American Journal of Food Science and Technology, 2025, Vol. 13, No. 1, 1-9
Available online at http://pubs.sciepub.com/ajfst/13/1/1
Published by Science and Education Publishing
DOI:10.12691/ajfst-13-1-1

Monitoring and Evaluation of the Quality of Kilishis Produced in the Savannahs of Northern Cameroon: Product with High Economic Potential

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Received December 14, 2024; Revised January 15, 2025; Accepted January 22, 2025

Abstract *Kilishi* snack food, made from strips of meat seasoned with a cocktail of ingredients, dried and/or grilled, has a high commercial potential (8 billion FCFA) and the artisanal nature of its production system is limited by various constraints resulting in a strong territorial variability of its quality and acceptability. This work was initiated with the aim of evaluating the relationship between unwinding (a preeminent constraint of the process) and the quality of *kilishi*. 5 kg of muscles (*Knuckle*, Scoter, Topside, *Eye round*, *Rib eye*, Chuck) from the carcass of zebu gudali slaughtered under controlled conditions were distributed to five *kilishi* processing operators in each of three cities (Ngaoundéré, Garoua and Maroua). The cocktail of spices identified in each urban center was imposed to the actors of each site with freedom of dosage. Physical analyses (dimensional and gravimetric measurements, trimming yield, unwinding flow rate, unwinding yield, hole density, *kilishi* disintegration), physicochemical (Water content, pH, TBArs, Tenderness) and microbiological analysis (TMAF, Thermotolerant coliforms, *Staphylococcus aureus*, *Clostridium perfringens*, Molds & Yeasts and Xerophilic moulds) were carried out on the different samples of meat and *kilishi*. This study highlighted that muscles with a low connective tissue content are more suitable for unwinding (6.62 $kg.h^{-1}$), carry the tenderness of *kilishi* (4.02 mm), have a low occurrence of holes (145 $holes/m^2$) and a low susceptibility to disintegration of the spice cocktail (6.33%). Furthermore, from the point of view of the physicochemical quality of the *kilishi*, the muscles rich in fat give a *kilishi* more susceptible to oxidation (0.98 mg MDA/kg). In addition, this susceptibility to oxidation is even higher when the *kilishi* is coated with peanuts (1.41 mg MDA/kg). The analysis of these indicators highlights the unique characteristics of the *Eye round* and the Scoter compared to the other muscles because the latter are more suitable for unwinding and producing a quality *kilishi*, in the technical production conditions of the northern savannahs of Cameroon. On the microbiological quality, the levels of contamination of *kilishis* by microflora (Total Mesophilic Aerobic Flora, *Escherichia coli*, *Staphylococcus aureus*, *Clostridium perfringens*, Molds and Yeasts, Xerophilic molds) are mostly higher than the maximum recommended limits for meat products. This confirms the problem of the hygienic quality of *kilishi*, and refers to a need to consider concrete actions in terms of systematic control of all inputs and training of production stakeholders on the quality assurance approach.

Keywords: *constraint, unwinding, oxidation, tenderness, quality*

Cite This Article: Aimé Christian Ndih, Robert Ndjouenkeu, Piérre Désiré Mbougueng, and François Xavier Etoa, "Monitoring and Evaluation of the Quality of Kilishis Produced in the Savannahs of Northern Cameroon: Product with High Economic Potential." *American Journal of Food Science and Technology*, vol. 13, no. 1 (2025): 1-9. doi: 10.12691/ajfst-13-1-1.

1. Introduction

A food made from dried meat strips, seasoned with a cocktail of ingredients and subjected or not to a grilling operation [1], *kilishi* constitutes, due to its secular popularity, a cultural, identity and economic value of the savannah regions of Northern Cameroon. Throughout the unwinding manufacturing process, operators build the final quality of the product by implementing technical practices based on specific quality indicators at each stage of the process; the aim being to obtain a *kilishi* appreciated for its flavor, texture (tenderness, friability, adherence of spices, low density of holes) and its suitability for conservation. The unit operations involved in its production (unwinding, drying, coating, grilling) are likely to lead to a differentiated construction of the final quality of the product, depending on the type of muscle used, the space and the production conditions [2,3,4]. Various scientific studies (drying, coating, microbiological and nutritional quality, etc.) have focused on the constraints of the traditional *kilishi* manufacturing process, but the preeminent constraint of the system deserves the same interest, but has not benefited so far from scientific and technical relish, this is the case for the meat unwinding operation which carries out the physical characteristics of the strips and the risks of injury of the operator [3,4]. This study is conducted in a dynamic of highlighting the process-quality relationship, with unwinding at the center, based on the hypothesis that the type of muscle is a major factor for both the efficiency of unwinding, the physical structure of the strips and the quality of the *kilishi.*

2. Materials and Methods

2.1. Source and Preparation of Animal Material and Ingredients

5kg of choice of a muscle (Table 1) from the carcass of zebu gudali, with an average age of 4 years, slaughtered under controlled conditions (compliance with good slaughtering practices) in the municipal slaughterhouse of each city (Ngaoundéré, Garoua, Maroua) in Cameroon, were distributed to 05 *kilishi* processing operators in each respective city. The operators were chosen on the basis of their reputation in the local *kilishi* production system and their willingness to get involved in the study and they selected the muscles according to their preference.

