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Characterization and manufacturing conditions of cooked local chicken sausage in Benin

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Abstract

Sausages are among the most common processed meat products in the world. The optimization of the manufacturing conditions makes it possible to reduce and determine the optimal conditions for manufacturing the sausage. For this fact, a material balance, a determination of the nutritional, physicochemical and sensory characteristics and the relationship that binds these different parameters have been. Two manufacturing technological diagrams have been adopted, namely the technological diagram for manufacturing local cooked chicken sausage with cooking in water (T5-1) and steam cooking (T5-2). The results showed that approximately 25% of losses are recorded grouping the bones and the aponeuroses in the two cases of technologies. At the end of the embossing, about 3.5% loss stuck in the machines and no significant difference (p>0.05) is observed at the level of the two cooking methods. After cooking, part of the sausage is deformed due to the increase in temperature. This loss is more remarkable (7.83%) for steam cooking (T5-2). At the end of the process, the yield is 94.46% for the T5-1 technology and 88.40% for the T5-2 technology. As for the nutritional and physicochemical results of local chicken sausages, they vary from one technology (T5-1) to another (T5-2).

Keywords: Sausages; Characteristics; Nutritional; Physicochemical; Sensory

1. Introduction

Cooked sausage with a fine meat paste (chicken) is a mixture composed mainly of lean, fat and water, the grinding of which is such that the added constituents can no longer be distinguished with the eye. It is a knack made using cold emulsion technology. They are the most consumed industrial charcuterie products. They consist of a casing (of intestinal or synthetic origin, in the shape of a tube and closed at the ends) filled with finely minced meat, seasoned and are therefore ready-to-eat foods (Penda, 1994).

In Benin, the increase in the consumption of cooked sausages with thin paste calls for the importation in quantity. However, several varieties of sausages are found on the market. In particular, we have five (5) brands of sausages imported into Benin: Minuano (chicken / Brazil); Amadori (Turkey / Italy); Knacki (pork); Franckup (chicken), Doux (chicken). This demand is greater for chicken sausages than for local broilers, but it remains an imported product (on average 284.81 Tons / Month), (DEP, 2016). There is a wide variety of sausages and the different variations are related to the modification of meat type, processing temperature, casing types and casing particle size (Hugo and Hugo, 2015; DEP, 2016).

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It is therefore urgent to characterize the manufacturing technologies of the cooked local chicken sausage by making a material balance and determining the nutritional, physicochemical and sensory characteristics as well as the relationship that connects them.

2. Material and methods

2.1. Materials

2.1.1. Sampling equipment

The sampling equipment is composed of:

- Sterile bags for sample collection ;
- Sterile latex gloves to protect the hands during sample collection ;
- Cooler with dry ice to maintain sample temperature ;
- Laser thermometer for sample temperature control.

2.1.2. Animal material

Lean and fat from locally raised broiler chicken, local sausage and imported sausage were the main materials used in this study. The casings used were synthetic casings of 19 mm caliber.

2.1.3. Manufacturing ingredients

The ingredients, additives and colorings used are ice cubes, cassava starch, whole sausage, spices, nitrite salt, phosphate, lactate and camin (coloring).

2.1.4. Manufacturing materials

Several sterilized equipment were used when making the sausage. It is:

- Knives
- Tapers
- Plucker
- freezers/cold room
- Chopper with several fixed perforated plates
- Mobile bowl cutter
- Portion pusher
- Electric cooker
- Packer
- Sterilizer
- Plant materials.

2.2. Methods

2.2.1. Identification of local sausage manufacturing units to house technological monitoring

The technological monitoring was carried out in the company VETAGRO SA located in Pahou, in the Atlantic department. The choice of this company was based on the following criteria :

- The only company that manufactures local thin-crust cooked sausage ;
- The only company willing to support this study.

2.2.2. Technological monitoring of sausage manufacturing technologies

For each of these technologies, three technological follow-ups were carried out in the identified company. During technological monitoring, samples were taken at the level of operations that could impact the quality, yield and losses of the sausages. Similarly, quantitative data related to technological parameters (yield and material balance of the technology) were collected.

Determination of technological parameters

- Material balance

The material balance was determined through the various weighings carried out at the level of each unit operation. The weighings focused mainly on :

  - Live mass of broiler chicken (kg)
  - Quantity of bones, aponeuroses (kg)
  - Mass of chicken lean and fat (kg)
  - Quantity of cooked thin chicken sausage (kg)
  - Quantity of broken or deformed sausage (kg)
  - Quantity of sausage face recovered in the machine (kg).

