A F T E R

African food tradition revisited by research

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1) Introduction

This deliverable reports the physical, chemical and textural criteria analyzed on traditional African products from Group 2:

- The Kitoza: salted and dried or smoked meat from Madagascar,
- The Lanhouin: salted and fermented fish from Benin,
- The Kong: smoked fish from Senegal.

The objective is to describe the attributes of the finished products manufactured using the traditional skills.

2) Material and Methods

a. Sampling

The sampling of products from group 2 was described in the deliverable 1.2.1.2 "SOP for sampling strategy for group 2".

➢ **KITOZA**

Sampling was done considering the variability of products identified during the prior surveys. The selected parameters were:

- Two processes:
    - Salted and smoked
    - Salted and dried
- Two types of meat:
    - Beef
    - Pork
- Three production zones:
    - Urban
    - Peri-urban
    - Rural
- Two collection levels:
    - Producers (P) who produce only salted/smoked Kitoza in urban and peri-urban areas
    - Producers for home consumption (PHC) who produce salted/dried Kitoza in urban and peri-urban areas and smoked Kitoza in rural areas

For this deliverable (and deliverables D1252, D1262 and D1272), 60 samples were collected as described in Figure 1.

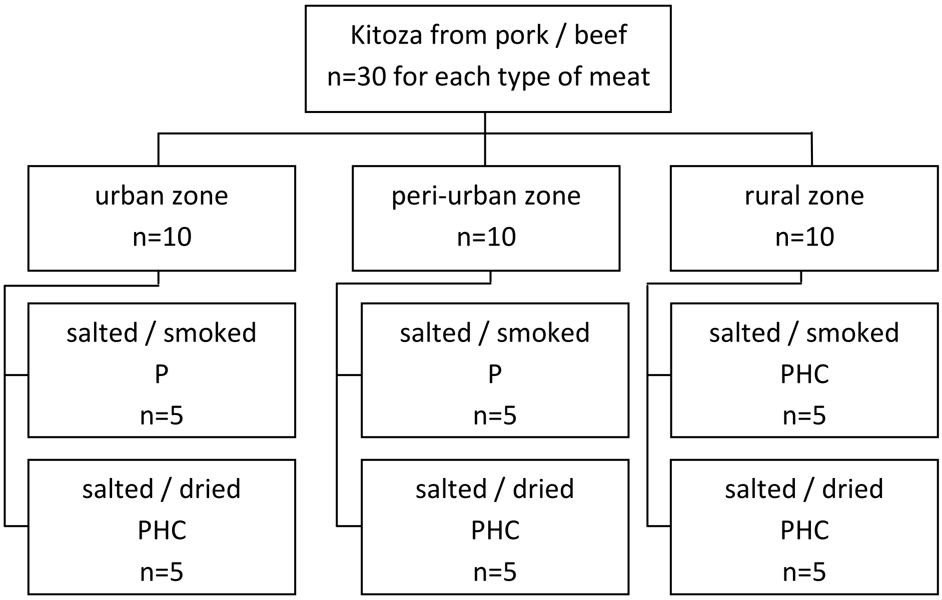

Figure 1: Diagram of the distribution and number of samples of Kitoza

(Legend of diagram: refer to variability of samples described above; n=number of samples)

- **LANHOUIN**

Sampling was be done by considering the variability identified during the survey. The selected parameters were:

- Three processes according to unit operations and material used for fermentation:
    - Fermentation in aerobic conditions with basket used as fermentation material (FA)
    - Fermentation in micro-aerobic conditions with container or basket with cement layer used as fermentation materials (FMA)
    - Fermentation in anaerobic conditions and without ripening (fish buried in the ground) (FAN)
- Two types of fish:
    - Lanhouin from Kingfish / Spanish mackerel which is a fatty fish (LK)
    - Lanhouin from Cassava croaker which is a lean fish (LC)
- Two collection levels:
    - Processing sites with Processor (P) as actors
    - Markets with Wholesaler (W) and Retailer (R) as actors

For this deliverable (and deliverables D1252, D1262 and D1272), 60 samples were collected as described in Figure 2.