Table 1. Muscles distributed to the five processors in each city (the figures represent the number of actors who chose each muscle in each city)

Muscles	Cities		
	Maroua	Garoua	Ngaoundéré
Knuckle	1		2
Scoter	1		
Top side	1	1	
Eye round	1	1	1
Rib eye	1	1	2
Chuck		2	

2.2. Muscle Processing and Monitoring of *kilishi* Production

Kilishi production was carried out in each processing workshop, by monitoring the unit operations of the process. Some environmental parameters (time, temperature, wind speed, duration of sunshine) were recorded with the support of local meteorological services and the intermediate and finished products were collected, weighed, packaged and sealed in sterile double density plastic bags for laboratory analysis.

3. Physical Analyses

3.1. Dimensional and Gravimetric Measurements of Samples

The weight of the samples taken during each stage of the process was measured using a Camry digital scale model EK5350 with a precision of 0.01g, their dimensions (length and width) using a graduated ruler and their thickness using a digital caliper, model King Force Professional (Precision: 0.01mm). The core temperature of the samples was determined using a digital thermometer, model TP 3001. The duration of the unit operations was determined by a Hybrid Stopwatch & Timer 3.1.2 digital and the dimensional and mass data collected at each unit operation made it possible to determine the production yields at the various intermediate and final stages:

i) Trimming yield (TY): percentage of mass compared to the mass of starting fresh meat (Eq. 1):

$$TY = \frac{(M_1 - M_2)}{M_1} x\ 100 \quad (1)$$

With: M_1: Mass in grams of meat to be trimmed; M_2: Mass in grams of trimming losses

ii) Unwinding flow rate (UFR): mass of meat unwounded into strips per unit of time (Eq. 2)

$$UFR = \frac{M}{t} \quad (kg.h^{-1}) \quad (2)$$

With: M: Mass in kilograms of the meat to be unwounded; t: Time taken (h) to unwind the mass M of meat

iii) Unwinding yield (UY): percentage of mass of strips compared to the mass of meat to be unrolled (Eq. 3):

$$UY= \frac{(M_1 - M_2)}{M_1} x\ 100 \quad (3)$$

With: M_1: Mass in grams of the meat to be unrolled; M_2: Mass in grams of losses during unwinding

iv) Density of holes on *kilishi* (DH): number of holes per unit area of the *kilishi* (Eq.4):

$$DH = \frac{N}{L x l} \quad (Holes/m^2) \quad (4)$$

N: number of holes; L: Length of dried meat strip (m); l: Width of dried strips (m)

3.2. Disintegration of the *kilishi*

The disintegration of the ingredient cocktail was obtained by vibrating a portion of approximately 50g of *kilishi* on a Sieve-Tronic A059-12 08.05 shaker for 5 min and the wreckage, consisting of a cocktail of dry spices detached from the strips, was collected and weighed. The disintegration (D) is expressed as a percentage of the mass of the disintegrated ingredient cocktail over the mass of the initial coated *kilishi* (Eq. 5): $D = \frac{(M_1 - M_2)}{M_1} x\ 100$ (5)

With: M_1: Mass in grams of the *kilishi* before vibration; M_2: Mass in grams of the *kilishi* after vibration.

4. Physicochemical Analyses

4.1. Water and Dry Matter Content

The water content of the meat samples and *kilishis* is determined by drying a mass of 5 g in an oven at 105°C to a constant mass [5]. The total dry residue or dry matter noted MS is expressed as a percentage compared to the fresh matter

With: M_0 = mass (g) of the empty capsule; M_1 = mass (g) of the capsule containing the test sample before drying; M_2 = mass (g) of the capsule containing the dried test sample. The water and volatile matter content noted H was deduced from the dry matter rate (Eq. 6): %H = 100-%MS (6).

4.2. pH Measurement

The pH measurements of meat and *kilishi* were carried out from 10 g of fresh ground meat or *kilishi* homogenized in a POLYTRON 10 homogenizer for 15 seconds in 20 mL of 5 mM Iodoacetic acid. Iodoacetic acid blocks the activity of glycolytic enzymes that can influence the pH value [6]. The measurements were carried out on the homogenate thus obtained using a Eutech electrode attached to a pH meter pH 510 Cyberscan.

4.3. Thiobarbituric Acid Index (TBArs)

TBArs (thiobarbituric acid reactive substances) are co-products formed during the peroxidation of unsaturated fatty acids (omega 3 series fatty acids and omega 6 series polyunsaturated fatty acids) [7]. Their determination allows the oxidation state of samples to be quantified. Substances reacting with thiobarbituric acid (TBA) consist mainly of Malondialdehyde (MDA), a product derived from membrane peroxidation. The principle of the assay is based on the reaction in an acidic medium and at high temperature between one molecule of MDA and two molecules of TBA to give pink chromophores absorbing at 530 nm. In this work, trichloroacetic acid and phosphoric acid were used to extract thiobarbituric acid-reactive substances from the samples according to the protocol described by [8].