The yield was determined according to the formula of Pakdeechot and Kaewsichan (2020).

$$\boldsymbol{T} = \frac{M_h}{M_f}\boldsymbol{X}100,$$

Where; Mh = mass of sausage obtained; Mf = mass of fresh sausage;

Optimal conditions for making sausages

The response surface method (RSM) through a centered composite plane was used to optimize the manufacturing parameters of the most sold and consumed chicken sausages in Benin (Kek et al., 2014).

For a good optimization of the manufacturing parameters, the losses, the pH, the water content, the water retention capacity are minimized compared to the value of the folding test, the acceptability which have been maximized but the NaCl is maintained within ranges of values recommended by the literature.

The experimental plan consisted of making a

- Optimization of manufacturing parameters (Dose, Duration and temperature).
- Response surface method through a centered composite plane.
- Dose of phosphate (1-3 g/kg), Duration (7 to 12 min) and Temperature (75 to 90 °C) manufacturing.

Table 1 Effect of varying temperature, time and phosphate dose in sausage manufacturing technology

Experience	Temperature (°C)	Time (min)	Phosphate Dose (g/kg)
1	75.0	12.0	2.0
2	82.5	12.0	3.0
3	75.0	7.0	2.0
4	82.5	9.5	2.0
5	82.5	12.0	1.0
6	82.5	7.0	1.0
7	90.0	9.5	1.0
8	90.0	12.0	2.0
9	90.0	9.5	3.0
10	90.0	7.0	2.0
11	82.5	7.0	3.0
12	75.0	9.5	1.0
13	75.0	9.5	3.0

Table 1 provided information on the variation of temperature, time and phosphate dose in the cooking-in-water manufacturing technology as well as the optimal combination of sausage production parameters. The experimental plan generated 13 trials indicating the manufacturing conditions.

3. Results

3.1. Material balance / Manufacturing technology of local thin-crust cooked chicken sausage

In Table 2, the point of raw materials and the losses of the different technologies (cooking in water T5-1 and steaming T5-2) for the production of local thin-crust cooked chicken sausage are presented. Starting from live chicken at deboning, about 25% loss was recorded such as bones and aponeuroses in both cases of technologies. At 75% lean and fat obtained, representing about 65.34 kg were added the other ingredients giving a total weight of 100 kg. At the end of production, the T5-1 technology had produced 94.46 kg of normal sausage; 2.33 kg of broken / deformed sausage and 3.21 kg of sausage recovered from the machines. On the other hand, the T5-2 technology had given 88.40 kg of normal sausage; 7.83 kg of broken/deformed sausage and 3.77 kg of sausage recovered from the machines. The drying time before firing did not vary from one technology to another. The duration of operations (hour / ton of sausage) was 2.17 for the T5-1 technology and 2.55 for the T5-2. After cooking, 5.86% loss was noted at T5-1 and 7.86% for T5-2. That is total losses of 14.02% for T5-1 and 21.21% for T5-2. With a yield of 94.46% when cooking was done in water (T5-1) and 88.40% for steam cooking.

Table 2 Material balance of the different production technologies for local thin-crust cooked chicken sausage

Parameters		**T5-1 eau**	**T5-2**
Live mass of broiler (kg)		86.66	86.77
Quantity of bones, aponeuroses (kg)		21.32	21.46
Mass of chicken lean and fat (kg)		65.34	65.47
Ingredients used		34.61	34.505
Quantity of cooked thin chicken sausage (kg)		94.46±0.1	88.40±0.02
Quantity of broken or deformed sausage (kg)		2.33±0.21	7.83±0.31
Quantity of sausage face collected in the machine (kg)		3.21±0.12	3.77±0.21
Duration of operations (hour/tonne of sausage)	Drying	2	2
	Steam cooking	-	0,5
	Boiling	0,12	-
	Sterilization	0,05	0,05
	Total	2.17±3,2	2,55±0,64
Sausage losses after cooking S gross (%)		5.86±0.02a	7.86±0.02b
Sausage losses after cooking S cooked (%)		14.02±0.03a	21.21±0.05b
Yield after cooking S gross (%)		78.51±0,05b	73.30±0,04a
Yield after cooking S cooked (%)		77.9±0,04b	72.9±0,04a

The same letters in a column indicate statistically similar means; The different letters (a and b) in the column indicate the statistically different means

3.2. Nutritional and physicochemical characteristics of chicken sausages

Table 3 presents the nutritional and physicochemical results of local chicken sausages varying from one technology to another. The results showed that the water content (TE) of local thin chicken sausages just after cooking is high (63.82 and 59.38%) compared to local thin chicken sausages after packaging (62 .6 and 58.47%). Similarly, these results showed that there is no significant difference between the values of the parameters protein content, lipid content and sodium chloride content.