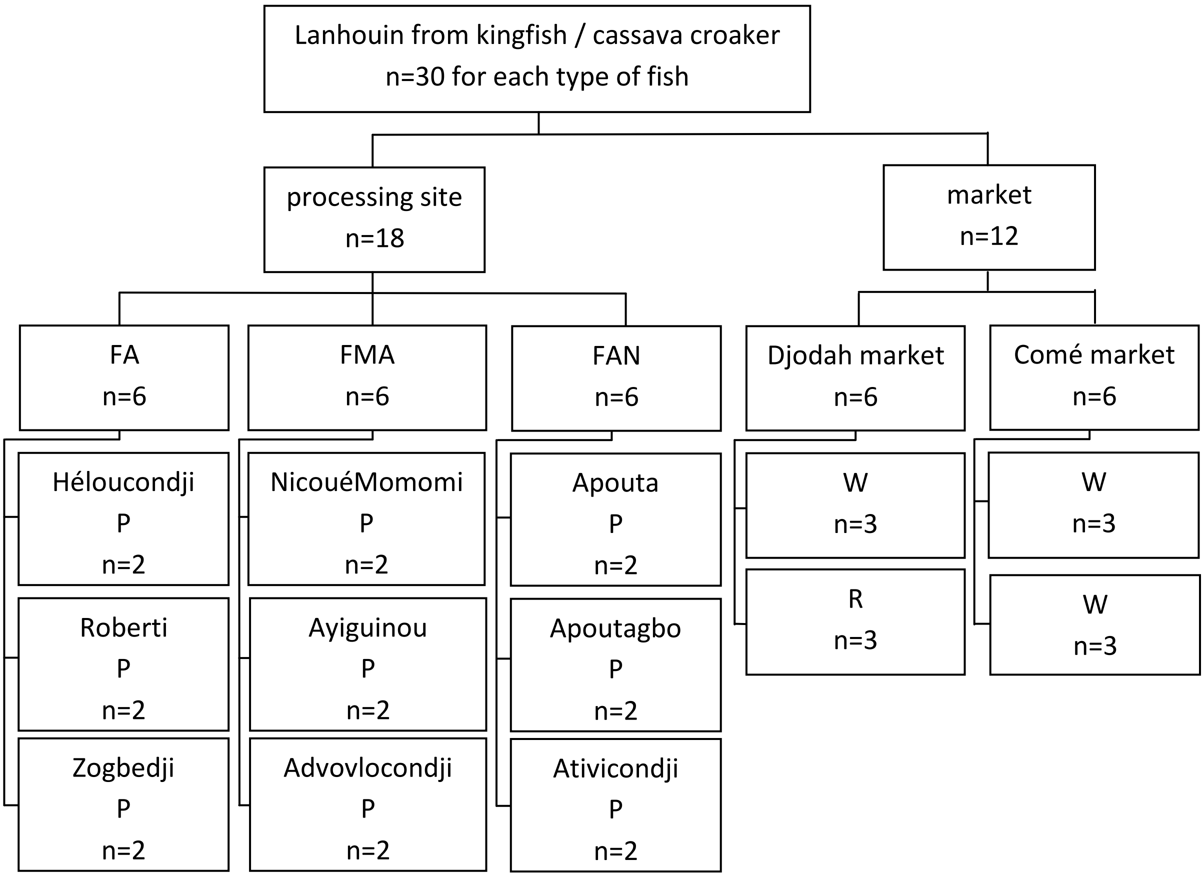

Figure 2: Diagram of the distribution and number of samples of Lanhouin

(Legend of diagram: refer to variability of samples described above; n=number of samples)

➢ KONG

Sampling was done considering the variability identified during the prior surveys. The retained parameters were the following:

- Two processes based on the degree of water content:
    - Well dried smoked Kong (D)
    - Wet smoked Kong (W)
- Two main production zones:
    - Urban zone of Dakar
    - Important Kong fishing's zone (Ziguinchor's region)

- Two collection level:
    - Producers (P)
    - Retailers (R)

For this deliverable (and deliverables D1252, D1262 and D1272), 35 samples were collected as described in Figure 3.

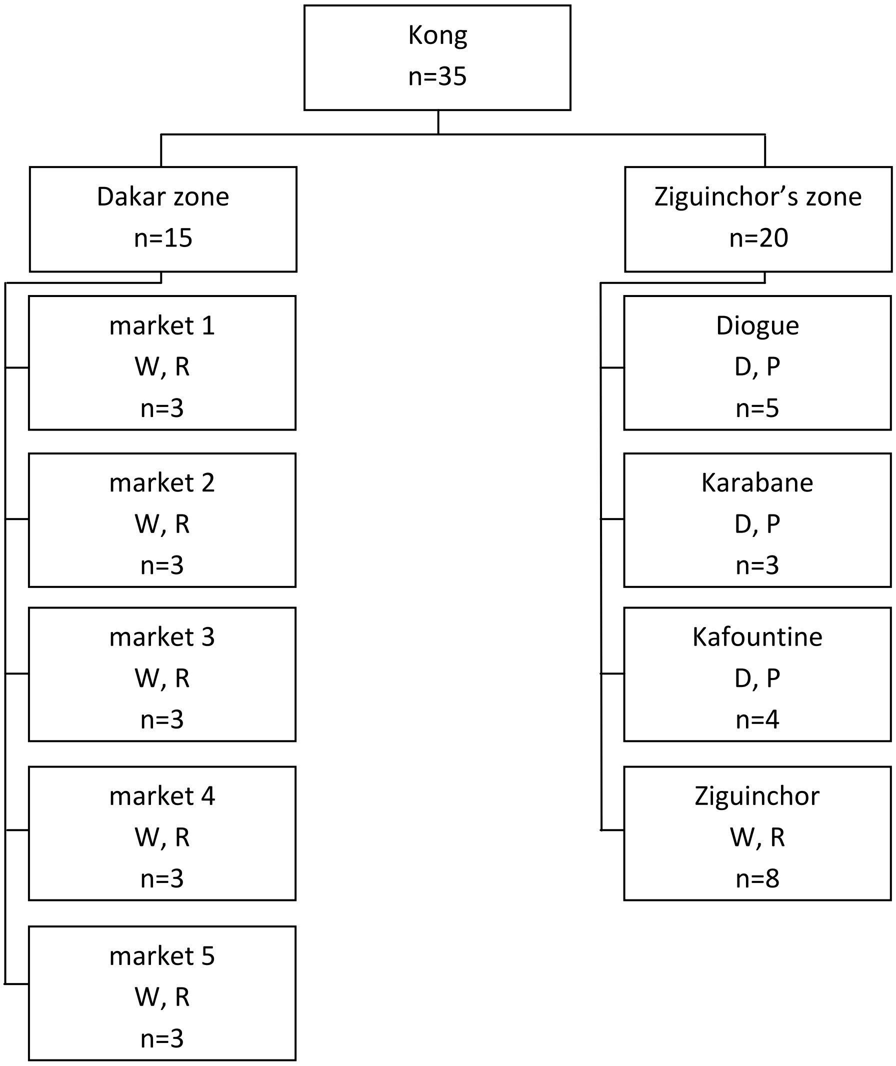

Figure 3: Diagram of the distribution and number of samples of Kong

(Legend of diagram: refer to variability of samples described above; n=number of samples)

b. Choice of analytic indicators

All laboratory analysis were conducted by the project partners by implementation of procedures of standardize methods (SOPs) specific to group 2 (deliverables of subtask 1.2.3).