-test sample: 20g of *kilishi* ground material

-suspend the sample in 50 mL of extractive solution (20% trichloroacetic acid in 2M phosphoric acid at 4°C) and homogenize for 1.5 min

- bring the overall volume of the sample to 100mL with distilled water and homogenize the mixture using a stirrer (Oscill 12; Prolabo) for 1 min

-filter 50 mL of the mixture through Watman filter paper No. 1. -transfer 5 mL of the filtrate into a test tube (15x200mm) containing 5 mL of TBA (0.005M in distilled water)

-close the tubes and mix the solutions using a vortex mixer (Jencons-PLS; VX 100)

-then keep the tubes in the dark at room temperature (20°C) for 15 hours

-measure the color obtained after this time with a UV/Visible spectrophotometer (Rayleigh vis-723N) at 530 nm.

• Expression of results The TBA value is obtained by multiplying the absorbance by 5.2 [9]. This is expressed in mg of malonic aldehyde per kg of *kilishi* sample. There are no threshold values for the TBArs index in the literature, however, a product containing less than 1 mg MDA equivalent/kg is generally accepted as being non-oxidized [7].

4.4. Evaluation of the Tenderness of *kilishis*

The tenderness was evaluated by penetrometry (digital penetrometer with standard RS232C interface) of *kilishi* samples of dimensions of approximately 2 cm in length, 2 cm in height and 1 cm in width. In order to avoid an erroneous reading of tenderness during the procedure, parts containing a lot of collagen or adipose tissue were avoided. The *kilishi* is placed on a horizontal support and the stress is applied perpendicular to the muscle fibers for 5 seconds and the distance traveled by the needle, reflecting the tenderness is read on the penetrometer, in this regard several measurements were made and the average being representative of the tenderness of the sample.

5. Microbiological Analyses

5.1. Preparation of Stock Solutions and Decimal Dilutions

25g of each *kilishi* sample are ground aseptically between two bensun nozzles in a sterile Robot-cop Blender GT 550, Switzerland with 225 ml of autoclaved Maximum Recovery Diluent (MRD), to obtain a 10^{-1} stock suspension. The different dilutions are made from the stock solution in accordance with ISO 6887-2 (ISO, 2004).

5.2. Inoculation and Enumeration

-Total mesophilic aerobic flora

Total germs indicate the degree of overall bacterial contamination of the sampled sites, thus allowing an assessment of their general healthiness. The enumeration of total mesophilic aerobic germs was carried out on Plate Count Agar (PCA) medium (Oxoid CM463) (ISO 4833:1991) from decimal dilutions inoculated in petri dishes and incubated at 37°C for 72 hours.

-*Escherichia coli* (Faecal coliforms)

The ISO 7251:2005 method was used for the detection and enumeration of *Escherichia coli* using the liquid culture technique with calculation of the most probable number (MPN) after incubation at 44°C.

-*Staphylococcus aureus*

The enumeration of *Staphylococcus aureus* was carried out according to the horizontal method referenced ISO 6888-1: 2021(F) on Baird Parker Oxoid CM 275 agar and the petri dishes were incubated at 37°C for 48 hours.

-*Clostridium perfringens*

The presumptive identification and enumeration of *Clostridium perfringens* were carried out according to the horizontal method referenced ISO 15213-2:2023 and the petri dishes were incubated at 37°C for 48 hours.

- Moulds & Yeasts and Xerophilic moulds

The horizontal method recommended by ISO 21527-2: 2008 for the enumeration of yeasts, moulds and xerophilic moulds by counting colonies in products with a water activity of less than or equal to 0.95 was used and the petri dishes were incubated at 30°C for 72 hours.

6. Data Analysis

All measurements were carried out in triplicate and the results expressed as mean ± standard deviation. Analysis of variance (ANOVA) of the data was used to assess the effect of the different factors and Duncan's test to compare the means at the probability threshold $p<0.05$. Statgraphics 5.0 software was used for this purpose.

7. Results and Discussion

7.1. Conditions for Obtaining Meat for the Study

Monitoring of slaughtering in each urban center made it possible to determine that the slaughtering conditions (Table 2) make it possible to affirm that the meat arriving at the *kilishi* manufacturing workshops is in a state of rigor mortis, which could negatively impact the ability of the muscles to be unwounded.

Table 2. Conditions for obtaining meat for the study

Paramètres	Maroua	Garoua	Ngaoundéré
Time between slaughter and entry into the kilishi processing workshop (h)	3h 30	3h 48	3h 56
Ambient temperature of the workshop	42.3 ±1°C	42.1 ± 1°C	27.1 ± 0.1°C
Meat core temperature	33 ±0.51°C	35.2 ± 1.16°C	28.6 ± 0.6°C
Meat pH at the start of trimming	6.56±0.01	6.64±0.01	6.5±0.12

7.2. Environmental Data During the Production of *kilishis*

Table 3 presents the environmental data recorded during the production of *kilishis* in the 03 urban centers which pre-note good conditions (drying, coating, roasting) for the construction of the physical structure of the lamellaes.

7.3. Muscle Unwinding Ability

7.3.1. Trimming Yields

The Eye Round and the Topside have the highest trimming yields (TY ≥ 90%) (Figure 1), unlike the Knuckle and the Chuck whose recovery rates do not exceed 80% (Figure 1), this is justified by the low connective tissue content of the Eye Round and the Topside, compared to the Knuckle and the Chuck. For each muscle, the trimming yield does not differ significantly ($P>0.05$) between the production areas, which could be justified by the fact that the samples analyzed come from the same bovine breed, and possibly by a relative homogeneity of the animal feed in the 3 regions.

