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Research Article

Influence of aging on the unwinding ability of the Eye round and the Scoter in the differentiated construction of the Kilishi Lamellae

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Abstract

Kilishi, a highly prized food for its organoleptic qualities, has a high commercial potential, estimated at around 08 billion FCFA in Cameroon and 40 billion FCFA in the Lake Chad region. However, the nature of its production system is limited by various constraints resulting in a high territorial variability of its quality and acceptability. If several scientific and technical studies have been interested in the process, the unit operation of aging of the muscle in a view of facilitating the construction of meat strips, has not aroused any scientific and technical interest. The present study focused on two muscles, Eye round and Scoter, with the aim of evaluating the influence of aging (0h to 96H at 4°C) on meat characteristics, on unwinding ability and consequently on kilishi quality. This study highlighted that the decrease in water content (75% to 70%), pH (6.8 to 5.6), CRE (70% to 50%) and the increase in ESS (4.5 to 20%) during aging reflects an improvement in tenderness. This justifies the improvement in flow rates (4.97 to 8.68 $kg.h^{-1}$; 3.91 to 6.63 $kg.h^{-1}$) and yields (97.94 to 99.89%; 96.19 to 97.59%) of unwinding of the Eye round and the Scoter. A reduction in holes density (162 to 96 holes/m^2; 213 to 138 holes/m^2) and susceptibility to disintegration of spices cocktail (19.67 to 16.13%; 22.33 to 18.13%) with a probable reduction in the risk of injuries, and consequently a reduction in the criticality of unwinding are observed during the aging period. However, the risk of injury is probably not reduced to zero at aging stage, particularly due to the fact that during unwinding, the operator's fingers remain exposed to the sharp knife. Eliminating the risk of injury during unwinding requires considering a dynamic centered on the analysis and improvement of the technical practice implemented.

Keywords: Constraints; Unwinding; Injuries; Aging; Quality

Introduction

If all unit operations in the manufacture of kilishi carry constraints, the production stakeholders place the unit operation of unwinding and the techno-functional quality of the meat at the top of the constraints [1] to be lifted to guarantee the quality of the product and improve the productivity of the process. The coherence and relevance of this ranking is due to the fact that the texture of the meat, in particular its tenderness, determines its suitability for unwinding, in terms of easing the passage of the knife for the manufacture of strips. The textural properties of the meat result among other things from the muscle aging conditions [2-4]. Therefore, the quality of the unwinding depends on this aging, insofar as the enzymatic reactions occurring during a suitable aging allow a restructuring of the muscle proteins and a redistribution of water, with consequence, the tenderness of the meat [2,5-8]. It goes without

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saying that beyond the aging conditions, the breeding and slaughtering conditions are also involved in the construction of the structure and quality of the meat and by extension of the kilishi. The Eye round (hind quarter) and the Scoter (front quarter) are commonly used in the manufacture of the kilishi, we can therefore assume that their suitability for unwinding is likely to be improved based on the hypothesis that the state of aging of the muscle is a factor in regulating the unwinding, with the aim of a differentiated construction of the quality of the kilishi.

Materials and Methods

The Eye round, muscle of the hindquarter of the carcass and the Scoter, muscle of the forequarter, are derived from the categorical cutting of the carcass of a 4-years-old zebu gudali, slaughtered under good practices at the municipal slaughterhouse of Maroua. The two muscles, transported to the laboratory, were trimmed on a stainless steel cutting table using a thin sharp knife by removing the aponeurosis and adipose tissue, then cut into pieces parallel to the fibers. Each muscle was divided into 2 batches:

- A first batch consisting of whole pieces from the cutting.
- A second batch divided into 15 cubic pieces of approximately 5cm on each side, with a mass of 50 ± 1g.

Muscle processing: aging, unwinding and manufacturing of kilishis

The two batches of samples were aged in a refrigerator (Samsung Multi flow 2015) at 4 ± 2 °C, for 0, 24, 48, 72 and 96 hours. At the end of each aging time, three samples from each batch were removed from the refrigerator for monitoring the analyses of the aging characteristics on the cubic pieces and on the whole pieces for unwinding.

