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Influence of dimensional mapping of meat lamella on Drying and Coating steps during processing of "*Kilishi"* a spicy dry meat from Western Africa

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Abstract- With the aims at contributing to quality of "*Kilishi*" a spicy dry meat from Western Africa, this study was carried out to understand the influence of lamella dimensional mapping on drying and coating steps. It was found that at each of these steps, there is variation in meat lamella dimensions.Themeat strips presentnon-uniform dimensions which impact the steps of drying and coating. When introducing the step of maturation in the process, it was observed that the meat results in more uniform strips during cutting and drying and promotes better coating success. The results of the sensory analysis corroborate these assertions with the choice of *kilishi* made from strips of meat matured at 76h and 96 hours.The*front quarter* muscle exhibits more aptitude for the production of *kilishi* compared to the *Rear quarter* muscles.

Keywords – meat, *kilishi*, Africa, drying, coating, quality

I. INTRODUCTION

Kilishi is a product made from strips of dried, coated and grilled meat with flavors and nutritional qualities sought after by consumers [1, 2]. The artisanal *kilishi* production techniques is facing processing problems which limit its consumption and marketing [1]. The first problem is that during cutting, meat is processed manually leading to a non-uniform dimensions strips [2]. This non-uniformity of the strips is a real problem during drying and coating [2, 3]. During drying the differentiation of dimensions extend the duration of drying, requires more intensity of solar energy, generates degradation caused by intrinsic and extrinsic factors linked to the meat, reduces the shelf life of the dried strips in the case where the water content of dried meat is still high [3]. This non-uniformity of the lamella also induce that the coating step become less efficient [3]. Indeed, the organoleptic and nutritional qualities of *kilishi*are exhaled during this phase. However, we notice an non uniform distribution of the coating cocktail, the diffusion and the adhesion of the brine in the slice of meat is disproportionate because of this differentiation of dimensions, the operation requires a relatively longer brining time and consumers also complain of losing a good part of the coating sauce when the product is consumed [4]. It thus important to master the steps in order to improve

the final quality of the *kilishi*. This work thus aims ant understanding the Influence of dimensional mapping of meat lamella on Drying and Coating steps during processing of "*Kilishi*" a spicy dry meat from Western Africa

II.MATERIAL AND METHODS

A. Material –

Animal material: To conduct this study, two muscles were used, the "*Rond de Gîte"* (rear quarter) called "maamakari" in local language and the Scoter (front quarter) called "haloua" in the local language.
Plant material: As plant material, we used spices: basil, ginger, garlic, peppers and onions.

B. Methods –

1. Preparation of samples
Two muscles, the "Rond de gîte" (rear quarter) and the Scoter (front quarter) from a carcass of a *Goudali*a local beef were purchased. Each muscle was divided into five batches, the first batch was used for unwinding in the *rigormortis*phase and the others were unrolled at 24h, 48h, 72h and 96h, (maturation times) at +4°C in a refrigerator . The previously prepared spice cocktail was used and the different strips were brined for 5, 7 and 10 min, dried and roasted in 5 min, the resulting *Kilishi* were wrapped for further analysis.