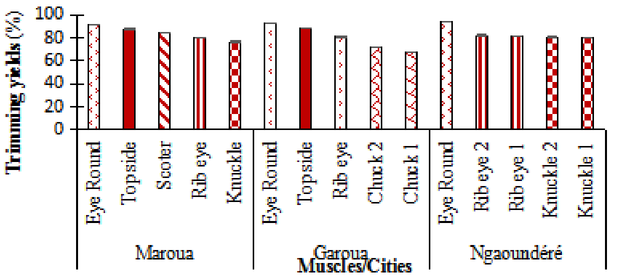

Figure 1. Mass yield profiles during muscle trimming

7.3.2. Flow Rate and Unwinding Yield

The flow rate and unwinding yield (Figure 2 and Figure 3) show a comparable profile from one region to another with decreasing values from the Eye round to the Knuckle, this is true for both the unwinding flow rate and the mass yield with a strong demarcation for the Eye round which has the highest yield, compared to the other muscles of the carcass. If this observation is very clear on the mass yields of unwinding (RD ≥ 98% for the Eye round and 96.5% ≤ RD ≤ 97.0% for the other muscles) without significant ($P> 0.05$) variation from one space to another (Figure 2). The unwinding flow rates are characterized by a more reduced variability between the Eye round and the other muscles and by a significant effect of the processing space. In this regard, the unwinding rates seem relatively higher in Ngaoundéré (Figure 1). The proportions of connective tissues in the Eye round (0.3%) and Scoter (0.5%) muscles [10], can justify their tenderness and consequently their relatively good unwinding ability, compared to other muscles whose connective tissue contents vary from 0.7% to 4% [10]. Unwinding, a major constraint of the process, also constitutes the essential component of the know-how of the actors in *kilishi* production.

Table 3. Environmental data during *kilishi* production

Cities	Unit operations	Time (min)	Temperature (°C)	Wind speed (m/s)	Sunshine duration (%h)
Maroua	Primary drying of the lamellae	340	40±2	3.7	18.75
	Coating	5	40±2	3.8	18.75
	Secondary drying of the lamellae	180	40±2	3.5	18.5
	Roasting	12	95±2	3.6	18.5
Garoua	Primary drying of the lamellae	360	39 ±2	3.1	17.7
	Coating	10	39 ±2	3.1	17.7
	Secondary drying of the lamellae	250	39 ±2	3.3	17
	Roasting	14	93±2	3,1	17
Ngaoundéré	Primary drying of the lamellae	400	30±2	1.2	16.6
	Coating	15	29±2	1.2	16.6
	Secondary drying of the lamellae	300	30±2	1.1	16.5
	Roasting	8	91±2	1.1	16.5

7.4. Behavior of Meat Strips During Drying

During the drying of the strips, the loss of water by evaporation promotes the retraction of the muscle tissues, which results in dimensional changes (Figure 4) and a better perception of holes (Figure 5).

7.4.1. Dimensional Changes of the Strips

The dimensional changes vary according to the muscles and are more prominent on the width of the strips than on their length. Indeed, the strips lose 2 to 3% of their length during drying compared to 4 to 12% of their width (Figure 4). In terms of the thickness of the strips, losses can be as high as 26 to 50%, particularly for the Chuck and the Knuckle (Figure 4). The longitudinal structure of the myofibrillar cells and the unwinding of the muscles parallel to the fibers justify this orientation of shrinkage during drying, since the elimination of water from the cytoplasm promotes cellular retraction in the direction of the reduction of the diameter of the cytoplasm of the muscle fibers, hence a more pronounced retraction of the thickness and width of the lamellae. Furthermore, the juxtaposition of the muscle fibers across the width of the lamellae imposes physical constraints between the juxtaposed fibers, limiting their retraction in the width direction, unlike the thickness of the lamellae which provide a surface from which evaporation takes place primarily. This justifies a greater contraction in the thickness direction.