Because of the specific manufacturing processes by product type, the choice of analytical indicators was adapted for each product from group 2, as summarized in Table 1. A list of essential indicators to characterize the products was stopped. Other indicators have been analyzed according supplements products and human resources available, particularly through the works of students in the lab of project partners.

Table 1: Minimum physical, chemical and textural analysis to evaluate the products of group 2

Indicator analyzed	**Kitoza**	**Lanhouin**	**Kong**
Phenol	Chem-MeatFish-001-fr	Not required	Chem-MeatFish-001-fr
aW	Chem-MeatFish-003-fr	Chem-MeatFish-003-fr	Chem-MeatFish-003-fr
Moisture	Chem-MeatFish-002-fr	Chem-MeatFish-002-fr	Chem-MeatFish-002-fr
pH	Chem-MeatFish-004-fr	Chem-MeatFish-004-fr	Chem-MeatFish-004-fr
NaCl	Chem-MeatFish-005-fr	Chem-MeatFish-005-fr	Chem-MeatFish-005-fr
Collagen	Chem-MeatFish-007-fr	Not required	Not required
Organic acids	Chem-MeatFish-009-fr	Chem-MeatFish-009-fr	Chem-MeatFish-009-fr

As mentioned in the 1st periodic report, the color and the texture measurements according to the SOP Phys-MeatFish-001.en and Phys-MeatFish-002/03-en could not be performed. However, for information on these attributes for Kitoza, we report in this deliverable the results of color and hardness parameters obtained in the framework of WP5 from the sensory tastes. Because of problems of product preservation, only smoked Kitoza were studied (3 from beef and 3 from pork). The details of these organoleptic characteristics are presented in Table 2. Concerning Lanhouin, analysis of texture have been performed on all samples by sensory analysis summarized in Table 3.

Table 2: Organoleptic characteristics measured on Kitoza

Sensory attributes	**Definitions**	**Protocol of tasting**
Hardness in mouth (aim at hard)	In the chewing, the texture of the piece of meat seems soft, supple, soft or on the contrary hard, firm, or intermediate.	When you chew the piece of Kitoza, note the resistance of the product in the chewing or on the contrary the ease to chew it.

Table 3: Organoleptic characteristics measured on Lanhouin

Sensory attributes	Definitions	Protocol of tasting
Texture	Soft but firm, limp and spongy	Measurement of intensity of the hardness of the piece of lanhoui, when you press it with a finger and note the resistance on a scale of 0-100 mm in a scale of 0-100 mm using a ruler.

Collagen content of Kitoza samples have not been measured due to the defective equipment in Madagascar.

For organic acids, D and L lactic acid contents of Kitoza samples were measured with the SOP Chem-MeatFish-006-fr in order to measure specifically D lactic acid content which can only be produced by lactic fermentation. Other organic acids content have not been measured because of lack of time and of availability of the equipment. Since any fermentation is observe during smoking operation, neither lactic acid content nor others acids organic content were determined in Kong samples.

Water activity of Kong samples have not been realized due to the lack of equipment available in Senegal at this moment.

Determinations of pH and phenol content have not been realized on all Kong samples due to insufficient quantity of some samples.

c. Treatment of results

For each of the physicochemical parameters studied, the mean and standard deviation (and minimum and maximum values for Kitoza) were calculated.

For each of the three products, the deliverable gives tables where the results are given for the different processes of manufacture and, depending of the product, raw material and areas of production. ANOVA were performed with Statistica program version 7.0 (StatSoft, USA). If a significant effect was found ($p<0.05$), pairwise differences between groups were analyzed using Fisher's least-significant-difference test.

3) Results for Kitoza

a. Kitoza from beef

The results of physical, chemical and textural analysis of beef Kitoza samples are summarized in Table 4.

Table 4: Results for physico-chemical analysis of beef Kitoza samples

Parameter and unit of measurement	Responsible partner and lab	Variety Process/Raw material/Area (Mean ± SD)					
		Smoked samples (n=15)			Dried samples (n=15)		
		Mean ± SD	Min	Max	Mean ± SD	Min	Max
Color	UT	6.4±0.2 (n=3)	6.1	6.5	nd		
Texture	UT	4.6±1.6 (n=3)	3.3	6.3	nd		
Moisture (g/100g)	CIRAD-R	49.4 ± 9.0^{a}	30.0	60.8	34.5 ± 8.3^{b}	18.6	49.3
NaCl (g/100g)	CIRAD-R	2.99 ± 1.14^{a}	1.94	6.03	3.52 ± 1.22^{a}	2.18	6.06
Water activity (Aw)	CIRAD-R	0.929 ± 0.050^{a}	0.770	0.970	0.861 ± 0.056^{b}	0.723	0.930
pH	CIRAD-R	5.88 ± 0.20^{a}	5.51	6.22	5.70 ± 0.20^{b}	5.26	6.11
Titrable acidity (meq/100g)	CIRAD-R	11.4 ± 2.2^{a}	8.5	17.4	12.4 ± 3.2^{a}	7.8	18.9
D lactic acid (g/100g)	CIRAD-R	0.094 ± 0.142^{a} (n=8) <0.014 (n=7)	0.016	0.442	0.162 ± 0.200^{a} (n=12) <0.014 (n=3)	0.015	0.581
L lactic acid (g/100g)	CIRAD-R	1.184 ± 0.171^{b}	0.895	1.594	1.46 ± 0.45^{a}	0.69	2.20
Total phenol (mg/100g)	CIRAD-R	2.30 ± 1.44^{a}	0.49	5.09	0.30 ± 0.40^{b}	0.02	1.45

n=number of samples; nd: not determined; within one line different superscript letters indicate significant differences ($p<0.05$)