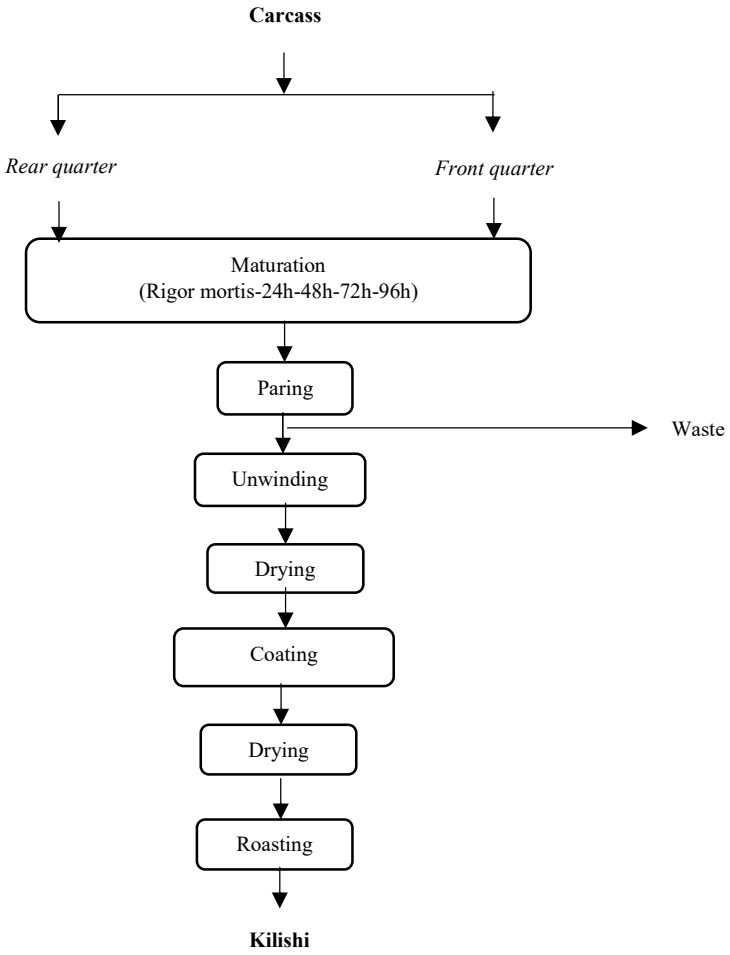


Fig. 1. Fowsheet of the *Kilishi* processing

2. Weight gain evaluation: The weights of the meats, strips and *Kilishi*were determined using a Camry digital model EK5350 precision 0.01g scale.
3. Measurement of lengths, widths and thicknesses of slices of fresh, dried, *Kilishi meat*: The lengths and widths of the pieces and strips of fresh and dried meat were recorded using a graduated ruler, a seam meter and the thicknesses by a King Force Professional brand digital caliper (Accuracy: 0.01mm) .
4. Temperature measurement: The temperature measurements were determined by the digital thermometer TP 3001 at the heart of the pieces of meat, at the surface of the strips of the meat during drying and grilling.
5. pH measurement: The pH of meats and *kilishi* was measured using 10g of ground fresh meat or *kilishi* crushed using a mortar or finely cut using a knife macerated for 5 to 10 minutes in 20 ml of 'distilled water. Insert the electrode into the meat solution and read the pH values displayed on the screen of the Cyberscan brand pH meter. The pH value was the average of three tests.
6. Determination of dry matter, water content: The determination of the water content and the dry matter was carried out by the method of [5], based on the dehydration of the product at 105 ° C to constant weight.
7 Rehydration time and capacity of dried strips in brine was evaluated by immersing the strips of dried meat in brine at room temperature (20°C) for 5, 7 and 10 minutes in the sauce recording the time required to rehydrate the meat stripsbybrine. The calculation of the rehydration capacity (h) was expressed as the mass of brine absorbed after 10 min of immersion, divided by the dry mass of each sample.
% h = (M brine absorbed) / (M sec)
8. Meat solubility test: Water absorption capacity and Solubility index.
The water absorption capacity (ACE) will be determined by the modified method of Phillips *et al.*[6]
A mass of Mo meat equal to 1g (M0) was mixed with 10ml of distilled water and the whole stirred for 30 min using a Bioblockcompsas type stirrer and centrifuged at 5600 rpm for 30 min. in a SIGMA brand type BioblockCompsas centrifuge. The pellet (M2) was collected, weighed and heated in an oven at 105 ° C for 24 hours. The weight of the dry pellet (M1) was recorded. The water absorption capacity (CAEr) is then calculated as follows:
$CAEr\% = ((M_2-M_1)) / (M_1) \times 100$
The solubility index was determined by the method of Anderson *et al.*[7] and calculated by the formula:
$IS\ (\%) = ((M_0-M_1)) / (M_0) \times 100$
The water retention capacity (CRE) of different muscles was determined as describe by Zayas and Lin [8] as follow: 1g sample of raw muscle is placed between two sheets of Whatman No. 4 filter paper and pressed between two flat glass plates for 20 min under a mass of 1 kg. The area of the filter paper soaked with the juice from the squeezed raw muscle as well as the area occupied by the muscle are measured.
The result is expressed as follow: $CRE\ (\%) = [1- (1-Sp / Sj)] \times 100$
Where Sp is the surface area of the muscle sample on the filter paper and Sj is the area of the juice that was soaked through the filter paper.
7. Sensory evaluations of *kilishi*
The sensory attributes of differents "*kilishi*" samples was carried out using a panel of 30 trained pannelist. The panelists were ask to evaluate 10 samples of "*kilishi*" produced. The descriptors of the characteristics evaluated for this purpose were: color, taste, texture, flavor and overall quality. Preliminary instructions and explanations were given to the tasters before the start of the tasting as required by Arnaud, [9]
8. Statistical analyzes
The values of the various parameters evaluated are the means of three repetitions (n = 3) and the responses are represented by the means ± standard deviations. Data analyzes were performed by Excel. Sensory analysis data processing was performed using Sphinx Plus 2-Edition Lexica-V5.InK software and Excel 2010.

II. RESULTS AND DISCUSSIONS

A. Coating Suitability Studies

Coating is the process of impregnating the cured meat with a sauce or peanut oil. The preparation of this sauce takes into account several parameters namely:

The state of maturation of the meat: Meat matured from 24 hours has more aptitude for cutting, drying and coating. We have found that during coating the strip absorbs the brine more easily [10], resulting in a better quality *Kilishi*. After rigor mortis the meat unrolls and dries more easily [11].

The preparation of the brine:

For this preparation, the quantity of the ingredients was determined beforehand and the following formula was obtained as presented:

Table 1 : Formulation of the coating sauce.

Ingredient	Quantity (g)	Proportion (%)
Pepper	222	5,67
Ginger	283	7,23
Garlic	151	3,86
Peanut	2000	51,09
Onion	202	5,16
Salt	40	1,02
Sugar	17	0,43
Water	1000	25,54
Total	3915	100

Coating:

Coating is a step that involves getting dried meat in a sauce or peanut oil. This step includes the preparation of the sauce. It should also be noted that there are various parameters that influence the success of the coating and therefore lead to the production of a best quality *kilishi*. Among these parameters are: the ripening state of the meat, the unwinding step, the quantity of ingredients used, the step of preparation of the brine, and the brining time.

Ripeness

The ripeness of the meat is a factor that influences the success of *kilishi* coating. Indeed, the maturation of the meat is necessary, because it aims to soften the muscle fibers and make the flesh tenderer and more aromatic with reduced juiciness [3, 12]. The role of maturation is therefore to raise the organoleptic and taste qualities of the meat, namely flavor and tenderness, but not only these qualities emerged during this process but even more during maturation, in the process of making *kilishi*, plays a role in the suitability for embedding. It has been found that the state of maturation of the muscle plays an important role in the suitability for embedding. By considering the results of the experiments carried out on two types of muscles (the front and rear quarter muscles), after having undergone 5 different maturation times (0h, 24h, 48h, 72h, 96h), we see, by comparing the weights of the coated strips, that the muscle having undergone a 24-hour maturation has more aptitude for coating because it better absorbs the brine. The coating being the step which gives the *kilishi* the characteristics desired by the consumer, the organoleptic and nutritional qualities sought, it will be more advantageous to mature the muscle within 24 hours then to coat to thus find a limit to the disintegration of the cocktail of coating and preserve the flavor of the *kilishi*.