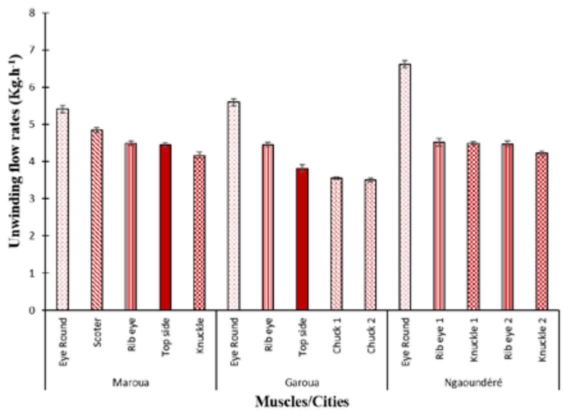

Figure 2. Muscles unwinding flow rates according to spaces

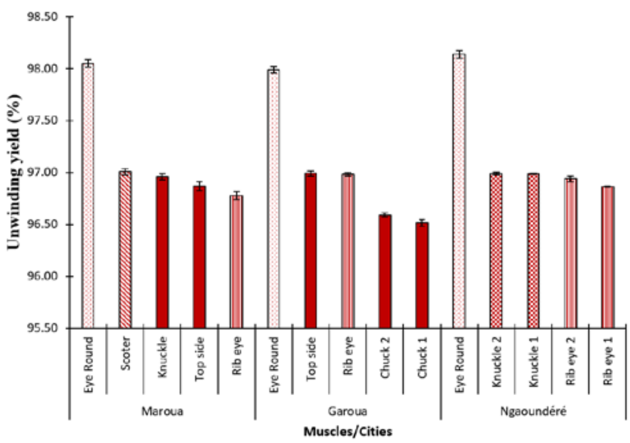

Figure 3. Mass yields of muscles at unwinding process according to spaces

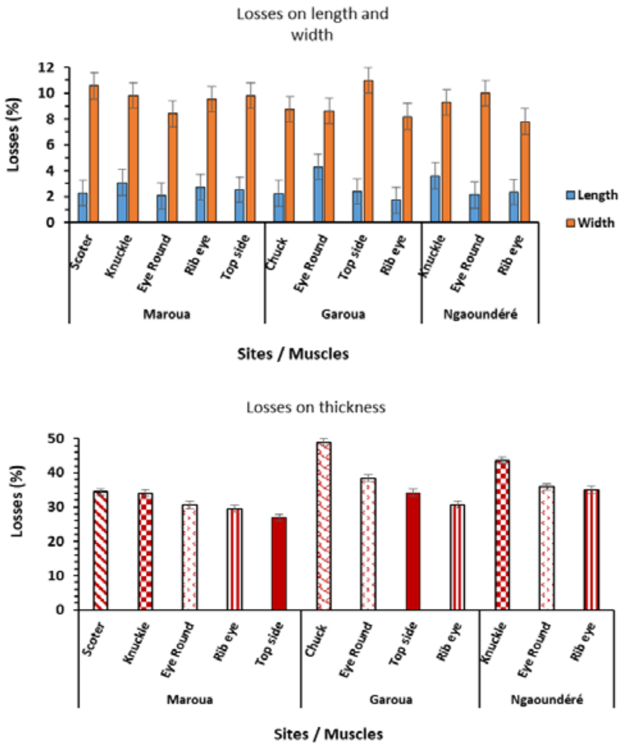

Figure 4. Dimensional variation profiles of the lamellae during drying

7.4.2. Holes Density

The occurrence of holes on the lamellae is perceived at the same time as an indicator of the physical structure of the muscle, in terms of the proportion of connective tissue, and of the ability to unwind the muscles. Cellular retraction during drying allows a better appreciation of the occurrence of holes and their density. The Eye round and Scoter lamellae display a tendency towards a reduction in hole density (Figure 5), in accordance with their flow rates and unwinding yields (Figure 2 and Figure 3). The production site has no significant effect ($P > 0.05$) on the occurrence of holes on the lamellae since for a given muscle, the density of holes remains comparable between the different spaces, which shows that the occurrence of holes would be more the result of the structure of the muscle, therefore of the anatomical origin of the muscle.

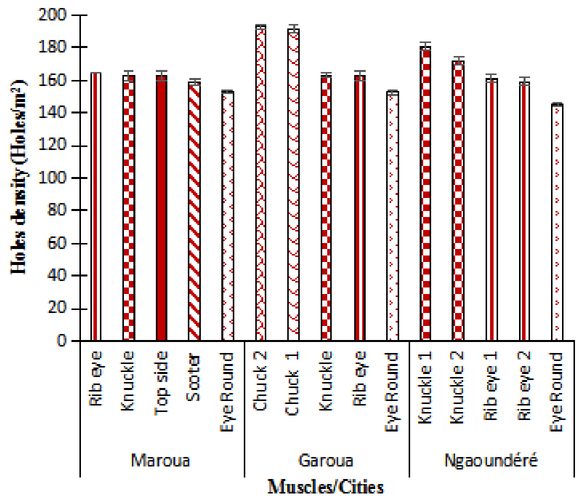

Figure 5. Holes densities

7.5. Disintegration of the Spice Cocktail

Disintegration is the detachment in plates of the spice cocktail on the *kilishi* slices after the unit operations of drying and roasting. It is also a descriptor of the quality of the coating and of the *kilishi* at consumption, in so far as it provides information on the adhesion of the spice cocktail on the strips. Overall, disintegration is systematically higher when the spice cocktail is integrated into the peanut paste (Figure 6), which indicates a limited adhesion of the peanut paste on the strips. Although the variability of the level of disintegration between the muscles is relatively low; it is noted that the Eye round and the Scoter (Figure 6) present, in all cases of coating (with or without peanut), the tendencies of disintegration, lower than the other muscles, without significant variation (P> 0.05) from one production area to another. This shows that the structure of the muscle and specifically the low connective tissue content reduces disintegration.