Moisture content of beef Kitoza ranges from 18.6 to 60.8 g/100g. Smoked Kitoza contain significantly ($p<0.001$) more water than dried ones (49.4 ± 9.0 and 34.6 ± 8.3 g/100g respectively). Among smoked Kitoza, those produced in rural areas are more dehydrated than those produced in urban and peri-urban zones ($p<0.001$). Water contents of dried

Kitoza are similar regardless of their production area. Moreover, all Kitoza produced at the family level have equivalent moisture content.

Salt content ranges from 1.94 to 6.06 g/100g with an average of 3.25 ± 1.19 g/100g with no effect neither of the process nor the production area.

Smoked Kitoza have a significantly ($p<0.01$) higher Aw (0.929 ± 0.050) than dried ones (0.861 ± 0.056). For both, there are no significant differences according to the production area.

Biltong is a product similar to dried beef Kitoza as it is salted and dried strips of beef or game meat. The work of Van der Riet (1982) show that its average water content is 23 g/100g (ranging from 8 to 44 g/100g), its salt content is 5.6 g/100g and its Aw is between 0.60 and 0.84 (n=20). Kitoza is thus less salted and less dehydrated than Biltong. However, the consumers prefer nowadays moist Biltong with water contents superior to 40 g/100g and Aw between 0.85 and 0.93 (Nortjé *et al.,* 2005). Dried beef Kitoza is also less dehydrated, salted and so with lowest preservation capacity than Kaddid, a similar traditionnal beef or sheep meat product from Morocco which contains 7 - 14 g/100g of water, 7 - 12 g/100g of salt and shows Aw ranging from de 0.49 to 0.65 (Bennani et *al.*, 1995). Dried Kitoza has similar characteristics to Pastirma (producs of Eastern countries of the méditerranée Egypt, Greece and Turkey) in which water and salt contents and Aw range from 39 to 52 g/100g, 2.7 to 9 g/100g and 0.85 to 0.90 respectively (Santchurn *et al.*, 2011). Dried or smoked beef Kitoza are less salted than Mexican Cecina (8 - 10 g/100g of salt) and Brazilian Charqui (10 - 15 g/100g of salt) (Reyes-Cano *et al.*, 1994; Torres *et al.*, 1994).

The pH value ranges from 5.26 to 6.22, values of the order of the post-mortem pH value of beef meat (5.5-5.9 (Laurent, 1981)). The pH of smoked Kitoza (5.88 ± 0.20) is significantly ($p<0.05$) higher than that of dried ones (5.70 ± 0.20). Urban smoked Kitoza have a pH significantly ($p<0.05$) lower than the other two smoked products and a pH equivalent to dried Kitoza for which there is no differences according to the production area.

Titrable acidity is between 7.8 and 18.9 meq/100g with an average of 11.9 ± 2.8 meqv/100g.

Concerning D-lactic acid content, 7 smoked Kitoza and 3 dried Kitoza are below the detection threshold (0.014 g/100g). The average concentration of D-lactic acid in samples above the detection threshold is 0.095 ± 0.156 g/100g with a minimum of 0.016 g/100g and a maximum of 0.581 g/100g. D-lactic acid content of dry sausages from France ranges from

0.30 to 0.70 g/100g (Durand, 1999). 1 smoked Kitoza and 3 dried Kitoza are close to this level.

The levels of L-lactic acid range from 0.69 to 2.20 g/100g. The L-lactic acid content of dried Kitoza (1.46 ± 0.44 g/100 g) is significantly higher ($p<0.05$) than for smoked Kitoza (1.18 ± 0.17 g/100g).

The sum of the D and L-lactic acid contents is on average 1.41 g/100g means 16 mmol/100g. When we compare this sum to titrable acidity (11.9 ± 2.8 meq/100g), it seems that there are no many other acids in Kitoza.

6 samples, among which, 5 are dried Kitoza, have contents in acid D-lactic superior to 0.1 g/100g. Among them, 4 have a D-lactic-acid content close to that of saucisson (0.3-0.7 g/100g (Durand, 1999)).

Total phenol content ranges from 0.49 to 5.09 mg/100g. For dried Kitoza, the content is 0.30 ± 0.40 mg/100g with a minimum and maximum respectively of 0.02 and 1.45 mg/100g. Although not smoked, dried products have a content of phenol non equal to zero which can be explained by the fact that Kitoza is dried under the sun during the day and into the kitchen where we can find a fire at night. Despite this, the levels of total phenols in smoked Kitoza (2.30 ±1.44 mg/100g) are significantly higher ($p<0.001$). Alonge (1987) found phenolic levels in 20 samples of Kundi (Nigerian salted and smoked beef meat) from 0.5 to 1.37 mg/100g with an average of 0.88 mg/100 g. In the city, the phenol content of smoked Kitoza is significantly higher ($p<0.001$) than in peri-urban and rural zones. This could be due to differences in smoking techniques used.

b. Kitoza from pork

The results of physical, chemical and textural analysis of pork Kitoza samples are summarized in Table 5.