The unwinding

Uncoiling is a step that may or may not contribute to the success of the coating depending on whether it has been done well or not. Indeed, it is an operation carried out manually and therefore we run the risk of obtaining non-uniform thongs. By obtaining strips that are too thick (greater than or equal to 5), the diffusion of the brine in the heart of the product takes longer than if the strips are thinner (1 to 2mm as recommended by *Ndih et al,*[3]), then we notice that the time required for seasoning will not be identical in all points, which also affects the final quality of the product. In the perspective of improving the cutting stage, it would be advantageous for producers to mature at 4 ± 2 oC for at least 24 hours the meat before cutting where the muscle begins to soften and become firm, which impacts on the quality of unwinding, namely the thickness and type of fiber of the slats. These results corroborate those obtained by Ndih*et al.,*[3]. According to him, the most favorable state for cutting is the state of maturation (24

hours post-mortem) which makes it possible to have very thin *kilishi*, facilitating the brining operation and obtaining thin strips making thus to succeed the operation of the coating and the improvement of the qualities of *kilishi*.

Photo 1: Unwinding the muscle

The amount of ingredients used

For a successful coating, you need a good formulation for a coating brine that is palatable. So we focused on finding a composition for the coating sauce, as well as the amounts of ingredients to use. From one *kilishi* producer to another, the formulation is different and determines the final taste of the product. To prepare this sauce, the following formula was used (Table 1).

The brining time

In order to improve the quality of the coating, we varied the brining time by taking as reference the work of Ndih*et al.,*[3] according to which the brining time is 2 to 4 min, we varied the time between 5, 7 and 10 min. As notice Figure 1 the time necessary for the best absorption of the brine is 10 min.

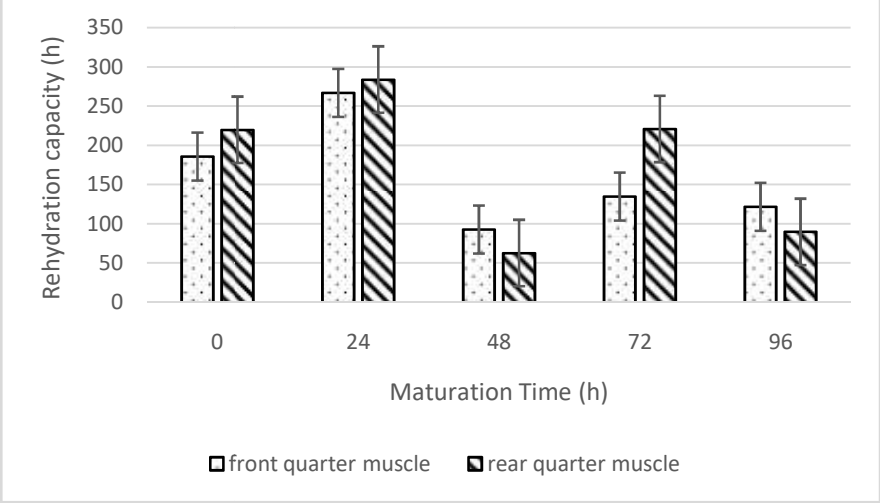


Figure 2: Brine absorption as a function of maturation time

B. Physical evolution of muscle during different steps of Kilishi processing

Mass gain

The mass gain at each stage of production has enabled us to determine the variations likely to occur and the behavior of the meat at these different stages of production. It appears from Table 2 that the masses gradually decrease during production, this decrease in mass is due on the one hand to the elimination of waste and inedible parts of the meat during trimming and on the other hand to the decrease. Of the moisture content of the meat during the process. This second is more noticeable at the level of drying where more than 60% of water of the muscle is lost.

Table 2: Variation of Muscle mass during different steps

Muscle	**Before trimming**	**After trimming**	**After unwinding**	**Coated strip before drying**	**Dry coated strip**	**Kilishi weight**
Rear quarter maturated 0h	414±10	383±10	354±11	273±10	153±9	123±9
Rear quarter maturated 24h	625±11	592±10	534±10	368±11	249±8	209±8
Rear quarter maturated 48h	565±13	487±12	453±12	110±10	89±8	74±8
Rear quarter maturated 72h	281±10	268±10	248±11	251±11	172±7	152±9
Rear quarter maturated 96h	280±11	235±11	222±11	123±11	81±8	81±5
Front quarter maturated 0h	548±12	484±12	442±10	320±10	210±9	169±6
Front quarter maturated 24h	455±10	415±12	375±10	253±10	151±9	124±7
Front quarter maturated 48h	400±11	354±10	302±11	125±13	80±7	63±7
Front quarter maturated 72h	424±10	367±10	346±12	185±12	121±7	102±8
Front quarter maturated 96h	383±10	346±13	320±11	164±10	125±8	91±6

pH variation of muscle during different steps of *Kilishi*processing

The measurement of pH allows us to determine the aptitude of the meat for processing. Fig 2 present us the variations in pH at the rigor mortis level after maturation, drying of the meat. Before the maturation pH is in the range 6.6-6.7 and fall between 5.5 and 5.8, it is consistent with those obtained by Elrammouz, [13] in his opinion the pH of the meat decrease gradually from 7 to 5.5, which shows the breakdown of glycogen for storage of meat.