Physicochemical analyses

Monitoring of maturation indicators

Water content

2.3.1.1 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 DM is expressed as a percentage compared to the fresh matter (Equation 1):

$$\%\,DM = \frac{(M_2 - M_0)}{(M_1 - M_0)} x\ 100 \quad (1)$$

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 (Equation 8): %H = 100-%MS (2).

2.3.1.2 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.

2.3.1.3 Water Retention Capacity (WRC) Water retention capacity is assessed by quantifying the volume of juice extracted (Expressible juice) from a meat sample under given conditions. This quantity depends on the method used and must therefore be determined by a standardized method. In this respect, we adopted a combined approach of [11] method and [12] measurement approach. 1g sample of raw muscle, approximately 2 cm long by 1cm wide, was placed between two sheets of Whatman No. 114 filter paper, previously tared, and pressed between two flat glass plates for 20 min, under a mass of 1kg. The weight gain of the filter papers relative to the initial weight of the meat defines the water retention capacity of the meat.

2.3.1.4 Soluble Dry Extract (SDE) The measurement of SDE was used to express the tenderness of the meat and the [13] method was used for this purpose.

-Dry the crucible and the filter paper in an oven at a temperature of 105°C for 1 hour and cool in a desiccator and weigh: Pc_1: Weight of the crucible

-Sieve (P2b g) of ground meat in a volume of water;

-Crush to pass through the mesh (1 mm) of a sieve the maximum of the ground meat until the water is clear for 5 min;

-Filter into the crucible through previously tared filter paper;

-Dry the filtrate contained in the crucible in an oven at 105 ° C for 24 hours;

-Cool the crucible in the desiccator;

- Weigh the crucible (Pc_2). The expression of the soluble solids content (ESS) is given by the formula:

$$EDS = \frac{(Pc2 - Pc1)}{P2b} x\ 100 \quad (3)$$

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

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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 (Equation 1):

$$\mathrm{TY} = \frac{(M_1 - M_2)}{M_1} \times 100 \quad (4)$$

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 unwound into strips per unit of time (Equation 2):

$$\mathrm{UFR} = \frac{M}{t}\ (\mathrm{kg.h^{-1}}) \quad (5)$$

With: M: Mass in kilograms of the meat to be unwound; 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 unwound (Equation 3):

$$\mathrm{UY} = \frac{(M_1 - M_2)}{M_1} \times 100 \quad (6)$$

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

iv) Density of Holes on kilishi (DH): number of holes per unit area of the kilishi (Equation 5):

$$\mathrm{DH} = \frac{N}{L \times l}\ (\mathrm{Holes/m^2}) \quad (7)$$

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

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 (Equation 6):

$$\mathrm{D} = \frac{(M_1 - M_2)}{M_1} \times 100 \quad (8)$$

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

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.

Results and Discussion

4.1 Conditions for obtaining meat

Monitoring of slaughtering in Maroua urban center made possible to determine that the slaughtering conditions (Table 1) allowed to set up 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 unwound.

Table 1: Conditions for obtaining meat for the study

Paramètres	
Time between slaughter and entry into the *kilishi* processing workshop (h)	199 min
Ambient temperature of the workshop	42 ± 1°C
Meat core temperature	32 ± 1°C
Meat pH at the start of trimming	6,55 ± 0,07

4.2. Physicochemical behavior of the Eye round and the Scoter during aging

The water content (75%) and pH (6.8 and 6.9) (Figure 1) present values in a range compatible with those commonly observed at the end of the panting state of bovine muscles [2,13,15]. The post-mortem evolution of the muscles results in a progressive decrease in water content (from 75% to 70%) and pH (from 6.8 to 5.6) during the 96 hours of the experiment. This decrease is attributable to the biochemical phenomena occurring in the muscles when the animal is killed, 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 progressive decrease in water content, as observed in the case of the Eye round and the Scoter (Figure 1), certainly results from the continued exudation of free extracellular water, or even intercellular to a lesser extent, and from the denaturation of proteins. It should be noted that the low speeds and amplitudes of this water loss (less than 4% in 96 hours) remain within acceptable limits, consistent with the values commonly observed in normal bovine meats. As for the post-mortem decrease in the pH of meats (Figure 1), a rapid drop rate is noted during the first two days of aging, which indicates a high activity of glycolysis. This enzymatic activity is significantly slowed down from the third day, due to the depletion of degradable glycogen [16]. After 96 hours, the pH reaches the value of 5.5, corresponding to the ultimate pH zone (the point at which the pH decreases, i.e. the final post-mortem pH value). The magnitude of the pH drop (degree of drop) and its rate of variation contribute to maintain the samples within suitable limits, in terms of meat quality. The drop in pH is also accompanied by an increase in the extractable exudate (Expressible juice), indicating a reduction in the ability of the muscles to retain their own water, i.e. their Water Retention Capacity (WRC) decreases.