Table 3 Nutritional characteristics of local sausages from production technologies T5-1 and T5-2

Sample	Technology	TE	Proteins	Lipids	NaCl
Brute thin crust chicken sausage	T5-1	63.82±0.12	13.47±0.17a	14.22±0.09a	1.41±0.01a
	T5-2	59.38±0.26	13.62±0.28a	14.45±0.25a	1.85±0.05b
Cooked Thin Chicken Sausage	T5-1	62.6±0.25	13.03±0.09a	13.65±0.25a	1.58±0.08ab
	T5-2	58.47±0.17	13.53±0.245a	14.5±0.1a	1.81±0.06b

The same letters in a column indicate statistically similar means; The different letters (a and b) in the column indicate the statistically different means

The results of the physicochemical characteristics of local sausages from production technologies (T5-1 and T5-2) are presented in Table 4. It emerges from the analysis of these results that the pH varies from 5.85 to 6.25. This parameter dropped at the end of production. As for the skyab coordinates, the luminance (L*), the saturation in red (a*) and in yellow (b*) varied respectively from 51.21 to 66.326, from 6.10 to 8.95 and from 66.98 to 64.76. The color parameter, it was more pronounced at the end of production that is to say after packaging. With respect to the water retention capacity parameter, it varied from one technology to another and decreased at the end of production. On the other hand, the Bend test parameter increased at the end of production with varying values from one technology to another.

Table 4 Physicochemical characteristics of local sausages from production technologies T5-1 and T5-2

Thin Chicken Sausage	Technology	pH	Color			Water holding capacity	Bend test
			L*	a*	b*		
Raw Thin Chicken Sausage	T5-1	6.06±0.04b	65,12c	8.24c	12.12a	66.98d	3.75b
	T5-2	6.25±0.05b	51.21a	6,10a	13,11b	65.34b	3.25a
Thin cooked chicken sausage	T5-1	5.85±0.05a	66,32d	8.95d	13.21c	66.26c	3.85b
	T5-2	6.25±0.05b	52.14b	6.45b	13.24c	64.76a	3.35a

The same letters in a column indicate statistically similar means; The different letters (a b & b) in the column indicate the statistically different means

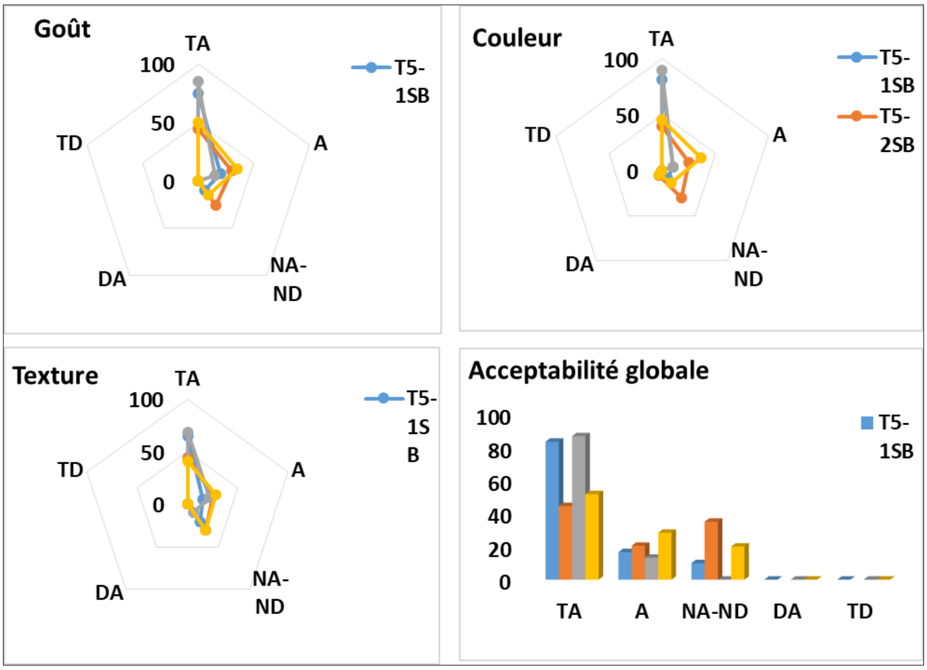

Figure 1 Sensory quality of local sausages from T5-1 and T5-2 production technologies