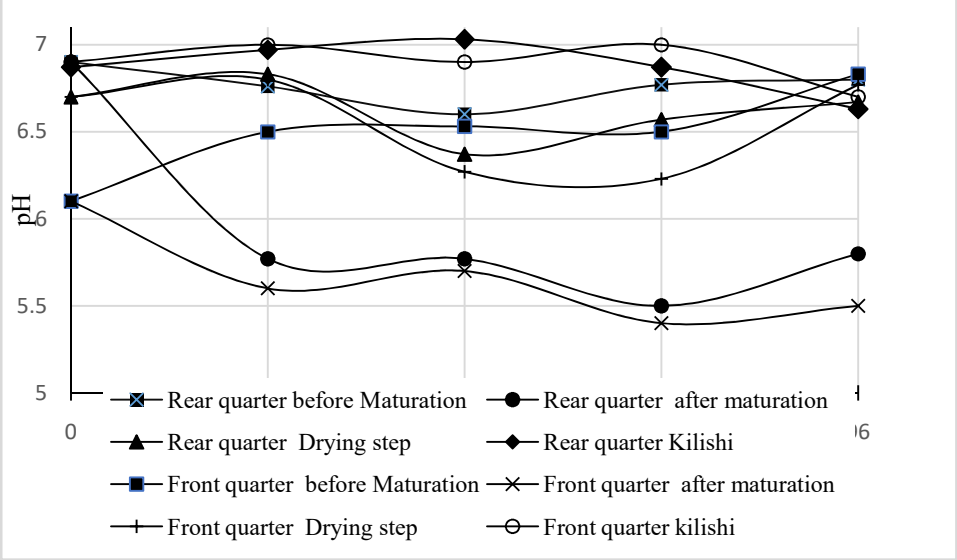


Figure 3: Evolution of the pH of at different stages of production

3. Measurement of water content

The obtained graphs of the variation of the water content of the meat show that these values vary between 74- 79% for round cottage and 72-79% for scoters, which are not very different from the results of Cheftel*et al.,* [14]. These values allow us to determine the time required for good drying.

On average, the moisture content of meat is between 55-75% according to Cheftel*et al.,* [14]. According to experiments, we find a water content between 74-79%. This result is slightly above that of Cheftel*et al.,* [14], this translates that several factors impact on the quality of the muscle (breeding conditions, breed, diet, type of quarter and muscle).

During maturation, the water content of the muscle drops slightly overall. This drop is due to the fact that during the process, the muscle loses a quantity of water. Indeed, during maturation, free water does not crystallize; therefore it escapes from the internal environment to the external environment via the pores, hence the decrease in the amount of water contained in the muscle.

When drying in the sun, the elements of the climate are not controlled and have an impact on the water content. When the sun's intensity is not high and prolonged, the muscle does not lose water quickly. In this case, there is a deterioration in the quality of the meat to be dried. In case the water content of the dried coverslips is high, the shelf life is reduced.

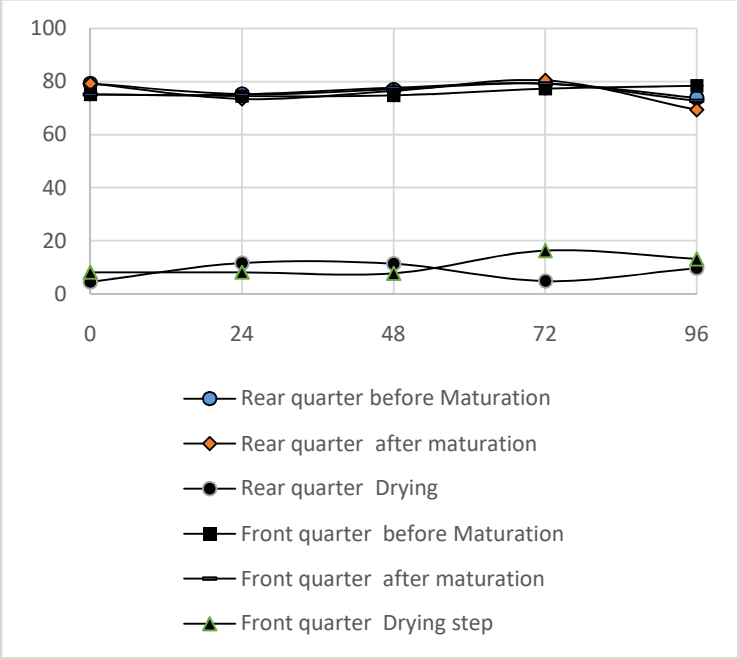
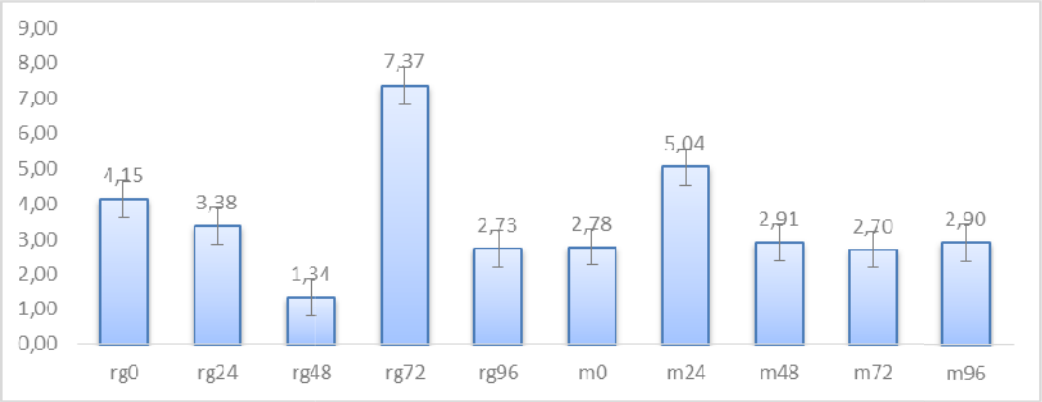


Figure 3: Evolution of the water content of Scoter at different stages of production.