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WRC is an indicator of the intensity of post-mortem muscle aging [17]. In this regard, in the context of the experiment, the capacity of the Eye round and the Scoter to retain their free water, goes from 70% at the beginning of aging, to approximately 50% after 96 hours (Figure 1). This decrease in the WRC goes hand in hand with the decrease in water content and the drop in pH observed (Figure 1). In the present case of the aging of the Eye round and the Scoter, the levels of drop in pH and WRC are found in the normal aging conditions observed in beef meat [11]. The loss of water during aging is not likely, under normal conditions, to cause a significant decrease in the soluble nutrients of the meat, which justifies the increase in the Soluble Dry Extract (SDE) of the Eye round and the Scoter samples during aging (Figure 1), reflecting a concentration of soluble nutrients in the meat. This concentration of soluble substances also results from the hydrolysis of myofibrillar proteins, and could be correlated with the tenderization of the muscle, or even with a facilitation of the ability to unwind. The parameters pH, WRC and SDE are among the main determinants of the construction of meat quality during muscle maturation, due to their regulatory action on the activity of proteolytic enzymes and water movements within the muscle.

4.3. Influence of aging on the ability to unwind and the quality of the strips

4.3.1. Behavior of the muscles during unwinding

The flow rate and the unwinding yield of the Eye round and the Scoter increase with the aging time (Figure 2,3), which justifies the improvement of the positive impact of the tenderness of the meat on its ability to unwind. Although the aging indicators of the two muscles are comparable (see Figure 1) with probably comparable levels of tenderness, the Eye round presents a higher flow rate (4.97-8.68 $Kg.h^{-1}$) and unwinding yield (97.94-98.89 %). This is justified by its low connective tissue content and its alveolar structure [2,5,18]. which lead to better tenderness and predispose it to easier unwinding, resulting in high flow and yield values, compared to the Scoter (3.91-6.63 $Kg.h^{-1}$; 96.19-97.59%), whose connective tissue content is higher [5,18] reducing its tenderness.