Table 5: Results for physico-chemical analysis of pork Kitoza samples

Parameter and unit of measurement	Responsible partner and lab	Variety Process/Raw material/Area (Mean ± SD)					
		Smoked samples (n=15)			Dried samples (n=15)		
		Mean ± SD	Min	Max	Mean ± SD	Min	Max
Color	UT	2.2±0.5 (n=3)	1.6	2.6	nd		
Texture	UT	3.4±0.8 (n=3)	2.9	4.4	nd		
Moisture (g/100g)	CIRAD-R	51.2±6.8[a]	40.4	60.7	31.0±9.1[b]	13.7	45.3
NaCl (g/100g)	CIRAD-R	2.61±1.09[b]	1.46	5.77	4.23±1.76[a]	1.30	6.78
Water activity (Aw)	CIRAD-R	0.955±0.020[a]	0.905	0.977	0.827±0.071[b]	0.646	0.946
pH	CIRAD-R	6.09±0.54[b]	5.08	7.06	6.48±0.30[a]	6.03	7.04
Titrable acidity (meq/100 g)	CIRAD-R	9.7±4.1[a]	3.3	17.5	10.2±3.0[a]	6.5	16.0
D lactic acid (g/100g)	CIRAD-R	0.158±0.176[a] (n=13) <0.014 (n=2)	0.015	0.667	0.171±0.153[a] (n=12) <0.014 (n=3)	0.020	0.553
L lactic acid (g/100g)	CIRAD-R	0.34±0.32[a]	0.02	1.00	0.13±0.15[b]	0.03	0.62
Total phenol (mg/100g)	CIRAD-R	3.25±1.98[a]	0.42	5.98	0.45±0.36[b]	0.04	1.44

n=number of samples; nd: not determined; within one line different superscript letters indicate significant differences ($p<0.05$)

Water content of pork Kitoza ranges from 13.7 to 60.7 g/100g The average water content of smoked products (51.2 ± 1.9 g/100g) is significantly higher ($p<0.001$) than that of dried ones (31.1 ± 2.1 g/100g). For each, there are no significant differences between production areas.
Samples revealed a salt content from 1.3 to 6.8 g/100g. Salt content of dried Kitoza is significantly higher ($p<0.01$) than that of smoked ones (4.2 ± 1.8 and 2.6 ± 1.1 g/100g respectively). This could be due to either a higher impregnation in salt or a higher concentration of salt in because of the highest reduction of the moisture content. There are also differences between production areas ($p<0.01$) but the differences are difficult to explain. Indeed, smoked Kitoza in the rural area are significantly more salty than the peri-urban area (2.9 ± 1.7 and 2.2 ± 0.5 g/100g, respectively) but equivalent to those of the urban

area (2.7 ± 0.9 g/100g). Dried Kitoza of urban areas are more salty than Kitoza collected in peri-urban areas (5.2 ± 1.6 and 2.4 ± 1.7 g/100 g, respectively) but similar to those in rural areas (4.0 ± 1.3 g/100g).

Aw shows a minimum of 0.65 and a maximum of 0.98. Smoked Kitoza (0.96 ± 0.02) show a higher Aw ($p<0.001$) than dried ones (0.83 ± 0.07). For both, there is no difference considering production area.

pH ranges from 5.08 to 7.06. The pH of fresh pork is on the order of 6.8 soon after bleeding the animal. After cooling, the pH is between 5.7 and 6.2 (Laurent, 1981). 15 samples have a pH above 6.2 and 3 a pH above 6.8. This could be due to transformation just after slaughtering. The pH is more acid in smoked Kitoza (6.09 ± 0.54) than dried ones (6.48 ± 0.30) ($p<0.05$). The pH of smoked Kitoza of the urban area is significantly lower than others ($p<0.05$).

Titrable acidity is between 3.3 and 17.5 meq/100g with an average of 9.9 ± 3.5 meq/100g. There is no effect of neither the process nor the production area.

Concerning D-lactic acid content, 2 smoked Kitoza and 3 dried Kitoza are below the detection threshold (0.014 g/100g). Average D-lactic acid content in samples above the detection threshold is 0.139 ± 0.158 g/100g. There is no significant difference neither between the two processes nor the areas of production. D-lactic acid content of. 2 smoked and 3 dried Kitoza are close to the D lactic content of dry sausages from France (that ranges from 0.30 to 0.70 g/100g (Durand, 1999)).

The mean levels of L-lactic acid are 0.34 ± 0.32 g/100g for smoked Kitoza and 0.13 ± 0.15 g/100g for dried Kitoza. Among the 30 samples, only 2 samples have a value close to the content of dry sausage that is 0.40 to 0.70 g/100g (Durand, 1999). After bleeding at the slaughterhouse, the meat becomes the object of very complex chemical reactions leading to the formation of acids, including L-lactic acid, and pH of the meat falls. The low values of the L-lactic must be connected to high pH values and could be explained by the fact that meat is processed immediately after slaughter. Smoked Kitoza of the urban area have a higher ($p<0.05$) L-lactic acid content than those in the rural one which is probably due to the variability of the lactic acid content of the raw material.

Titrable acidity expressed in g lactic acid/100g is in average 0.89 ± 0.32 which is lower than the sum of D and L-lactic acid contents (0.37 ± 0.33 g/100g) probably because of the presence of others organics acids.

Smoked pork Kitoza have an average total phenol content of 3.3 ± 2.0 mg/100g. For dried Kitoza, minimum and maximum are respectively of 0.04 and 1.44 mg/100g. Although not smoked, some have a non equal to zero content that may be due to the manufacturing environment.