4.Rehydration capacity of the strips dried in brine

It can be notice that the rehydration capacity of “Rond de Gîte” lamellae varies between 1.34 and 7.37% and the scoter lamellae varies between 2.70 and 5.04% (Fig. 3). The rehydration peak is observed among the slices of “Rond de Gîte”, which will mean that this type of muscle has a greater rehydration capacity than that of the scoter and therefore allows better absorption of the brine which gives the *kilishi*a pleasant flavor.



rg= "*Rond de gite*" m="*Macereuse*" (*rear quarter*)

Figure 4 : Representation of the rehydration capacity of the dry strips.

5. Meat solubility test

- **Water absorption capacity and Solubility index.**

Water absorption capacity is the quantity of water that is retained in the meat during storage [15]. According to Wang *et al.*[16], high water absorption capacity values are important in order to help maintain moisture content in products. Moisture loss adversely affects the yield and quality attributes of meat products, and therefore results in economic losses for industries [17]. From the figure below, it can be notice that each muscle has its own water absorption capacity and gives it an ability to absorb water in the event of rehydration after drying. .

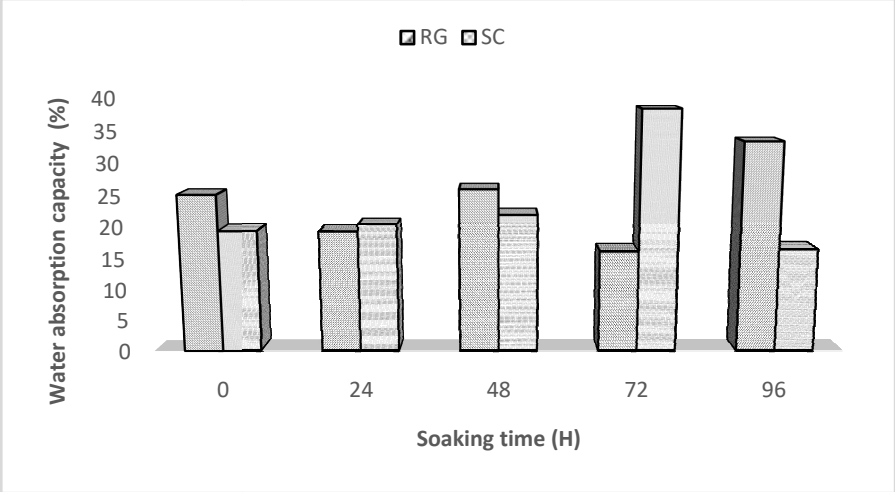


Figure 5:Water absorption capacity.

The recorded figures indicate that the best amount of water (moisture) taken up by meat to achieve the desirable consistency and create quality end product may be for *"Rond de gite"* 96h and for the Macereuse (Scoter) 72h (Fig 5). These are the optimum amount of water required to allow the muscles to become excessively sticky for the process.

It can also be notice that the solubility index decreases as a function of the muscle maturation time for the "*Rond de Gîte"* but in the Scoter it increases up to 48 hours and then decreases (Fig. 6). This information reveals that the meat strips are likely to be soluble in water or in the coating brine

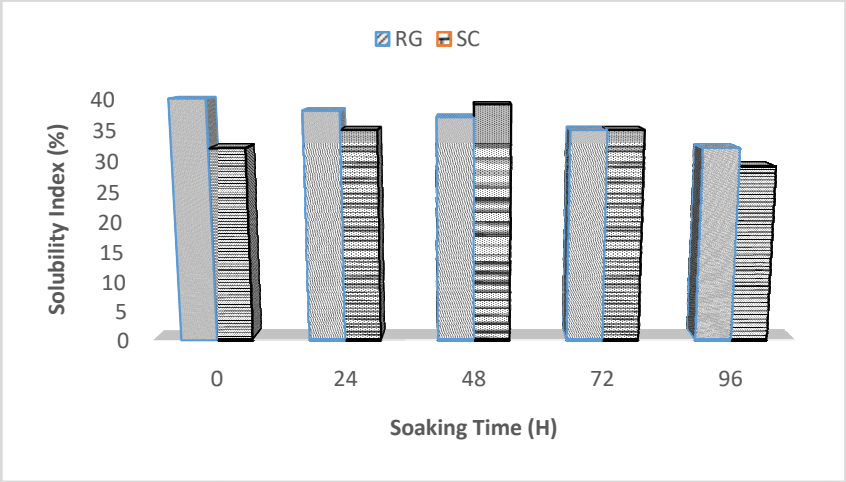


Figure 6: Solubility index.

- **Real water retention capacity of muscles**

From Fig 7below, we can see that for the "Rond de Gite"that the values decrease during maturation. This decrease in the real water retention capacities of the refrigerated muscle is consecutive to a denaturation of the proteins, denaturation which originates from the combined action of the cooling which they undergo as the quantity of available water decreases. Under these conditions, the pH induces a significant denaturation of the proteins which are no longer capable of retaining water in the muscle, which makes it possible to draw the conclusion that the maturation of meat impacts on the real water retention capacity of the muscle by reducing it.

The pH has an influence on the real water retention capacity, the drop in pH also causes a drop in the water retention capacity.

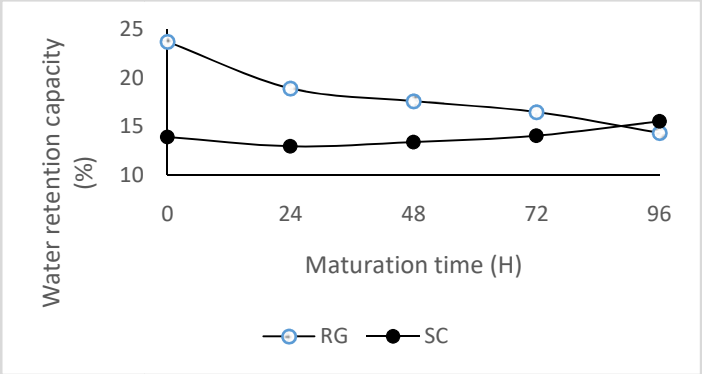


Figure 7 : Representative curve of the real water retention capacity of the two muscles

II.3. SENSORY ASSESSMENTS OF *KILISHI*

1. The colour

Color is the visual aspect that determines the attractiveness and the purchase decision. It is important for two reasons for its attractive and commercial value to the consumer. The figure 8 shows the different colors perceived by the consumer of the *kilishi* according to the type of muscle and the maturation time.