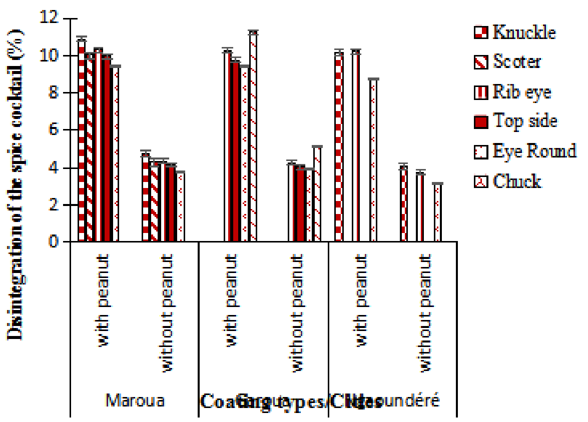

Figure 6. Disintegration of the spice cocktail on the kilishis of the savannahs of northern Cameroon

7.6. Quality of *kilishis*

7.6.1. Physicochemical Quality

7.6.1.1. Water Content

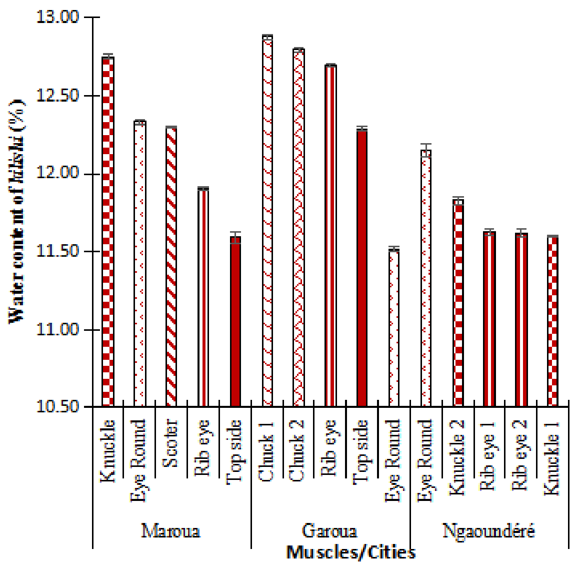

Figure 7. Water content of *kilishis*

The *kilishi* strips are sufficiently dried (11.51-12.88%) to minimize microbial growth (Figure 7), although this content varies depending on the production site, muscle typology and muscle location, it remains within the range allowed by the Cameroonian (PNC 6292) and Nigerian NN 01-01-001 (TE ≤ 15%) standards. These results are similar to those obtained by [1,11].

7.6.1.2. pH

The pH values of meats after slaughter (Table 4) show values in a range compatible with those commonly observed at the beginning of rigor mortis in bovine muscles [11,13]. Stopping blood circulation at slaughter, places the muscle in anaerobic condition and sets in place various physicochemical phenomena integrating the activation of anaerobic glycolysis, which will result in the production of lactic acid from glycogen, which contributes to lowering the pH of the meat. The pH results show that rigor mortis takes place in good conditions that predict an efficient construction of the technological quality of the meat that will be used for the production of *kilishi* strips.

Table 4. pH of meat after slaughter

Villes	Muscles frais	pH
Maroua	Knuckle	6.46 ± 0.02^{b}
	Scoter	6.43 ± 0.02^{ab}
	Rib eye	6.4 ± 0.02^{a}
	Top side	6.51 ± 0.02^{b}
	Eye Round	6.42 ± 0.04^{a}
Garoua	Chuck 1	6.7 ± 0.07^{c}
	Eye Round	6.48 ± 0.03^{b}
	Chuck 2	6.43 ± 0.05^{ab}
	Top side	6.53 ± 0.05^{b}
	Rib eye	6.4 ± 0.02^{a}
Ngaoundéré	Rib eye 1	6.41 ± 0.02^{a}
	Knuckle 1	6.56 ± 0.01^{b}
	Knuckle 2	6.55 ± 0.02^{b}
	Rib eye 2	6.42 ± 0.02^{a}
	Eye Round	$6.43 \pm 0.02A^{a}$

Mean values denoted by different letters in the same column are significantly different (p <0.05).

7.6.1.3. Oxidation Level (TBArs) of *kilishis*

The rupture of myofibrillar cells during unwinding, coupled with successive post-unrolling treatments (drying and grilling), releases the fat from the muscle and exposes it to oxidation phenomena, at the same time as the fat provided by the coating. Overall, the oxidation level of *kilishis* at production (Figure 8), represented by the thiobarbituric acid index (TBArs), is within a tolerable range, since, on the one hand, the majority of muscles have a TBArs index lower than 1 mg MDA/kg, and on the other hand, the values obtained for the samples (≤ 1.41 mg MDA/kg) are not at a level likely to allow a sensory perception of rancidity [7]. Overall, peanut paste coated strips had a higher TBArs index than strips coated without peanut paste, confirming that peanut paste coating increases the oxidation potential of *kilishi*. Oxidation levels were significantly (P< 0.05) differentiated by muscle typology, coating sauce formulation, and production location.