Among similar products to smoked pork Kitoza, Boucané (Réunion, French Overseas) have a water and a salt content of 24-37 g/100g and 4-19 g/100g respectively, a Aw from 0.75 to 0.84 and a phenol content of 3-7 mg/100g (Poligné, 2001). Pork Kitoza is thus less salted, dried and smoked. To our knowledge, there is no a traditional product in developing countries made from pork meat strips salted and dried.

4) Results for Lanhouin

The results of physical, chemical and textural analysis of Lanhouin samples are summarized in Tables 6 and 7.

The moisture content of all samples varied between 51.77 ± 1.90 and 57.69 ± 1.40 g/100g. Significant difference ($p<0.05$) was observed in moisture content of Lanhouin within and between species of fish and type of technology used. These levels of moisture contents recorded in the market samples of Lanhouin agreed with those reported in Lanhouin samples, Momone samples and salted anchovy samples (Essuman1992; Sanni *et al*. 2002; Anihouvi *et al*. 2006). It was suggested that the variation in moisture contents of samples could be the result of variable drying time, and level and type of salt used for the processing. However, the moisture content seems to be an inexact indicator of the susceptibility of a product to undergo microbial spoilage. A major factor, which determines the microbial, chemical and enzymatic stability of foods, is the water activity (Aw) (Anihouvi *et al*. 2006). The water activity for all samples varied from 0.73 ± 0.00 to 0.77 ± 0.00. Significant difference ($p<0.05$) was also noted within and between species of fish and type of technology used to process the Lanhouin samples. All these water activity values of Lanhouin samples were slightly above 0.70 as specified by Anihouvi *et al*. (2006). These values of water activity are relatively low to support enzymatic activity and microbial proliferation including food poisoning bacteria during storage. pH values of samples ranged from 6.76 ± 0.20 - 7.67 ± 0.30 and 6.23 ± 0.50 - 7.67 ± 0.30 for cassava fish and kingfish Lanhouin samples respectively. There was significant differences ($p<0.05$) between the pH of Lanhouin samples obtained from anaerobic fermentation and all Lanhouin samples from aerobic and semi aerobic fermentations conditions and other Lanhouin collected at market level. These pH values recorded agree with those reported on Lanhouin samples prepared from cassava fish (7.3 ± 0.6) and kingfish (7.6 ±0.3) (Anihouvi *et al*. 2006). Some of these pH values were higher than those of Momone (6.47 ± 0.1 -6.56 ± 0.1) (Sanni *et al*. 2002) and Adjuevan samples (5.20 ± 0.5 - 6.10 ± 0.1) (Koffi-Nevry *et al*. 2011). The salt content of Lanhouin samples varied from 8.26 ± 0.66 - 13.30 ± 1.7 g/100g and 7.78 ± 2.1 - 12.03 ± 4.6 g/100 g for cassava fish and kingfish respectively. No significant difference ($p<0.05$) was observed for all samples. These values of salt content were slightly higher than those reported during a previous study (7.3 ± 1.6 g/100 g for cassava fish and 5.2 ± 1.0 for kingfish

Lanhouin collected in the Atlantic municipalities) (Anihouvi *et al*. 2006); but these values agree with the salt contents of 12.7 ± 1.20 for cassava fish and 11.8 ± 0.03 for kingfish, reported by Dosso-Yovo *et al*. (2011) on laboratory samples of Lanhouin. Various organic acids including lactic acid, citric acid, malic acid, formic acid, acetic acid and propionic acid were detected in the Lanhouin samples from both cassava fish and kingfish. However lactic acid was the most important organic acid in terms of amount, meanly in the Lanhouin samples obtained from semi-aerobic and anaerobic fermentations. The production of organic acids could be due to the presence of little fermentable carbohydrate in the fish flesh or to the presence of a few numbers of lactic acid bacteria in the fermented fish. Similar observation was also made during the fermentation of soybeans into dawadawa (Dakwa *et al*., 2005).

Table 6: Results for physico-chemical analysis of Lanhouin market samples

Parameter and unit of measurement	Responsible partner and lab	Variety Process/Raw material/Area (Mean ± SD)			
		Comé market		Djoda market	
		Cassava fish (n=6)	Kingfish (n=6)	Cassava fish (n=6)	Kingfish (n=6)
Texture sensorial appreciation (mm)	UAC	52.50±3.70[a]	24.96±3.70[b]	46.50±3.70[c]	20.40±3.80[d]
Moisture (g/100g)	UAC	51.77±1.90[ab]	54.15±3.40[ac]	53.74±2.50[ac]	55.11±2.20[ac]
NaCl (g/100g)	UAC	10.00±3.30[a]	9.60±3.90[a]	8.26±0.66[a]	7.33±2.90[a]
Water activity (Aw)	UAC	0.730±0.003[a]	0.762±0.005[b]	0.761±0.003[b]	0.772±0.004[b]
pH	UAC	7.44±0.30[a]	7.69±0.10[a]	7.67±0.30[a]	7.67±0.30[a]
Lactic acid (g/100g dwb)	UAC	2.40±1.00[a]	3.21±1.40[b]	0.70±0.30[c]	3.90±0.10[b]
Citric acid (g/100g dwb)	UAC	0.24±0.21[a]	0.14±0.11[b] (n=4) 0.00 (n=2)	0.19±0.21[b] (n=4) 0.00 (n=2)	0.10±0.00[c] (n=1) 0.00 (n=5)
Malic acid (g/100g dwb)	UAC	0.13±0.18[a] (n=4) 0.00 (n=2)	0.10±0.09[a] (n=2) 0.00 (n=4)	0.28±0.27[a] (n=3) 0.00 (n=3)	0.11±0.12[a] (n=2) 0.00 (n=4)
Formic acid (g/100g dwb)	UAC	0.07±0.07[a] (n=4) 0.00 (n=2)	0.07±0.04[a] (n=4) 0.00 (n=2)	0.18±0.31[b] (n=4) 0.00 (n=2)	0.26±0.33[b] (n=3) 0.00 (n=3)
Acetic acid (g/100g dwb)	UAC	0.50±0.21[a]	0.52±0.11[a]	0.44±0.24[a]	0.47±0.20[a]
Propionic acid (g/100g dwb)	UAC	0.24±0.20[a] (n=4) 0.00 (n=2)	0.22±0.15[a]	0.08±0.04[b] (n=5) 0.00 (n=1)	0.30±0.10[a]