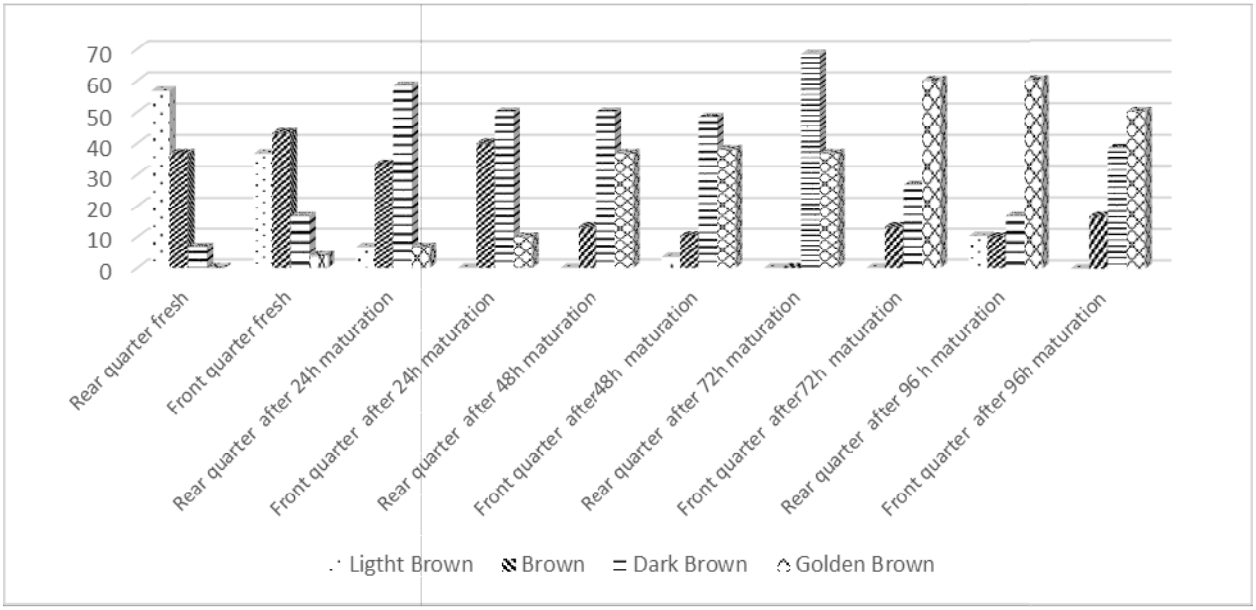


Figure 8 : Appreciation of *kilishi* according to color.

Most of the panelists the color chosen is brown for the Front quarter, for the *Rear quarter* we observe brown and golden brown were perceive. The difference is in the type of muscle, the *Front quarter* having a pale red color beforehand allows to obtain a final *kilishi* of brown color and the *Rear quarter* which has a bright red color when fresh allows to obtain a *kilishi*. Brown and golden brown after grilling. The intensity of the grilling also determines the intensity of the colorof the *kilishi*.

2. The flavor

The acceptability of *kilishi*according to flavor is shown in the figure below

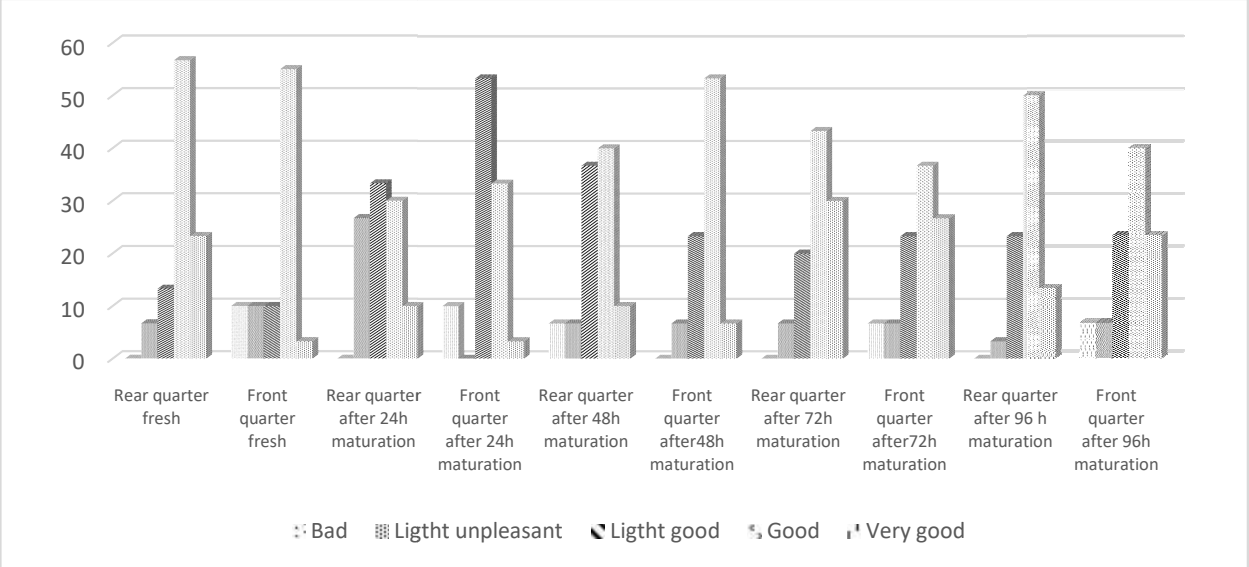


Figure 9: Assessment of *kilishi* according to flavor

The flavor mainly reveals the characteristics of seasoning and the action of grilling which enhances the taste and aroma of the product. According to figure 9, More than 75% of the panelists appreciate the spicy *kilishi*with the non-spicy *kilishi* and note the *kilishi*of possessed a pleasant flavor. More than 60% of the panel gives a pleasant appreciation of the *Rear front* muscles, which would mean that the *kilishi* made from this muscle presents more advantage for the production of the .. The taste of *kilishi* varies depending on the state of maturation of the

meat, the more the meat is matured the more it absorbs the coating sauce the more it is seasoned and therefore tastes better and appreciated by consumers.

