### Conclusion

The survey revealed that types of *kilichi* include *ja*, *fari*, *rumuzu*, *maiaya*, and *danko*, differentiated by process including mainly thin straps production, sun drying, enrobing and grilling, and the types of seasoning used which probably affect the organoleptic, nutritional, and sanitary quality of *kilichi*. The lack of adequate equipment, good hygiene practices, and standardization of the processing techniques and the use of inappropriate packaging constitute the major constraints identified. Future studies are needed to assess the sanitary quality of the products in order to sensitize the processors and sellers. The results of this study constitute a baseline for development intervention and suggest some opportunities for innovation with the aim to improve the practices, the quality, and the market value of *kilichi* produced in Niger. The main focus of future investigations of interest for the processors are the improvement of the production of thin straps (sheets of fresh meat), efficient drying and grilling equipment, packaging, and overall safety of *kilichi*. Awareness-raising among processors and sellers of *kilichi* on good hygienic practices during production and distribution in order to limit the risks of chemical and microbial contamination is imperative.

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