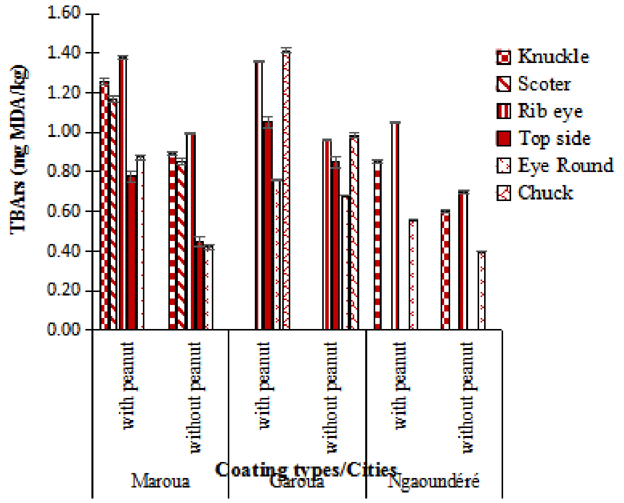

Figure 8. TBArs of the *kilishis* of the savannahs of Northern Cameroon

7.6.1.4. Tenderness of the *kilishis*

Tenderness is the most important sensory descriptor for consumers [14]. This attribute seems to be more driven by the type of muscle than by the treatments undergone by the strips. In this regard, the Eye Round, the Rib eye and the Scoter have the highest levels of tenderness, regardless of the treatment applied (Figure 9). It can be assumed that this is due both to the low relative proportion of connective tissue and to the more pronounced tenderness of these muscles [10,12,13], which is likely to drive this tenderness of the strips, in accordance with their high flow rates and unwinding yields (see Figure 2 and Figure 3). The tenderness of *kilishi* can be explained by the correlation between low connective tissue content and tenderness and moreover the type of coating (with or without peanut) secondarily influences this tenderness through the phenomenon of crusting and encrustation of pores observed preferentially on coated in a matrix made of peanut paste.

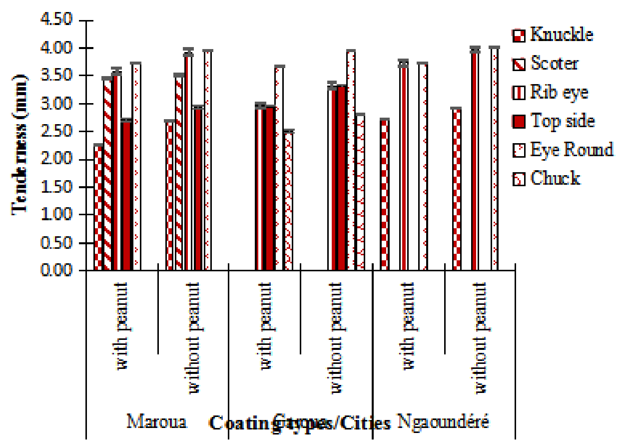

Figure 9. Tenderness profiles of *kilishis*

7.6.1.5. Comparative Analysis of Muscles Based on Unwinding and *kilishi* Quality Indicators

The integrated analysis of unwinding indicators (flow rate, yield and hole density), coating (disintegration) and *kilishi* quality (tenderness and TBArs) based on the different types of muscles (Figure 10), highlights the unique characteristics of the Eye round and the Scoter compared to the other muscles. These two muscles are characterized by the highest flow rates and unwinding yields, a low occurrence of holes on the lamellae, a low level of disintegration during coating and lead to a softer *kilishi* and less susceptible to oxidation. These results allow us to affirm that the Eye round and the Scoter are the muscles most suited to the production of a quality *kilishi*, in the technical production conditions of the northern savannahs of Cameroon.

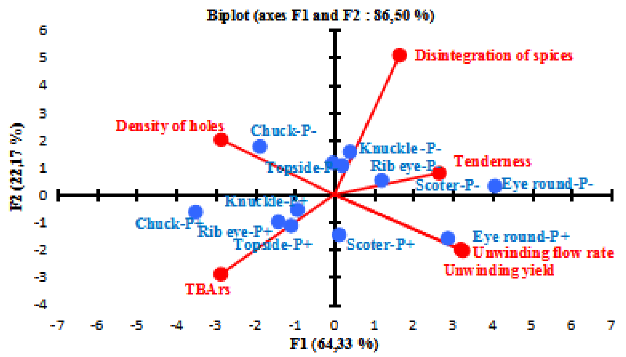

Figure 10. Relationship between muscle type and *kilishi* process indicators (P+: coating with peanut; P-: coating without peanut)

7.7. Microbiological Quality of *kilishi*

At the microbiological level, we note as others authors [15,16,17] have pointed out, that there is a problem with the hygienic quality of *kilishi* (Figure 11). When we look globally at the hygienic quality of *kilishi*, we realize that, although this problem is global, there are some differentiations in contamination levels between the actors. The analysis of the total mesophilic aerobic flora (Figure 11 a) (contamination germs) of the *kilishis*, suggests a priori an acceptable level of contamination of certain products without peanut, whereas in reality, the levels of contamination by others microflora are mostly higher than the maximum values admitted by the microbiological criteria that cooked meat products must meet to be officially recognized as fit for consumption. The peanut coating systematically appears as a source of contamination in view of the conditions of preservation and processing of the peanut to integrate the cocktail of spices. Thermotolerant (fecal) coliforms are indicators of recent or ongoing contamination, of human or animal fecal origin, and their density is generally proportional to the degree of pollution produced by the fecal matter and systematically all peanut-coated *kilishis* (Figure11b) present contamination levels beyond the recommended limits, as also reported by [15,16,17]. *Staphylococcus aureus* and *Clostridium perfringens* (Figure 10 cd) are found at levels beyond the acceptable limits, representing potential risks to consumer health. This result is comparable to those of [15,16]. The levels of contamination by molds & yeasts and xerophilic molds (Figure 11ef) are beyond the recommended limits and seem to be higher in the city of Ngaoundéré, as confirmed by the work of [16] which attributes them to environmental conditions (relative humidity and rainfall). Systematically, all coated *kilishis* are heavily contaminated by molds and yeasts, which presents a potential risk of contamination by mycotoxins [16]. One of the potential sources could be peanuts. These microbiological results confirm the problem of the hygienic quality of *kilishi*, and refer to a need to consider concrete actions in terms of systematic control of all inputs and training-awareness of production stakeholders on hygiene rules.