dwb: dry weight basis; n=number of samples; within one line different superscript letters indicate significant differences ($p<0.05$)

Table 7: Results for physico-chemical analysis of Lanhouin processing sites samples

Parameter and unit of measurement	Responsible partner and lab	Variety Process/Raw material/Area (Mean ± SD)					
		Aerobic fermentation		Semi aerobic fermentation		Anaerobic fermentation	
		Cassava fish (n=6)	Kingfish (n=6)	Cassava fish (n=6	Kingfish (n=6)	Cassava fish (n=6)	Kingfish (n=6)
Texture sensorial appreciation (mm)	UAC	48.30±4.30[a]	29.80±2.90[b]	58.30±3.90[ab]	38.60±3.80[b]	47.60±4.30[a]	34.30±3.70[b]
Moisture (g/100g)	UAC	55.15±1.60[a]	55.93±1.90[a]	55.73±1.90[a]	56.27±2.00[b]	57.33±2.50[b]	57.69±1.40[b]
NaCl (g/100 g wwb)	UAC	13.30±1.70[a]	7.78±2.10[b]	9.97±3.30[b]	10.32±7.10[b]	11.68±2.90[a]	12.03±4.60[a]
Water activity (Aw)	UAC	0.741±0.003[a]	0.761±0.006[b]	0.755±0.004[b]	0.767±0.005[b]	0.735±0.003[a]	0.746±0.005[a]
pH	UAC	7.15±0.20[a]	7.07±0.80[a]	7.41±0.20[b]	7.32±0.30[b]	6.76±0.20[a]	6.23±0.50[ab]
Lactic acid g/100 g dwb)	UAC	0.00 (n=6)	1.36±0.85[a]	3.04±0.70[a]	4.52±0.03[b]	4.90±1.40[b]	2.62±2.66[a]
Citric acid g/100 g dwb)	UAC	0.42±0.33[a] (n=4) 0.00 (n=2)	0.25±0.13[b] (n=5) 0.00 (n=1)	0.19±0.18[b] (n=5) 0.00 (n=1)	0.14±0.09[b] (n=3) 0.000 (n=3)	0.14±0.10[b]	0.57±0.00[a] (n=1) 0.00 (n=5)
Malic acid g/100 g dwb)	UAC	0.33±0.36[a] (n=4) 0.00 (n=2)	0.40±0.00[b] (n=1) 0.00 (n=5)	0.05±0.02[ab] (n=3) 0.00 (n=3)	0.03±0.00[ab] (n=2) 0.00 (n=4)	0.11±0.13[bc] (n=5) 0.00 (n=1)	0.16±0.18[bc] (n=3) 0.00 (n=3)
Formic acid g/100 g dwb)	UAC	0.27±0.24[a] (n=5) 0.00 (n=1)	0.10±0.02[a] (n=4) 0.00 (n=2)	0.13±0.15[a] (n=5) 0.00 (n=1)	0.09±0.01[a] (n=4) 0.00 (n=2)	0.07±0.03[a] (n=5) 0.00 (n=1)	0.11±0.02[a] (n=2) 0.00 (n=4)
Acetic acid g/100 g dwb)	UAC	0.53±0.10[a]	0.50±0.10[a]	0.50±0.10[a]	0.50±0.08[a]	2.60±0.05[b]	0.40±0.01[a]
Propionic acid g/100 g dwb)	UAC	0.19±0.13[a] (n=4) 0.00 (n=2)	0.87±0.82[b] (n=4) 0.00 (n=2)	0.28±0.27[a] (n=4) 0.00 (n=2)	0.24±0.16[a] (n=5) 0.00 (n=1)	0.18±0.18[a] (n=3) 0.00 (n=3)	0.20±0.10[a]

dwb: dry weight basis; n=number of samples; within one line different superscript letters indicate significant differences ($p<0.05$)

5) Results for Kong

The results of physical, chemical and textural analysis of Kong samples are summarized in Table 8.

Table 8: Results for physico-chemical analysis of Kong samples

Parameter and unit of measurement	Responsible partner and lab	Variety Process/Raw material/Area (Mean ± SD)		
		Zone 1: Ziguinchor		Zone 2: Dakar
		Well dried smoked	Wet smoked	Wet smoked
Moisture (g/100g)	UCAD	15.87±4.40[a] (n= 12)	52.89±6.34[b] (n= 8)	57.31± 3.51[b] (n=15)
NaCl (g/100g)	UCAD	1.45±0.74[a] (n= 12)	0.83±0.40[a] (n= 8)	0.40 ±0,26[b] (n=15)
pH	UCAD	6.48 ±0.09[a] (n= 4)	nd	6.36 ± 0.07[a] (n=4)
Total phenol (mg/100g dwb)	UCAD	61.00±21.58[a] (n= 4)	43.00±9.42[b] (n= 3)	46.03±24.48[b] (n=6)

dwb: dry weight basis; n=number of samples; nd: not determined; within one line different superscript letters indicate significant differences ($p<0.05$)

The results of this analysis provide biochemical characteristics very different between the wet and dried smoked Kong. The water contents were respectively in average 56.20 ± 4.79 and 15.87 ± 4.40 g/100g and are equivalent to previous results (Rivier *et al.*, 2010). These authors also measured water activity which was found to be at maximum of 0.8. According to Goli (2006), it is a value-reference proven the stability that extends the life of the finished product. Nevertheless smoked kong sells in Senegal has no primary packaging (D.1.1.2.2). Storage conditions in market also induce quick degradation of the end-product. All these conditions allowed a short shelf-life of two to three days.