3. The Crusty aspect

The crusty aspect of *kilishi* is shown in the figure10:

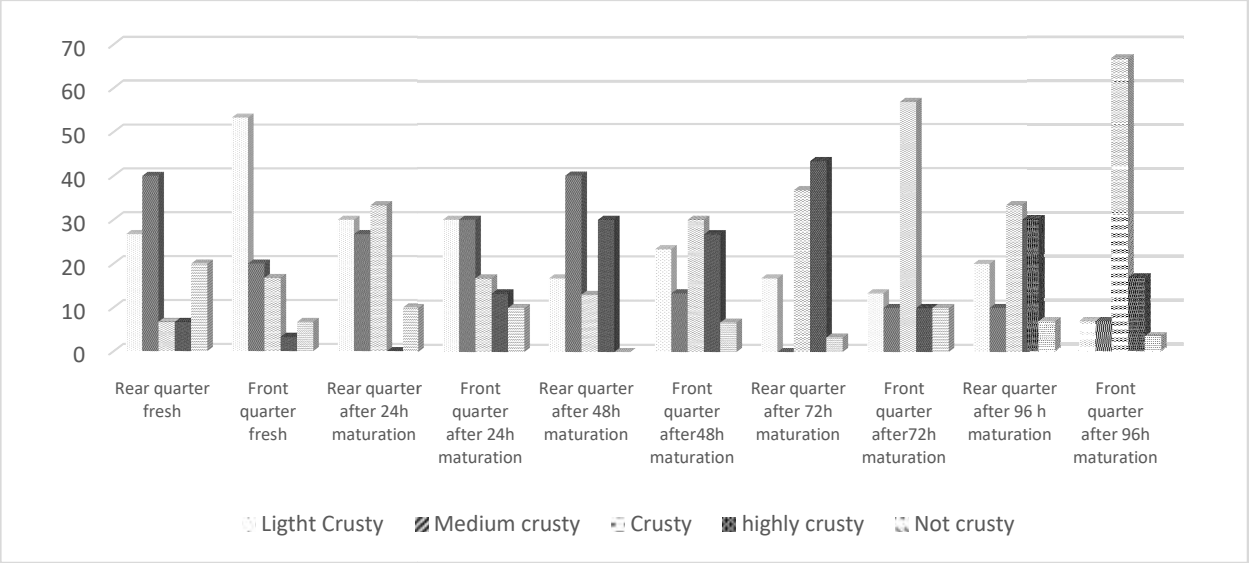


Figure 10 : Assessment of *kilishi* according to its crusty appearance.

Figure 10 shows that the more mature the muscle, the more it becomes crusty. According to Tom, [18] the *kilishi* must have a dry appearance that is to say it must be crusty, we see that the *kilishi* becomes crusty after 24 hours of maturation according to the conclusion of the panel. This translates that the maturation of the meat has an impact on the appearance of the final *kilishi*; depending on the crusty aspect, the scoter muscle is more crusty because its capacity for rehydration or brine absorption is less than that of the Rond de Gite, the water content of rehydrated lamellae is lower therefore dries more quickly. Hence the crusty appearance of the scoter.

4. The ripeness aspect

The figure 11below shows the ripeness aspect of the *kilishi* :

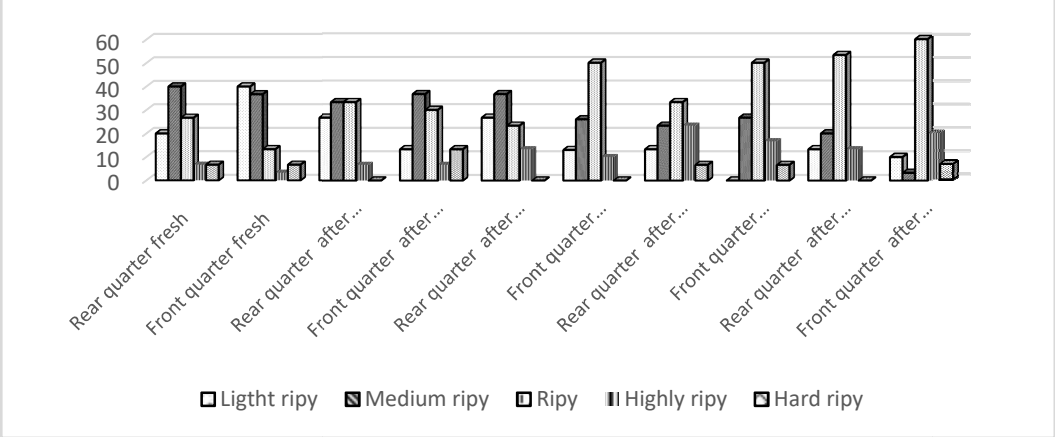


Figure 11 : Appreciation of the *kilishi* according to its ripeness aspect

According to the rip test, Figure 11 reveals that *kilishi* are 50% qualified to be ripeness. This criterion makes it possible to affirm whether the *kilishi* can be easily eaten or not. It is noted that chewing will be done more easily when the muscle is mature. Maturation leads to a ripeness*kilishi*.