Figure 1 presented the sensory quality results of local sausages from T5-1 and T5-2 production technologies. These results proved that the tasters very much appreciated the sausage resulting from the T5-1 technology from the point of view of taste (more than 90%), color (more than 90%), texture (more than 70%) and overall appreciation (more than 80%).

3.3. Relationship between technological performance, physicochemical and sensory characteristics of sausages from T5-1 and T5-2 technologies

The results of the Principal Component Analysis (PCA) showed that 97.5% of the total variability was expressed by the first two axes (Table 5).

Table 5 Eigenvalues of the correlation matrix between the variables

Axes	Own values (%)	Proportion (%)	Cumulative (%)
1	12.77	79.8	79.8
2	2.828	11.77	97.5
3	0.404	0.25	1.000
4	0.000	0.000	1.000

Axes 1 and 2 expressed respectively the proportions 79.8 and 97.5% of this variability and could be used to explain the existing relationships between the nutritional, physicochemical and sensory characteristics of the different types of sausages. Figure 2 presented the relationship between the nutritional, physicochemical and sensory characteristics of different sausages from the technologies while Figure 3 showed the representation of the technologies in the PCA factorial plane. By comparing these two figures, the technologies studied are classified into three main groups.

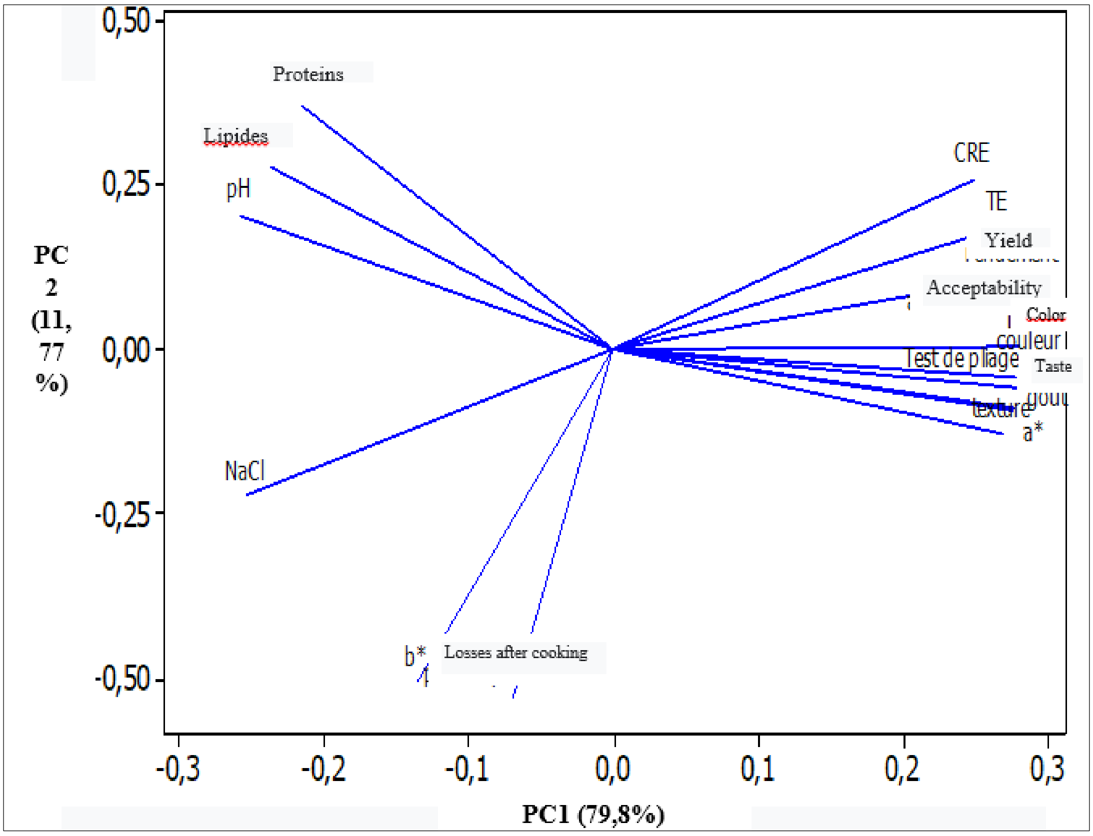

Figure 2 Relationship between the nutritional, physicochemical and sensory characteristics of different sausages resulting from technologies