The salt content is too low (0.40 ± 0.26 to 1.45 ± 0.74 g/100g) to limit microbial growth. They testify to the absence of a salting operation before smoking.

The pH values are quite identical to fresh fish (Sainclivier, 1985). This result shows no significant changing of pH due to the smoking in the end product. These pH values indicate that no fermentation occurs during production.

The degree of smoking is marked by total phenolic contents that vary between a minimum value of 18.00 and a maximum value of 95 mg/100g dry matter whatever the kind of smoked Kong. However, dried smoked Kong contains more phenols and less moisture because this product is exposed longer to the smoke (D1.1.2.2).

The two areas of sampling may be compared through wet smoked Kong samples. Comparison shows equal characteristics excepted salt content which is still very low.

6) Conclusion

➢ KITOZA

Kitoza, being they of beef or pork, contain approximately 40 g/100g of water and 3 g/100g of salt. They show a water activity on average 0.89. Smoked beef and pork Kitoza are less smoked than Boucané but more smoked than Kundi.

Dried Kitoza are more dehydrated than smoked ones and are also more salted as regards those with pork. As a result, their water activity (Aw) is lower (of the order of 0.83). Smoked Kitoza (Aw 0.94) are classified so mainly in food with high moisture content while dried products are for the greater part in the zone of intermediate humidity food (Leistner and Rödel, 1976). However, phenols of the smoked products strengthen their ability of preservation. Among smoked beef Kitoza, those produced at the rural level are more dehydrated than at the urban and peri-urban levels. Dried Kitoza (and beef smoked Kitoza of the rural zone) are thus the driest products and show the lowest Aw. For pork Kitosa they also contain more salt. These products are only made at the level of the households for their own consumption. While in urban and peri-urban zone, the consumers consume Kitoza quickly after purchase or have refrigerators, in rural zone the product has to have a better capacity of preservation mostly at room temperature where it continues to dry or to be smoked if the preservation is made above a fire. Furthermore, producers of smoked Kitoza in urban and peri-urban zones should not rather obtain products too much dehydrated because of the lower engendered yields and products not corresponding to the taste of the urban consumers. The characterization of traditional process that will be done in WP3 (D3.1.2.2) will probably explain rural products characteristics (duration of smoking higher in rural zone, additional sun-drying step….).

Pork Kitoza were significantly ($p<0.05$) scored less in terms of color, contrary to beef Kitoza and this was in accordance with the type of meat (beef is a red meat and pork a white meat). There were no significant differences for texture.

The high pH values of pork Kitoza (6.3) could be explained by the fact that meat is processed immediately after slaughter. pH of beef Kitoza is lower (of the order of 5.8). These pH values indicate that Kitoza is not a fermented food. However, compared to smoked ones (pH 5.9) dried beef products show significant lower pH (5.7). This value is of the order of pH values of

Kaddid (5.32) (Bennani *et al.*, 1995), Pastirma (5.7± 0.18) (El-Khateib, 1997), Charqui (5.46) (Lara *et al*., 2003) and Biltong (5.85 ± 0.24) (Osterhoff et Leistner, 1984), salted/dried beef meat products being considered spontaneous fermented by certain authors. Kaban (2009) noticed that pH of Pastirma decreased to 5.6-5.4 during salting before re-increasing to 5.8 at the end of drying/ripening. Moreover some samples (9/60 of which 3 dried beef, 1 smoked beef, 2 smoked pork and 3 dried pork) have some D-lactic acid content of the order the level in saucisson, a well known fermented meat product. Even there, a kinetic study of the evolution of the biochemical and microbiological characteristics during the process will allow to define better the unit operations involved in particular as for an operation of spontaneous lactic fermentation.

- **LANHOUIN**

This investigation revealed that the pH values of the majority of samples were above 7. Such level of pH is too high to inhibit microbial activity during storage. However pH levels around 6 were observed on some samples (23.3%) mainly the ones obtained from anaerobic and semi-aerobic fermentations. In the same way, the salt content of some samples (58%) were lower than 10 g/100 g. Salt contents of less than 10 g/100g were too low to inhibit microbial histidine decarboxylase activity. For all Lanhouin samples the water activity (Aw) values were slightly above 0.70. These levels of Aw are relatively low to prevent enzymatic activity and microbial proliferation including food poisoning bacteria during storage. So, for the reengineering activities, one of the suitable manners to upgrade the quality of Lanhouin is to find a way to lower the pH of Lanhouin during processing. Low pH combined with low Aw and appropriate packaging could allow the production of safe Lanhouin and improve as well the preservation of Lanhouin during storage.

- **KONG**

According to our results, dried smoked Kong is quite different for wet smoked one. A short smoking time induced a high level of moisture and less phenolics contents in the wet smoked Kong. These characteristics do not allow a long shelf-life when compare to dried smoked Kong

7) Bibliography

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