5. Tenderness

The following graphic representation is that of the tenderness of the *kilishi*tested by sensory analysis:

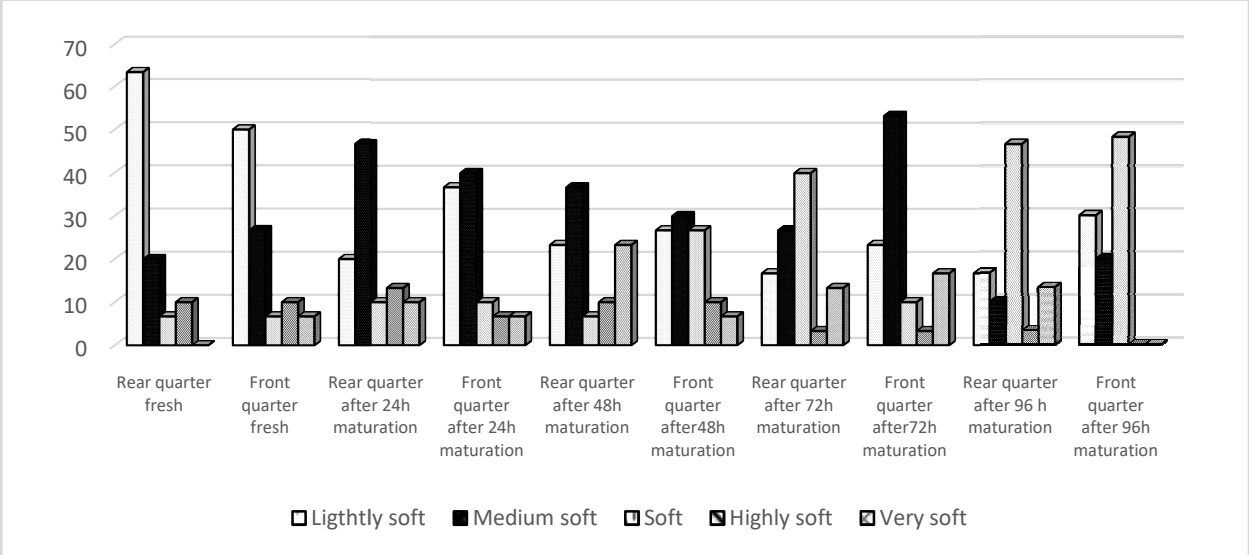


Figure 12 : Appreciation of *kilishi*according to tenderness.

Tenderness is a very essential criterion for appreciating the quality of *kilishi*, it induces the quality of the consumer's purchase. For the consumer, the tenderness of the meat is a criterion of prime importance, a criterion which is greatly influenced by the pre-slaughter conditions and the post-mortem period. Figure 12 of the sensory data confirms the results previously established with respect to tenderness according to which tenderness is a function of the muscle used and the time of maturation. The *kilishi*made from the heel ring are softer than those made from the scoter. The scale goes from moderately tender to very tender, this figure shows that the longer the maturation time is extended, the tenderer the meat becomes. These results corroborate those of Yacouba[19] (2015) according to which the maturation of the meat after 48 hours makes it possible to obtain meat with acceptable tenderness.

6. Overall acceptability

The overall acceptability of *kilishi* is based on the various assessment criteria submitted to the panelist. According to the choice of the consumer, the criterion of appreciation is for the most part “liked”. Note, however, that the assessment differs from one muscle to another, for the heeling round the most repeated acceptability was “liked” and “much liked” according to the opinion of the panelist. Consumers prefer *kilishi* made from Rond de Gîte whose maturation time is accentuated because Rond de Gite has a higher absorption capacity than scoter; this absorption of the brine gives the dry slices a better seasoning, which would therefore mean that the *kilishi*made from the Rond de Gite is better seasoned and more tender, which then explains the choice of the panel. The *kilishi*from the 96h, 72h and 48h maturation are more appreciated in terms of color, flavor and tenderness.

7. The preference

According to the assessment criteria noted above, the panel made the choice of *kilishi* according to its preference. The assessment criteria which guided the choice of the panel were the color, the flavor, the crusty aspect, the tearing aspect and the tenderness of the *kilishi*. The choice of *kilishi* according to consumer preference made it possible to retain four types of *kilishi*, the most ultimate choice turns to RG0, which has a light brown color, a pleasant flavor, which is moderately crusty, tearing and tender and which is much loved by most panelists then comes RG96, RG72 and finally comes M96. For a general classification, we can conclude that the state of muscle maturation also influences the quality of the final *kilishi* because it induces the tenderness of the *kilishi*, it allows a better seasoning, and improves the crusty and tearing aspect of the *kilishi*.

III. CONCLUSION

In order to improve the quality of *kilishi*, the influence of the dimensional mapping of the meat lamella during drying and coating steps of the production of *kilishi*, on its quality was study. To achieve this, the dimensions of the strips of dried meat were recorded in order to evaluate variations which take place at the stage of drying and coating and to understand the influence of this variation on the final sensory quality of the product. It results from the various observations that lamellae presents a non-uniformity in their shape. The values clearly show a constant variation of thickness. This variation is generated by the quality of the practice of the unwinding operation which is done according to the skill of the unwinder and which gives the lamellae the shape and the final thickness.To solve the non-uniformity of the strips problem the maturation of the meat was recommended as it was observed that the more the muscle is mature the more it's easy to cut into lamellae thus to linked operations of drying and coating. The sensory evaluationindicate that the 72 h and 96 h mature meat *kilishi* was more appreciated than the other for overall acceptability and preference test. The best brining time for better coating was found to be 10 min. Considering the rehydration ability, we retain the "round of gite" muscle as the idealfor *kilishi* processing.

V. REFERENCE

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