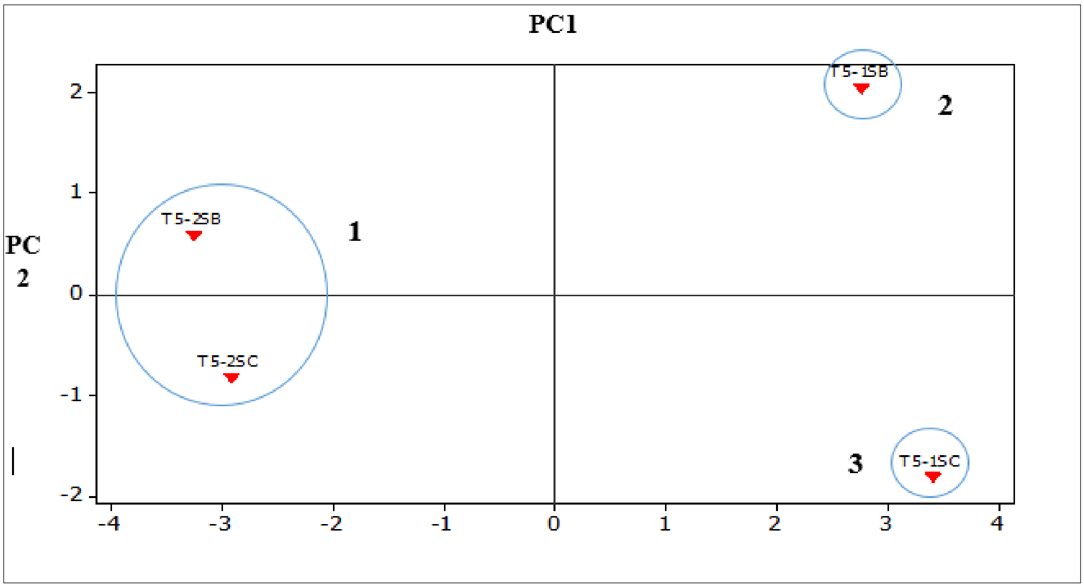

Figure 3 Representation of technologies on the PCA factorial plane

4. Discussion

The cooking yield is an important parameter in the manufacture of products. The technological diagram for making local cooked chicken sausage shows two cooking methods: cooking in water (T5-1) and steaming (T5-2). From these two firings, losses are recorded until the finished product. From live chicken to deboning, approximately 25% of losses are recorded such as bones and aponeuroses in both cases of technologies. These losses are not only usable in dog food but also the bones are salted and smoked for human food. These smoked carcasses are very recommended for the elderly and all people with calcium deficits. The 75% lean is added 25% of the other ingredients giving a total weight of 100 kg. This total weight is reported as 100 kg due to the total capacity of the cutter used to mix the materials. At the end of cutting and embossing, the entire face is not recovered, part remains stuck in the machines. This represents a loss of about 3.5% and has no significant difference in the two cooking methods. This loss is frozen to be incorporated during the cutting of another production batch of sausage. During cooking, portions of sausage are deformed or broken due to the rise in temperature or the weight of the sausage chain. This loss is higher (7.83%) for steam cooking (T5-2) because the sausage strings are suspended and receive steam baths. Cooking in water (T5-1) has a low loss (2.33%) with a significant difference between the values. This difference is obviously observed on the quantity of finished products (normal sausages) which are 94.46% for cooking in water and 88.40% for cooking in steam. With regard to the duration of the operations, the drying time before cooking (2 h) and the sterilization time (0.05 h) of the finished products do not vary from one technology (T5-1) to another (T5-2). On the other hand, the cooking time in water (0.12 h) is relatively shorter than that of steam cooking (0.5 h). This implies a total duration of operations (hour / ton of sausage) at 2.17 h for the T5-1 technology and 2.55 h for the T5-2. By relating all of the above to the initial mass of live chicken, after cooking, 5.86% of losses are noted at the level of T5-1 and 7.86% for T5-2. That is total losses of 14.02% for T5-1 and 21.21% for T5-2. Finally, a yield of 94.46% when cooking in water (T5-1) and 88.40% when cooking with steam is noted.