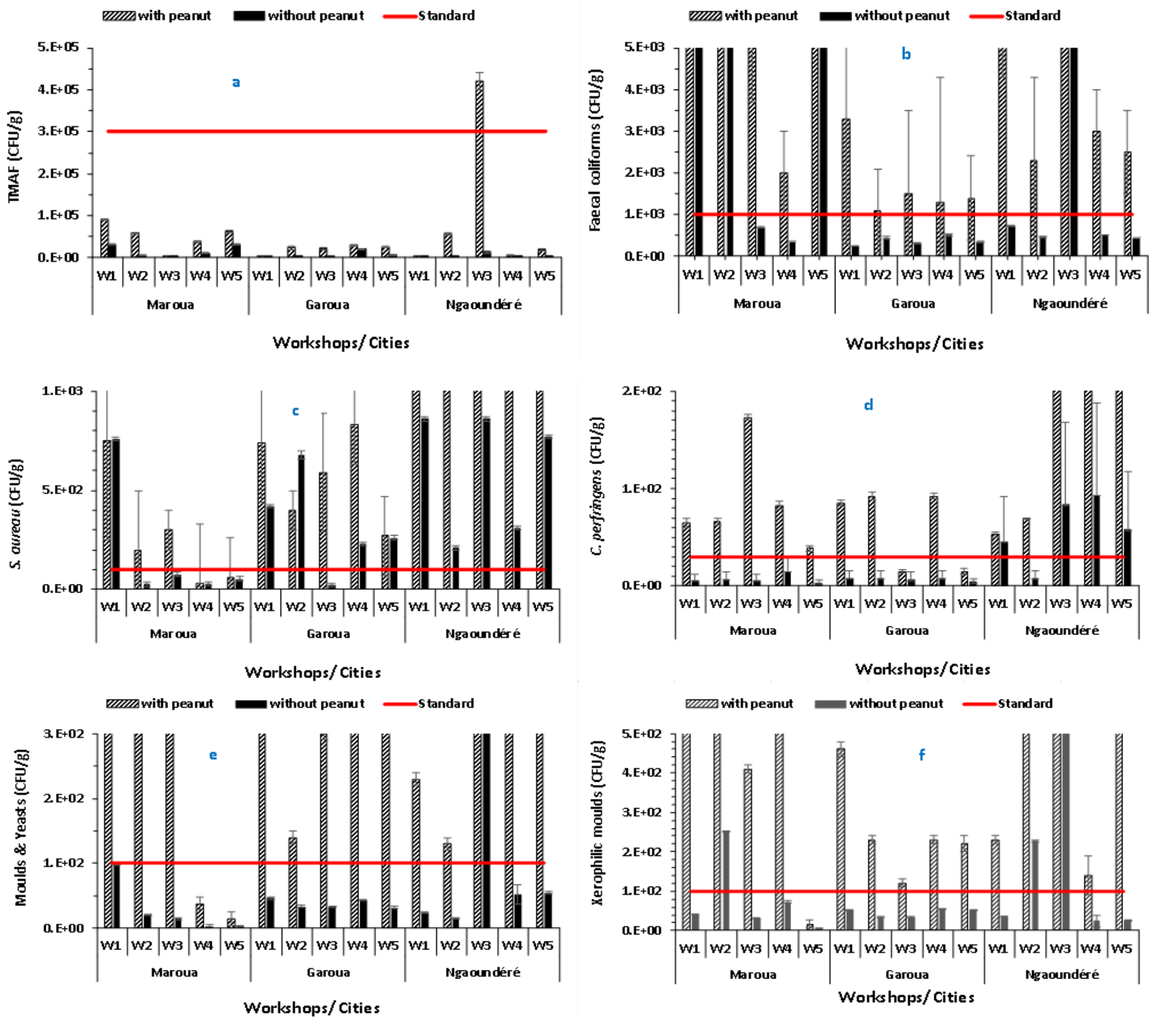

Figure 11. Microbial profiles of *kilishis* in urban center workshops in northern Cameroon

8. Conclusion

The objective of this study was to assess the quality of kilishi in different production areas, based on the technical practices implemented, taking into account the nature of the muscle used. This study highlighted that muscles with a low connective tissue content are more suitable for unwinding, carry the tenderness of kilishi, have a low occurrence of holes and a low susceptibility to disintegration of the spice cocktail. Furthermore, from the point of view of the physicochemical quality of kilishi, muscles rich in fat give a kilishi more susceptible to oxidation. In addition, this susceptibility to oxidation is even higher when the kilishi is coated with peanuts. The analysis of these indicators highlights the unique characteristics of the Eye round and the Scoter compared to other muscles. This allows us to affirm that the Eye round and the Scoter are the muscles most suitable for unwinding and producing a quality kilishi, in the technical conditions of production of the northern savannahs of Cameroon. The tenderness of the muscle carries the tenderness of the kilishi, but in the process of passing from muscle to meat, this tenderness is built during aging, which means that aging is likely to improve unwinding.

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