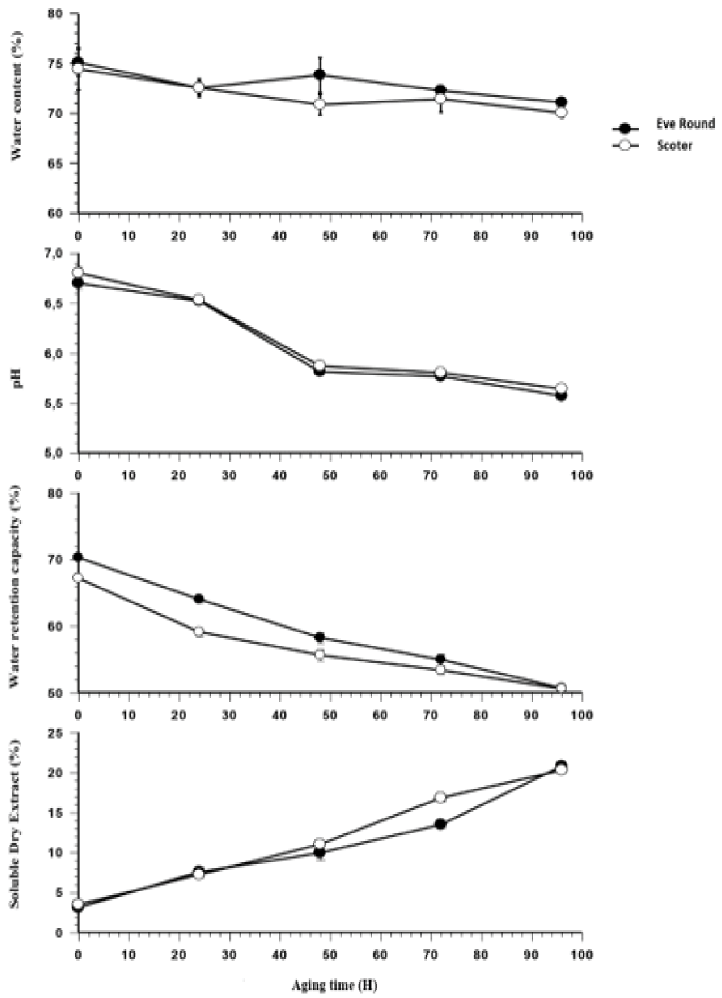

Figure 1: Evolution of the physicochemical indicators (WC, pH, WRC, SDE) of the Eye round and the Scoter during aging

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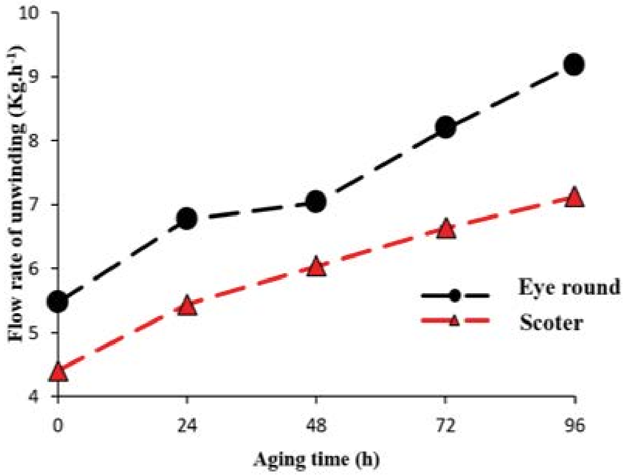

Figure 2 : *Evolutions of unwinding flow rate of the Eye round (●) and the Scoter (▲) during aging*

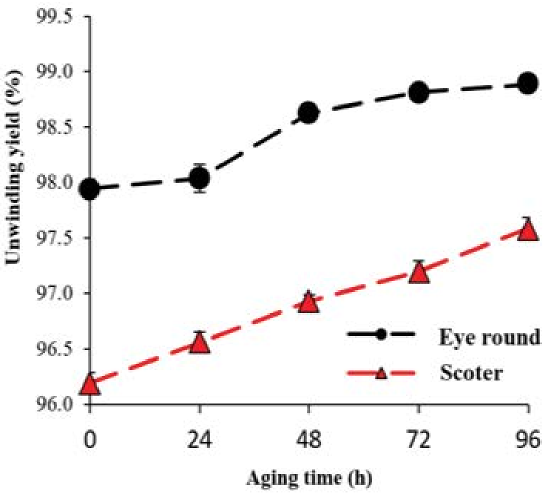

Figure 3 : Evolutions of yield unwinding of the Eye round (●) and the Scoter (▲) during aging

4.3.2. Behavior of meat strips during drying

a) Holes densities

The holes density of the strips decreases during aging for both muscles (Figure 4), with profiles inversely comparable to the effects observed on the unwinding flow rates (Figure 2). This suggests a causal link between the high unwinding flow rate and the low holes density, which means, as the tenderness of the muscles gradually improves during aging, the actors are able to unwind the pieces of meat more easily, which results in a low occurrence of holes and injuries on operators fingers. However, the holes density is relatively higher for the Scoter due to its connective tissue content. If the low connective tissue content of the Eye round [2,3,5,7] predisposes it to a low occurrence of holes, this factor alone cannot justify this differentiation in holes densities observed for the two muscles. This differentiation could possibly be associated with the alveolar structure and the cylindrical shape of the Eye round which would predispose it to a better aptitude for unwinding.