The nutritional and physicochemical results of local chicken sausages vary from one technology (T5-1) to another (T5-2). These results demonstrate that the water content (TE) of local sausages with thin chicken paste just after cooking is high (63.82 and 59.38% for T5-1 and T5-2 respectively) compared to local sausages with fine chicken paste after packaging (62.6 and 58.47% for T5-1 and T5-2 respectively). This loss of water content is due in part to unintended drying caused by the time taken for packaging and also to the canning temperature. Indeed, cooking in water allows the sausage to absorb a little water, which explains this significant difference between the water contents of T5-1 and T5-2 whether it is raw sausage or cooked. These results show that there is no significant difference between the values of the parameters protein content, lipid content and sodium chloride content. The results of the physicochemical analyzes show that only the pH of T5-1 dropped from 6.06 to 5.85 with a significant difference. This parameter decreases at the end of production. As for the color parameter, it is more pronounced at the end of production, i.e. after packaging, so it is associated with the refining of the ingredients. With respect to the water retention capacity parameter, it varies from one technology to another and decreases at the end of production. Therefore, the temperature influences the water retention capacity. After the cooking temperature, all additional temperatures decrease this water-holding capacity. On the other hand, the bend test parameter increases at the end of production with values varying from one technology to another. This variation in the bend test is due to variation in temperature and water content.

From the results of the sensory test highlighting the T5-1 and T5-2 technologies, it appears that it is the raw cooked sausage or the packaged cooked sausage from T5-1, requires the best appreciations. The latter have a taste, color, texture and overall appreciation highly appreciated by more than 80% of tasters with a greater appreciation for the packaged cooked sausages (final). For sausage flavor, it is given by the non-volatile compounds of sausage taste and the volatile compounds of odor. It essentially develops during cooking (Vierling, 2003). These results confirm the previous qualities detected for this T5-1 technology. In view of all the above, the T5-1 technology is adopted for the remainder of this study.

The relationship between the nutritional, physicochemical and sensory characteristics of different sausages from the technologies and the representation of the technologies in the PCA factorial plane make it possible to classify the fruits of the cooking technologies studied into three main groups. The first group is made up of sausages from the T5-2SB and T5-2SC technologies. They are characterized by low NaCl, lipid, protein, pH value and high water content and water retention capacity. The second group includes sausages from the T5-1SB technology and is characterized by sausages containing a high protein and lipid content, a low pH value and then a low rate of losses after cooking. As for the third group (sausages from T5-1SC technology), it is less appreciated for its water content, its yield, its water retention capacity, its color, its texture, its taste and its folding test. But much appreciated for the loss rate after cooking.

5. Conclusion

In order to characterize the manufacturing technologies of the cooked local chicken sausage, a material balance and a determination of the nutritional, physicochemical and sensory characteristics as well as the relationship between them are carried out in the study. The technological diagram for making local cooked chicken sausage shows two cooking methods: cooking in water (T5-1) and steaming (T5-2). Starting from live chicken at deboning, about 25% of losses are recorded such as bones and aponeuroses in both cases of technologies. To the 75% lean and fat obtained, 25% of the other ingredients are added giving a total weight of 100 kg. At the end of embossing, a loss of approximately 3.5% of the face stuck in the machines is recorded and no significant difference ($p>0.05$) is observed in the two cooking modes. After cooking, portions of sausage are deformed or broken due to the rise in temperature or the weight of the sausage chain. This loss is higher (7.83%) for steam cooking (T5-2). Cooking in water (T5-1) has a low loss (2.33%) with a significant difference ($p < 0.05$) between the values. With these losses, at the end of the process, the normal sausages obtained (yield) are 94.46% for cooking in water and 88.40% for cooking in steam. Surpluses of time are also noted in terms of the duration of operations. This implies a total duration of operations (hour/tonne of sausage) of 2.17 h for the T5-1 technology and 2.55 h for the T5-2. The nutritional and physicochemical results of local chicken sausages vary from one technology (T5-1) to another (T5-2).

Sensory tests carried out on raw cooked sausages and packaged cooked sausages from T5-1 and T5-2 technologies show that: whether raw cooked sausage or packaged cooked sausage from T5-1, is full of better appreciations with a deeper appreciation for the wrapped cooked sausages (final); hence the adoption of the T5-1 technology for the rest of our research.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare that there is no conflict of interest in this study.

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