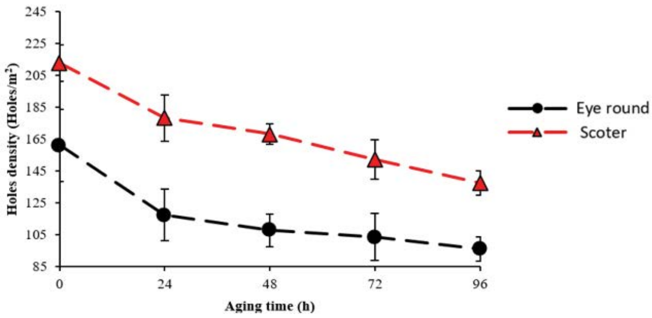

Figure 4: Evolution of the holes density of the Eye round (●) and the Scoter (▲) during aging

b) Dimensional changes (L, l, e) of the lamellae

During drying, water loss by evaporation promotes the retraction of muscle tissues, resulting in a dimensional variation of the lamellae that mainly affects the width and thickness of the lamellae. While the magnitude of the losses in length and width is comparable between the two muscles, whereas it is different in terms of thickness (Figure 5). The Eye round undergoes the greatest loss in thickness due to its high water content and low connective tissue content, coupled with its alveolar structure [2,3,5,7]which predispose it to this high dimensional variation, since meat with an alveolar structure with less connective tissue will dry more easily than firm meat with a high connective tissue content.

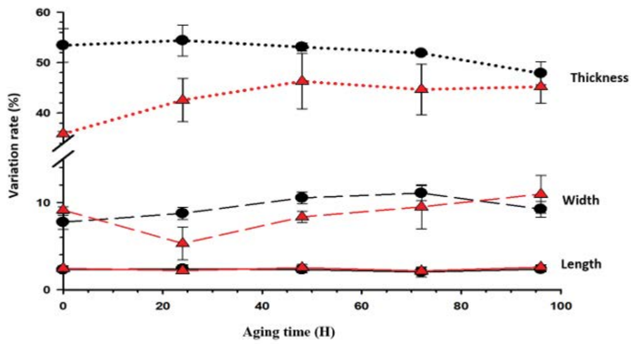

Figure 5: Dimensional variation of the Eye round (●) and of the Scoter (▲) strips during drying as a function of the aging time

c) Disintegration of spices cocktail

The disintegration of spices cocktail, integrated in a matrix made of peanut paste, decreases for both muscles with the aging time and is more marked for the Eye round (Figure 6). Overall, the decrease in the disintegration of the cocktail of spices could be explained by the post-mortem evolution of the muscles, which results in conformation changes causing unmasking of active groups, modifications of solubility properties that would have favored the diffusion

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and the encrustation of the cocktail of spices. This lower disintegration with the Eye round of lodging certainly reflects the positive impact of its low content of connective and adipose tissues and its alveolar structure with regard to the adhesion of the spices cocktail.

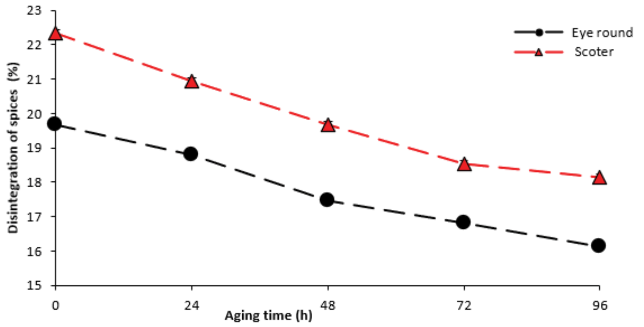

Figure 6: Evolution of the disintegration of the cocktail of spices of the Eye round (●) and the Scoter (▲) according to the aging times

Conclusion

The objective of this study focused on the need to see how aging influences the techno-functional properties of the meat and consequently its suitability for unwinding and the quality of the kilishi. This study made it possible to highlight that the aging of the muscles results in an improvement in the flow rates and yields of unwinding, by a decrease in the density of holes and a reduction in the susceptibility to disintegration of the spices cocktail. In addition, the decrease in pH, WRC and the increase in SDE during aging reflect an improvement in tenderness, which justifies the ease of unwinding the muscles with a probable decrease in the risk of injuries, and consequently a reduction in the criticality of unwinding unit operation, which is moreover the preeminent constraint of the kilishi manufacturing process. However, the risk of injury is probably not reduced to zero at aging, particularly because during unwinding, the operator's fingers remain exposed to the sharp knife. Therefore, optimal minimization of the risk of injury during unwinding requires a dynamic focused on the analysis and improvement of the technical practice implemented.

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